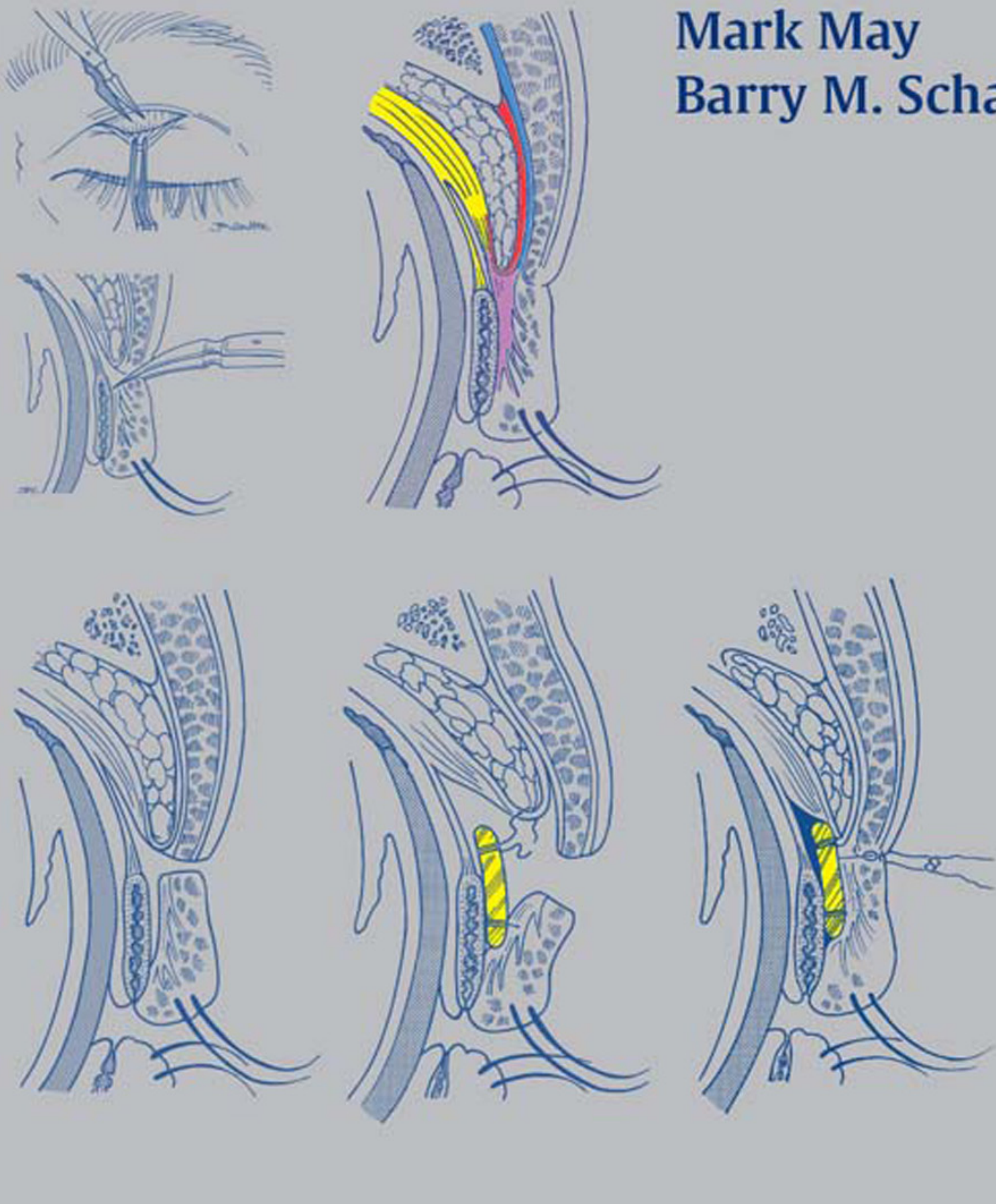
Facial Paralysis

Rehabilitation Techniques

Mark May
Barry M. Schaitkin



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Contents

Preface

The beginning of wisdom is the fear of The Lord.
Psalms 111:10

The second edition of The Facial Nerve was published in the year 2000 and has received high praise from peer reviewers. The encyclopedic offering contained in the 855 pages of that second edition, however, is overwhelming to many practitioners (according to comments surveyed by the publisher, and the authors' personal communications with colleagues). Yet, there is great interest in Section VI, which specifically deals with rehabilitation techniques for acute and long-standing facial paralysis. As a result of that survey and to satisfy this special interest, the publisher agreed with us to reproduce Section VI as a separate volume—this book.

This book on surgical rehabilitation of the paralyzed face represents 30 years of experience by a single surgeon. Between January 1963 and June 1996, 3,068 procedures were performed in 859 patients. The facial rehabilitation surgeon (general; plastic; maxillo-facial-oral; ophthalmoplastic; otolaryngologist–head and neck; skull base; neurosurgeon) will find this special edition unique. General principles are followed by specific techniques that are illustrated step by step and accompanied by information on patient selection, indications, contraindications, and complications. Procedures are discussed and illustrated in great detail to enhance their value to other surgeons. The clinician will find useful guidelines to apply to specific patient problems. In addition, this book includes a chapter offering non-surgical techniques that can augment surgical efforts by employing cosmetic camouflage.

The authors were reluctant to subdivide the original comprehensive textbook, since it is our belief that most surgeons asked to manage a patient with facial paralysis may not be aware of all the basic science principles so necessary to properly match patient candidates with the variety of rehabilitation approaches. Those surgeons who desire that sort of information can refer to the original text, The Facial Nerve, 2nd Edition.

The authors are humbly reminded that concepts that have evolved are being modified, and recommendations that now seem attractive, based on available data, may require revision in the future. This book, however, shares an extensive experience that will be a useful guide to all rehabilitation surgeons.

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1

Perspective in Facial Reanimation

John Conley, M.D., and Mark May, M.D.

Nathan Bedford Forrest, an American Civil War Confederate general, was asked how to be successful in battle. He replied "Get there first with the most."

The best results achieved with facial reanimation techniques require nerve repair as soon after injury as possible or a combination of techniques that will give the strongest facial movement.

The condition of facial paralysis has attracted the attention of the artist and sculptor through the ages as a stylistic grotesqueness for which there was no reprieve. In the mid-19th century, the medical profession recognized the problem as one that might be improved by muscle transposition and skin tightening. These meager steps were fraught with disappointment because of technical deficiencies and a lack of understanding regarding the neuromuscular and physiologic changes associated with facial paralysis. What followed was a period of stagnation regarding correction of the vast variety of anatomical and physiologic conditions with which congenital and acquired, immediate and long-standing, and partial and complete facial paralysis are associated. Over the past 100 years, the approach to these conditions has changed greatly as the result of advances made in otologic and general surgery during World Wars I and II.

Originally management of facial palsy focused on the facial nerve itself; appreciation of the important role of the facial muscles came later as the fundamentals of facial paralysis began to come into focus. Within the past three decades, greater understanding of and more significant advances in the treatment of this condition have been achieved than in all preceding periods. Literally an avalanche of new ideas in this field has provided clinicians with hitherto unavailable basic information about the regenerative potentials of damaged nerves and muscles in the face. A host of new tests document the degree, the level, the severity, and the progress of the paresis. New and imaginative techniques for suturing, grafting, crossing, and implanting nerves, and for transferring regional muscles and implanting free muscles have greatly improved the results of facial nerve repair. Advancements in instrumentation and technology have paralleled the development of these new techniques. This renaissance also has had its confusions and its flawed experiments, but enough techniques have been developed based on sound knowledge of principles of nerve innervation and regeneration that a new era of facial nerve reanimation has been entered.

Evolution of Facial Reanimation Techniques

Historical Review

The possibility that surgery could be performed on the facial nerve was conceived in 1821 when Sir Charles Bell[1] established that the facial nerve was indeed the motor nerve to the muscles of the face. He described the condition of facial paralysis with such detail and clarity that the idiopathic variety still bears his name.

Nerve Repair Drobnick[2] performed the first nerve anastomosis in 1879 by connecting the facial nerve to the spinal accessory nerve. Manasse[3] performed anastomoses with the spinal accessory, hypoglossal, and glossopharygeal nerves in 1900. Stacke[4] resected a portion of the facial nerve in the fallopian canal and juxtaposed it in 1903. Ballance[5] reported on anastomosis to the spinal accessory and hypoglossal nerves in 1924. Martin[6] repaired the facial nerve in the fallopian canal by end-to-end suture in 1927. In 1927, Bunnell[7] sutured the nerve in the fallopian canal, and in 1930, he performed the first facial nerve graft. Ballance and Duel[8] both established the feasibility of facial nerve grafting in 1932. Lathrop's,[9] and Myers'[10] contributions during World War II were most important in that they established the fact that this particular cranial nerve had exceptional capabilities for regrowth and that significant, and at times astounding, improvements in facial paralysis could be accomplished by simple and routine techniques. At that time, nerve grafting and nerve approximation were accomplished using 4-0 silk and under direct visualization (without magnification). There was no doubt that these humble and unpretentious efforts were effective. After World War II, Conley subsequently applied these concepts to tumor surgery in the head and neck, Maxwell introduced them into the university circles, and Miehlke carried them to Europe.

Myoneurotization Myoneurotization was first advanced by Lexer and Eden[11] in 1911. Erlacher[12] reported on this phenomenon in 1915. Owens[13] advocated the transplantation of the masseter muscle into the face to accomplish this neurotization in 1947. A review of the variety of regional muscle transposition techniques with their limitations is illustrated in Figure 1–1. In 1971, Thompson[14] proposed the free transplantation of skeletal muscle under certain criteria. Hakelius[15] supported Thompson's work in 1974. Conley[16] reviewed his experience with the facial nerve in parotid gland surgery in 1975. Rubin[17] emphasized the criteria for and usefulness of muscle transposition in 1977, while Harii, Ohmori, and Torii[18,19] used free muscle transposition with neurovascular anastomosis to rehabilitate the paralyzed face. Weiss[20] and Sunderland[21] wrote texts describing myoneurotization.

Cross-face Graft Scaramella[22] described the technique for placing a cross-face nerve graft in 1970. Anderl[23,24] modified this technique and discussed some of its limitations and criteria for use (Fig.1–2).

Oriented Fascicular Nerve Repair Miehlke[25] and May[26] both described the spatial orientation of fibers in the facial nerve in 1973, permitting Millesi[27,28] in 1977 to use techniques of fascicular grafting to develop a technique of facial nerve grafting.

This, in essence, was the beginning of a new era in managing facial paralysis, but its wellsprings go back over 100 years to the original pioneers, experimenters, and investigators just described.

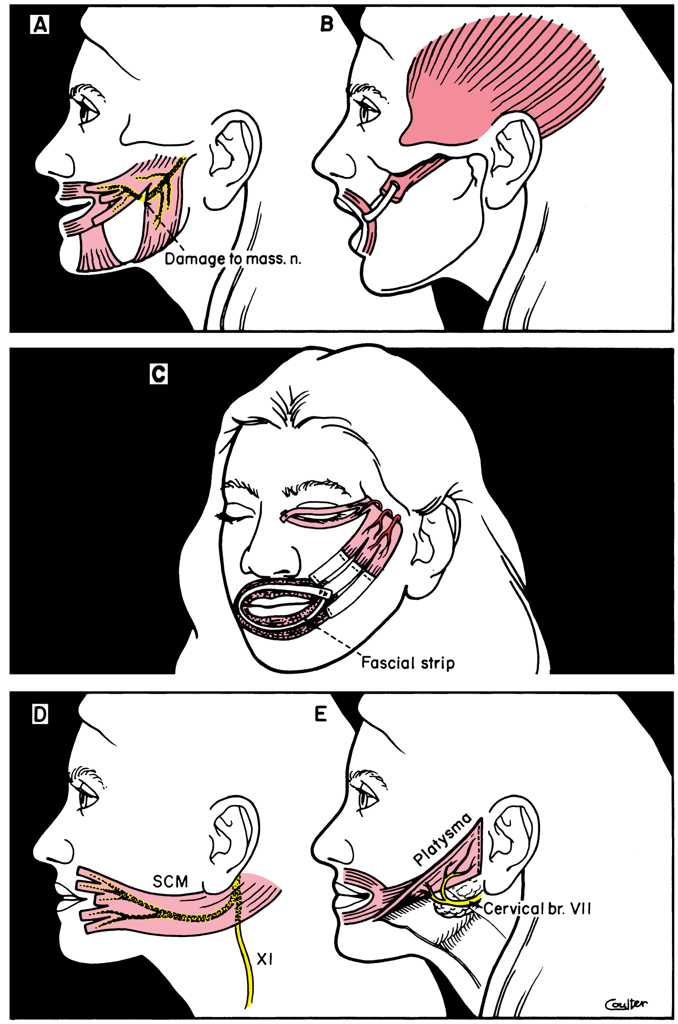


Figure 1–1. Historical review of regional muscle transposition with limitations of each technique. Some types of regional muscle transpositions: **A**, Lexer's original technique risked transecting nerve supply to masseter muscle. **B**, McLaughlin procedure attaching coronoid process to circumoral fascia lata suspension. Movement is not at the lip-cheek crease. **C**, Original technique of temporalis transfer with fascial strips or superficial temporal fascia turned down to obtain length. This technique as depicted can cause eye closure with chewing, ectropion of lower eyelid, muscle bulk in cheek area, and trismus from circumferential perioral fascia. **D**, Sternocleidomastoid transposition. Movement is more unnatural, in the wrong direction, and muscle is bulky. **E**, Platysma transposition. Muscle is thin and delicate, and does not provide much power; pull is in the wrong direction.

Evaluation of Modern Concepts

There has been a maturing of the process of rehabilitation of the paralyzed face since the publication of the first edition of this book. This maturation emphasizes the most practical surgical techniques, and adds significant scientific data to enhance treatment. Some of the more complex procedures, which had theoretical endorsement, have become less appealing. The introduction of the simpler and more effective treatments that deal primarily with eyelid closure have, in the main, superseded the Silastic encircling and temporalis muscle transposition (Fig. 1–1C)[17] and free muscle transplantation[14] for this purpose. The mechanics of the use of spring leverage, gold weight loading, and improved lower lid tightening are not only technically appealing, but also functionally and aesthetically effective (see Chapter 6).

The brilliant concept of cross-face grafting, with its variety of variations (Fig. 1–2), delayed staged procedures and protracted morbidity, and at times unpredictable results, is now much better understood as to what it entails and can offer than when it was first presented as a potential method of choice. This has caused a significant reduction in its clinical applicability, but also has highlighted its value in certain complex cases. It became realized that it was not

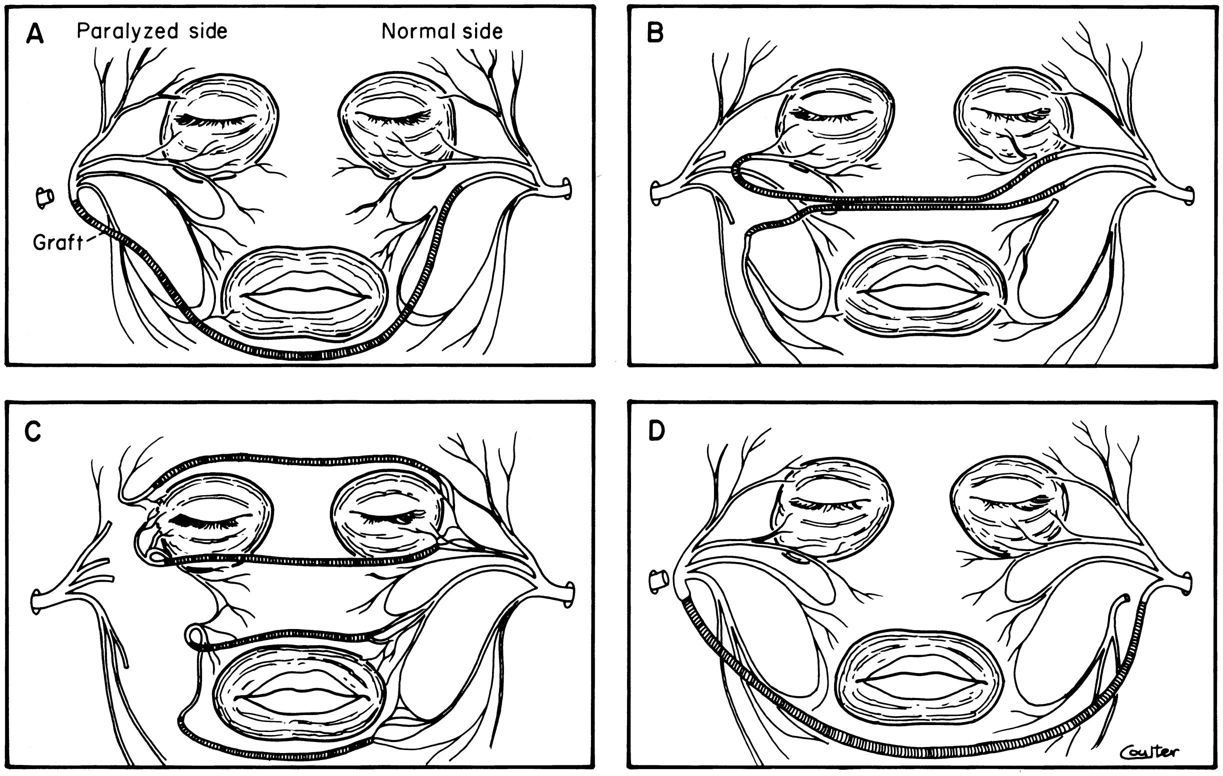


Figure 1–2. Variety of techniques for faciofacial cross-face graft. **A**, Scaramella's cross-face graft. The graft may also be passed over the upper lip. **B**, Fisch's technique. **C**, Anderl's modifications. In Conley's experience the frontal and marginal mandibular functions return in only 15% of patients, even with primary nerve grafting. **D**, Conley's preferred technique is to anastomose the entire lower division of the normal side with the main trunk of the paralyzed side. Exposure is easily obtained with standard parotid incisions. The graft may be passed over the upper lip.

competitive with other techniques for a variety of reasons in the management of these problems.

The concept of oriented fascicular facial nerve repair was based on a false premise. It has been established that the facial nerve is not oriented as it courses through and exits the temporal bone.[29] Further, oriented fascicular repair has not been demonstrated to improve results.

The techniques used to rehabilitate the paralyzed face have increased in sophistication from merely suturing the nerve to techniques of nerve and muscle substitution that incorporate microvascular procedures (see Chapter 5). Each has a place in treatment. Some are quite specific, some give similar results, and many will be modified. The final degree of rehabilitation achieved may be spectacular, but because all operations incorporate elements of experimentation regardless of the indications for surgery or the surgeon's skill, some may fail to reanimate the face, and some may even cause greater deficits. Techniques to treat facial paralysis are by no means perfect, and many problems remain to be solved. Operations such as the cross-face nerve graft and free muscle graft attest to the innovators' genius and ambition. However, they unquestionably have limited and specific roles in rehabilitation of the paralyzed face. Thus, some operations gain temporary popularity and are performed on the basis of an enthusiastic presentation. This process appears to have become integral to the evolution of knowledge, but the need to state the criteria for use of every new operation needs to be emphasized. There is no single operation applicable to all cases of facial paralysis. A careful preoperative assessment will point the direction of management, depending on the etiology, clinical status, optimum course of treatment, and expected results.

The patient quite understandably wishes to have a normal face, and the surgeon can usually restore some degree of normalcy: today it is possible to achieve some degree of improvement in every case of facial paralysis. The improvement may be in tone, in protection for the eye, or some degree of movement of the face upon intention. However, these enhancements often leave much to be desired, and the patient as well as the surgeon must appreciate that once the facial nerve is damaged, there is no chance to restore normal facial function. Even in the most successful cases where voluntary movement has been dramatically restored, there will be significant and permanent deficiency in involuntary control. This is all too evident when the patient involuntarily responds to emotion and only the normal side of the face moves. This imbalanced muscular movement with involuntary emotion is the hallmark of paralysis. The involuntary nerve pathways and mechanisms for involuntary muscle movement are unknown and thus can never be restored after injury. This does not mean that the patient cannot accommodate for deficiency; he/she can accommodate a great deal by supervening some degree of restrictive control on the normal side and some degree of intentional movement on the paralyzed side. However, the creation of human expression that is balanced, restrained, and symmetric requires effort and practice.

Three Basic Operations for Reanimating the Face

Many of the stigmata of facial paralysis can be improved by three basic operations (see Chapters 2 through 4 for details of surgical technique). The most effective of these techniques is *facial nerve repair* (Figs. 1–3 and 1–4). *Hypoglossal nerve crossover* (Figs. 1–5 and 1–6) has been extremely effective when the proximal segment of the facial nerve is not available for grafting, and regional *muscle transposition* has proved to be helpful when the mimetic muscles are either nonexistent or nonfunctional or the distal facial nerve is fibrotic. It is fully appreciated that there are many variations on these three basic techniques that may be indicated and may be helpful under certain circumstances. **The time between nerve injury and repair was the most significant factor in determining which procedures were appropriate and whether the surgery would be successful. The best results were achieved when the central nerve stump was connected to the peripheral system of the facial nerve performed within 30 days of injury**. When the central stump was not available or the time between injury and repair was between 1 and 2 years, the procedure of choice

A–C

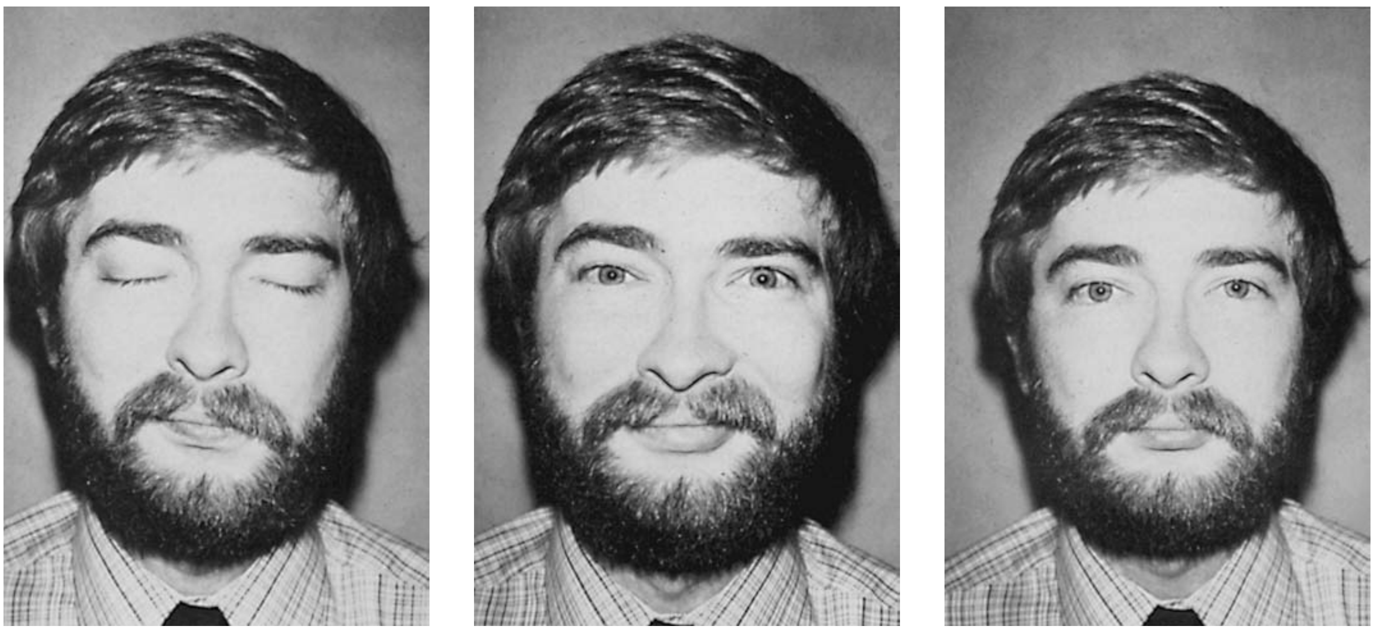


Figure 1–3. A-C, Excellent results in free ipsilateral facial nerve grafting following radical ablation for cancer of the parotid.

A, B

Figure 1–4. A, Free autogenous cervical nerve graft to right facial nerve following adenoid cystic carcinoma of parotid 2 years previously. **B**, Excellent movement and simulated emotional response.

A, B

Figure 1–5. **A**, Complete facial paralysis following gunshot wound of skull. **B**, Hypoglossal crossover has produced good symmetry of the face and eyebrows and a simulated smile.

A–C

Figure 1–6. **A**, Return of function to the right side of the face by hypoglossal nerve crossover 4 to 6 months following radical resection of the parotid gland. There is good tone in repose. **B**, The facsimile of a smile is produced by movement of the tongue. Muscular response in all quadrants of the face is strong with the exception of the forehead. **C**, Although the right hypoglossal nerve was crossed over to the facial nerve, there is no atrophy or limitation of movement of the tongue in this instance.

was a hypoglossal-facial nerve crossover. When repair was performed between 2 and 4 years after injury, frequently the hypoglossal-facial nerve crossover was combined with a muscle transposition procedure (Fig. 1–7). If the distal nerve and muscle system were not suitable for the procedures just described, temporalis muscle transposition was the preferred reanimation technique. This procedure is competitive with free muscle transplantation neurovascular anastomoses (see Chapter 5). The "three basic operations" work to some extent in every case; however, results can be improved further by periodic fine tuning surgery. Facial symmetry at rest with oral competence and creation of a dynamic smile is the goal of the reanimation surgeon. Eyelid reanimation is achieved by performing separate procedures, thus allowing patients to close the eye independently from mouth movement (see Chapter 6).

A, B

Figure 1–7. **A**, Facial paralysis following resection for cancer of ear canal. Masseter muscle was transposed. **B**, Three years postoperatively with good facial movements and regional neurotization into the orbicularis oculi.

Factors in Selecting Surgical Technique

Selecting the appropriate technique for each given situation must address many questions: (1) What was the cause of the paralysis? (2) Is the paralysis complete? (3) How long has the paralysis been present? (4) How old is the patient? (5) Is the patient in good health? (6) What is the patient's psychological status; in particular, are the patient's expectations for rehabilitation realistic? (7) What problem does the patient feel should be addressed; is a particular aspect of facial function troublesome? (8) What are the functional defects? (9) What is the patient's life expectancy? (10) Are any other cranial nerves involved, such as the trigeminal, vagus, or hypoglossal? (11) What surgical reanimation procedures have already been performed? When, and what were the results? (12) What is the surgeon's role in decision making?

Cause of Paralysis

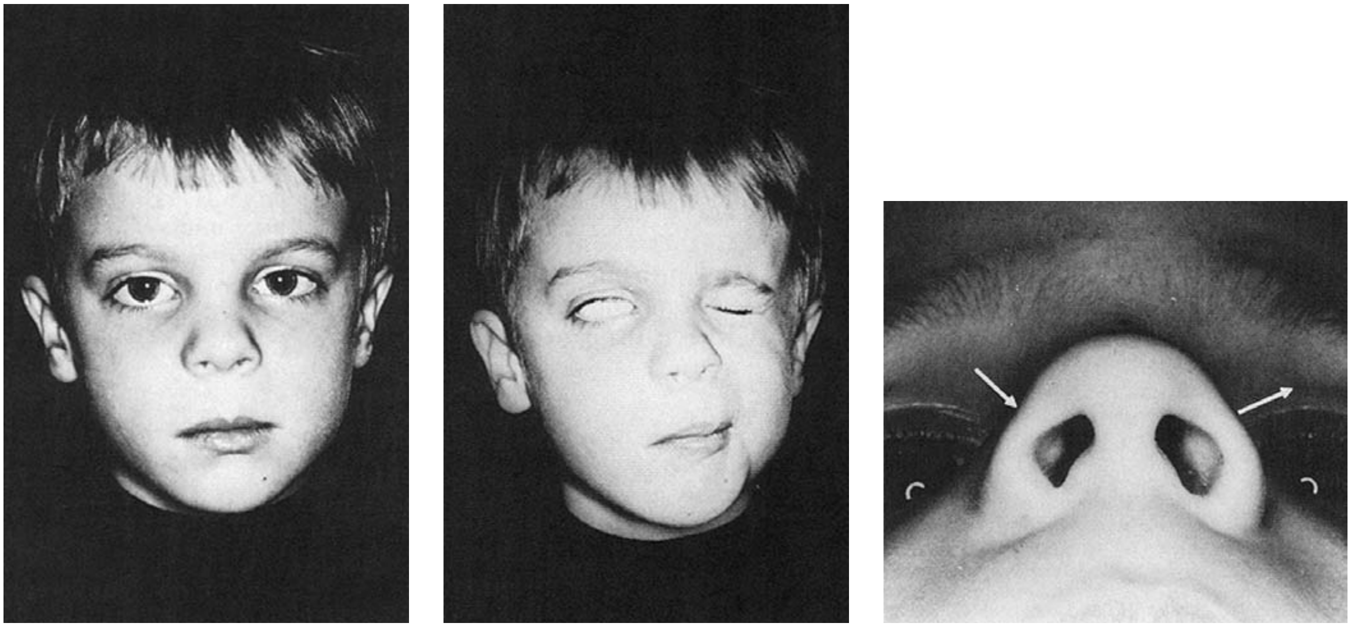
Knowing the cause of facial paralysis may be critical in determining how best to restore function. Most facial palsies evaluated for possible rehabilitation will be the result of trauma, either surgical or accidental. If the injury was acute and the nerve was severed, the best results are achieved when repair is performed within 30 days of injury. The following situations demonstrate how the causes of facial paralysis influence treatment:

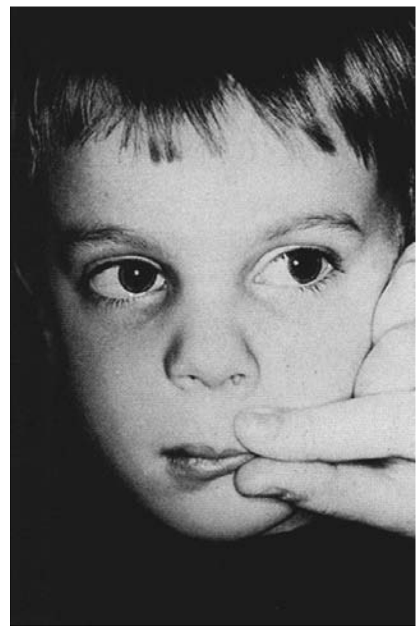
- Disruption of the facial nerve that occurs during surgery to manage an acoustic tumor is best treated by end-to-end repair or grafting of the nerve at the time of surgery;[30] if this is not possible, a hypoglossal-facial nerve crossover technique is the treatment of choice (see Chapter 3).
- A facial nerve resected in surgery to treat von Recklinghausen's disease (neurofibromatosis Type II) should not be reanimated by the hypoglossal-facial crossover technique because of the likelihood of subsequent additional cranial nerve involvement. Should the contralateral hypoglossal nerve or the tenth cranial nerve become involved in a patient whose hypoglossal nerve had been used to reanimate the face, the patient's swallowing mechanism would be severely crippled. It is far more reasonable to reanimate the face of such a patient by hypoglossal-facial jump graft (see Chapter 3) or by temporalis muscle transposition (see Chapter 4).
- Finally, every effort must be made to find the cause of facial paralysis before planning or performing facial reanimation surgery in order to appropriately treat a patient with a potentially lethal tumor of the posterior fossa, temporal bone, parotid, or skull base.

Degree of Paralysis

It is important to determine if the facial paralysis is complete before planning reanimation surgery. Although patients may have facial paralysis of long-standing, some may have partial or complete sparing of parts of the face, while others may have experienced some spontaneous regeneration of the facial nerve. In the latter case, some synkinetic movement will be evident; for example, smiling may cause the eye on the involved side to close. Evaluation of a small degree of facial motor function may require that the examiner use his finger to break the pull of the muscle on the opposite (intact) side when trying to determine if there is any spontaneous motion on the paralyzed side; it also helps to look for nasal flaring, to evaluate eye closure by noting whether the eyelids approximate, and looking for facial movement with the patient lying down to eliminate the influence of gravity (Fig. 1–8). Clearly, if there has been partial recovery of facial

A–C





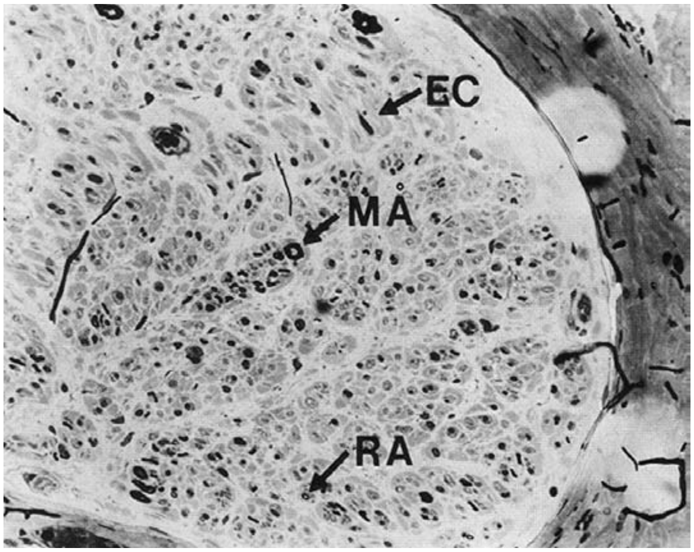
D

Figure 1–8. Evaluating facial function in a 5-year-old boy 3 days postonset acute Bell's palsy, right side. **A**, Facial tone impaired when face examined in repose. Note widening of the interpalpebral fissure and slight sagging of the corner of the mouth on the right side. **B**, Attempt at eye closure and grimacing. Eyelids do not approximate. The cornea rolls up underneath the upper lid indicating good Bell's phenomenon. No movement of the mouth. **C**, The nasal ala flares on the normal side but not on the involved side. **D**, Fixing the corner of the mouth on the normal side so that the weak side will not be pulled toward the normal side. This may uncover some minimal movement on the weak side.

nerve function or if only certain branches of the facial nerve are involved, rehabilitation efforts should be directed to the most involved region. Specific rehabilitation procedures will be discussed in Chapters 2 through 9. The results of electrical tests are useful in that they help the surgeon to determine the degree of injury. This is especially true in the acute stage, although they can help to evaluate functioning of the peripheral nerves in long-standing injuries as well.

Duration of Paralysis

The time following onset of the paralysis must be taken into account. No irreversible procedure such as a nerve graft, facial cross-face graft, or hypoglossal crossover should be undertaken while spontaneous recovery remains possible. If the facial nerve was spared following acoustic tumor surgery, it is advisable not to perform a procedure that interrupts the integrity of the facial nerve less than 12 months from the time of injury in order to allow adequate time for evidence of spontaneous recovery to occur. Twelve months is a good waiting period because it has been the author's experience that if no recovery has been noted in this period of time, spontaneous recovery of useful function is unlikely. Despite the foregoing recommendations, the period of observation for spontaneous recovery may be shortened to 4 months if it is uncertain that the facial nerve is intact following trauma or temporal bone or extracranial surgery. In the event that there is any uncertainty regarding the integrity of the facial nerve, re-exploration should be performed once loss of response to electrical stimulation has been determined. Time is of the essence in achieving the best possible results since an 8-fold decrease in axon



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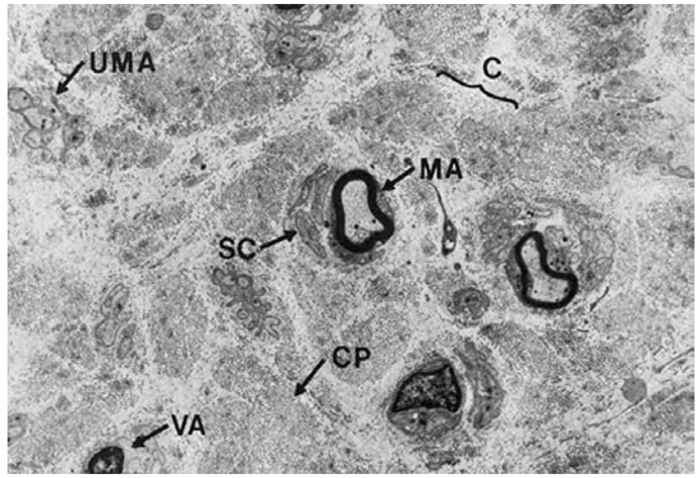

B

Figure 1–9. Nerve biopsy of frontal branch of facial nerve in a patient with slowly progressive facial weakness over a period of 2 years. Although a tumor was suspected none was found, despite exploration of the facial nerve throughout its course in the temporal bone and extracranial distribution. **A**, Light microscopy: 1-μ plastic-embedded section stained with Toluidine blue reveals significant diminution in myelinated axons (MA). There is marked increase in endoneurial collagen (EC). Remyelinated axons (RA) are seen. ×250. **B**, Electron micrographs demonstrate marked reduction in myelinated (MA) and unmyelinated (UMA) axons. Vacuolated axons (VA) are seen. Collagen pockets (CP) are prominent. Schwann cell (SC) processes are extensive. Collagenization (C) may be noted. ×5000. (Courtesy of Smith J, Martinez AJ, Department of Neuropathology, University of Pittsburgh School of Medicine.)

diameter occurs over 3 months.[31] The decrease is due to shrinkage and later gradual thickening of the collagen of the endoneurial sheath[32] (Fig. 1–9). This suggestion that nerve repair be undertaken without delay is to encourage axons that regenerate early to grow into the collapsing tubes, thus reinflating them and suppressing collagenization before it progresses too far.

In general, the sooner reinnervation begins, the better. The ideal time for nerve grafting is within 30 days and not later than 4 months following injury; beyond 6 months, the results of nerve grafting by any technique have been disappointing. The best results with a hypoglossal-facial crossover were achieved when surgery was performed within the first 2 years after injury, although satisfactory results were noted following surgery performed up to 4 years after injury.[33] The ideal time to perform the hypoglossal-facial jump graft is within 30 days and up to 1 year of injury. Recovery has been noted with later repairs in cases where part of the peripheral system was spared or spontaneously regenerated. In most cases when reanimation surgery has been delayed beyond 2 years after injury, muscle transposition to reanimate the mouth and brow lift, gold weight or spring implantation for the upper lid, and the Bick procedure for the lower lid are the preferred techniques (see Chapters 4 through 8).

Patient Age

The age of the patient may have a great bearing on the procedure selected. Young children, even with a transected nerve, may show facial symmetry while the face is at rest, and eye closure may be adequate because of excellent tissue turgor, subcutaneous fat, and tissue elasticity (Fig. 1–10). These factors make the performance of muscle transposition procedures more difficult in children; for instance, it is harder to elevate the mouth region to meet the transposed muscle in a temporalis muscle transposition. On the other hand, in elderly patients who already have lost a significant degree of subcutaneous fat and elasticity of the skin, facial palsy will often produce grotesque sagging, oral incompetence, and severe problems with tearing of the eye because of lagophthalmos and ectropion (Fig. 1–11). This tendency for the faces of the elderly to sag, however, makes it easy to combine reanimation of the face with a face-lift in these patients. It has been interesting to note that young children rarely have complications of corneal exposure, even when lid closure is incomplete. It is speculated that this may be because children's tears contain protective properties lacking in the tears of adults. In addition, it has been found that almost any attempt at reinnervating the face that makes use of nerve grafting techniques will be more successful in young people than in the elderly because the nerves of younger patients have a greater potential for regeneration, perhaps the result of their large population of available proximal axons and distal tubules. A decrease in nerve fiber population is associated with the aging process.[34] Another consideration in treating a preteenager is that fibroblastic activity seems greater in youngsters than in adults, and this occasionally results in hypertrophic or spreading scars. This rarely occurs in elderly patients in whom wounds heal neatly to an indistinguishable hairline. Further,

A–C

Figure 1–10. Tone and eye closure may be maintained in children in spite of a transected facial nerve. **A**, An 11-year-old boy with a left-sided facial paralysis 4 days following temporal bone fracture. The facial nerve was found transected in its tympanic segment and was repaired with a graft. **B**, Tone maintained. **C**, Eyelid closure may appear intact, but actually eyelid closure is incomplete. Note the sclera showing.

A B C D

Figure 1–11. **A**, Complete facial paralysis 1 week following Bell's palsy. Note severe sagging of the involved side on the right. **B**, Significant lagophthalmos due to ectropion. **C**, **D**, Severe ectropion and conjunctival reaction.

the elderly often have natural skin folds that facilitate hiding or camouflaging of incisions. These skin folds are usually not present in youngsters. For these reasons, elective reanimation procedures requiring that external incisions be placed in conspicuous sites should be delayed until the child has reached the teen years. Of course this recommendation does not apply for acute injuries remedial to nerve repair or hypoglossal-facial crossover. When these procedures are appropriate, the sooner they are performed following injury the better the results.

Patient's General Health

A patient who is severely debilitated by generalized disorders will require special considerations. Patients who are diabetic, malnourished from chronic disease, debilitated with cancer, or who have had radiation therapy to the head and neck may present special problems. In such cases, healing may be delayed, soft tissue edema prolonged, and the incidence of wound dehisence higher. Regional or distant flap coverage may be required. Although there have been mixed reports of the effects of radiation therapy on nerve grafts, overall the impression is that successful reanimation can be achieved even when the radiation is delivered over the part involving the grafted area.[35] The effects of chemotherapeutic agents on the fate of a nerve graft are still open to question. Some chemotherapeutic agents have a direct effect on the myelin tubes,[36–38] which may in turn affect the health of a nerve graft significantly. For this reason, muscle transposition techniques might be more appropriately employed than nerve grafting to reanimate the face of a patient in whom chemotherapy is planned. Another reason for using muscle transposition to reanimate such a patient's face is that the results of muscle transposition are seen immediately, which is important for a patient with a questionable prognosis.

Psychological Considerations

Rehabilitation of the paralyzed face demands excellent rapport among the surgeon, the patient, and the patient's family. At the outset, the patient must be made to understand the nature of his or her facial impairment in terms of the functional, cosmetic, and psychological aspects. Viewing a videotape of the patient's facial language, and eye and mouth function, recorded at the time of the initial interview has been most helpful for this purpose. Some patients, upon looking at the videotape comment, "I didn't realize I looked so bad"; others refuse to look at themselves on the videotape. It has not been unusual for patients to break down and cry at this moment of confrontation with reality. Patients with facial paralysis experience mild to moderate emotional difficulties in response to their facial disfigurement. They may exhibit behavioral alterations including manic depression followed by guilt, anger, hostility, and withdrawal before recovery. If recovery is delayed and symptoms are severe, psychiatric counseling is appropriate.

At the presurgical consultation, the patient is advised of the risks and complications of the planned procedure and what is realistic in terms of expected results. Patients are informed that rehabilitation of the paralyzed face may require several procedures to achieve optimal results and that prolonged periods of time will often be necessary between the performance of each procedure and its results. Patients often appreciate viewing the early and late results of the procedures planned for them as documented on videotapes of other patients, but must understand that in some cases procedures planned for them will produce new disabilities in order to restore facial function; for instance, performing a hypoglossal-facial crossover may lead to disability in speech and swallowing. This approach gives the patient and the family a realistic understanding of what can be expected with facial rehabilitation. It is stressed that it is not reasonable to expect perfect return of function by any means of facial rehabilitation now available. Improvement can be expected, but the degree of that improvement cannot be predicted with certainty. While the surgeon should not present a discouraging picture, because it is important that the patient have a positive outlook, it is also essential that he or she has realistic expectations of what may be achieved. Approximately two out of every three candidates for facial reanimation agrees to undergo the surgery.

What Does the Patient Want?

Several other factors may affect selection of the best approach for restoration of facial function. A farmer who spends most of his time in the fields and who has little or no contact with people other than his family members may realistically not wish to undertake the cost, time, and discomfort necessary for a major rehabilitation procedure. For such a patient, assuring appropriate protection for the eye may be enough. At the other extreme, facial symmetry and reasonable function may be critical to a patient's socioeconomic and/or psychologic well being. An actress, politician, lawyer, or member to the clergy, might fall into this category, and in these cases, extensive rehabilitation procedures may be desired.

What Are the Functional Impairments?

The history and physical examination are directed to detecting functional defects involving incompetence of the sphincters around the eye, nose, and mouth.

Brow Brow droop on the involved side presents a cosmetic blight because of the noticeable asymmetry and can be corrected by a brow lift. *In such a case, the lift should be conservative so as not to impair eye closure further* (see Chapter 6).

Eye Eyelid closure is particularly important because an exposed cornea is at risk to ulceration and loss of vision. One must determine whether the cornea rolls up underneath the upper lid with attempted eye closure. If it does, the patient retains a good Bell's phenomenon. Tear production can be detected by a Schirmer's test. The presence of sensation can be determined at the same time by asking the patient the following questions: Do you feel the paper in both eyes? Is there a difference in sensation between the two eyes? In addition, the presence of corneal sensation can be determined by observing whether the patient squints or pulls away when the paper is placed in the involved eye. The BAD syndrome—loss of *B*ell's phenomonen, loss of sensation (*a*nesthetic), and loss of tear production (*d*ry eye)—attributed to Dr. Pierre Guibor, calls for surgical correction to restore lid closure (Chapter 6). Often the patient will not be aware of these important risks of facial dysfunction, relating that they are concerned about restoring their smile only. In such a patient, eye reanimation must be combined with efforts to restore mouth function. Another important sequela of lack of blinking due to paresis or paralysis of the orbicularis oculi is blurred vision. This results from lack of distribution of tears by the upper lid over the cornea, which in turn leads to drying of the cornea, irritation, and epiphora. Lack of blinking is common following incomplete recovery in patients with Bell's palsy, as well as following nerve injury due to other causes. The voluntary blink can be restored by implanting a gold weight in the eyelid, a procedure that is ideal for patients with paresis, or implanting a spring in the eyelid, restoring not only voluntary but also spontaneous reflex blinking to some degree.

Nose Some patients with impaired facial nerve function complain of nasal obstruction, which is caused by failure of the dilator nares to hold the alae open with inspiration.[39,40] In some patients this condition can be improved with nasoseptoplasty if the septum is deviated; in others a "nasal alar" lateralization procedure may need to be performed as well (see Chapter 7).

Mouth Other patients may consider mouth drooping, drooling, or a crooked smile to be the main problem of facial nerve dysfunction; the fact that one eye does not close may not bother them.

Lower Lip Inability to expose the lower teeth on the involved side with attempts to smile may be troublesome to some patients. If this is an isolated deficit, such as may occur with injury to the marginal mandibular nerve during submandibular gland surgery, the defect is correctable to some degree by a number of techiques (see Chapters 4 and 7). However, correction of this isolated deformity must not be combined with reanimation to lateralize and lift the corner of the mouth, such as would be achieved with temporalis muscle transposition because this would cause severe oral incompetence. It would be a disservice to a patient with a paralyzed face to correct the part that bothers the surgeon and neglect the complaint of the patient. Reanimation surgery should focus on the specific needs of the patient, unless in the surgeon's judgment significant improvement could be achieved in the functioning of all facial components: eye, nose, and mouth.

Life Expectancy

Another factor that might have bearing on plans for facial reanimation is the patient's life expectancy. Clearly, to reanimate a face paralyzed as a result of surgical extirpation of a malignancy in a patient who has a poor prognosis for survival, the surgeon should choose a technique that gives immediate results. For example, following resection of a temporal bone malignancy, a hypoglossal-facial crossover would be the reanimation technique of choice; recovery may begin as early as 4 months after this procedure. In some instances, the proximal end of the nerve can be connected to the peripheral portion with an interposition graft, but recovery will not begin to be seen until at least 6 to 8 months following surgery. Both of these techniques give good results eventually, but because maximal useful function is not restored until 1 to 2 years after surgery, they should not be performed on patients with limited life expectancies. The treatment of choice for such patients would be temporalis muscle transposition, which results in immediate reanimation and rehabilitation of the face.

Injury to Other Cranial Nerves

The patient with a facial paralysis resulting from resection of an acoustic tumor may have other cranial nerve deficits. Injury to the fifth cranial nerve would denervate the masticatory muscles and exclude the use of the temporalis or masseter transposition technique. If the tenth cranial nerve was injured during removal of the acoustic tumor, a hypoglossal-facial crossover should not be done because adding a twelfth cranial nerve deficit to a tenth cranial nerve deficit may leave the patient unable to swallow without aspirating. Further, the hypoglossal nerve should not be sacrificed in cases of neurofibromatosis Type II for the reason already stated: the possibility of subsequent involvement of other cranial nerves.

Other Surgical Reanimation Procedures

If a patient has not recovered facial nerve function within 1 year of placement of a nerve graft, the anastomotic site may be re-explored. Re-exploration of the anastomotic site in such instances may reveal that the graft has pulled apart because of tension or that a neuroma is present proximal or fibrous tissue distal to the graft. In rare cases, a residual benign tumor may be found; it should be resected and a new graft placed. However, in most cases, revisions of nerve repair procedures such as grafting, hypoglossal-facial crossover or facial cross-face grafts, even when performed within 1 year of injury, gave unsatisfactory results. On the other hand, if the temporalis or masseter muscles were transposed and the results are not satisfactory, it is quite possible to revise these procedures to achieve useful, lasting results. This can be done by re-exposing the transposed muscles, freeing them from the surrounding tissues, and reattaching them under tension. In some cases, it has been possible to transpose residual undisturbed temporalis muscle, even after previous temporalis muscle transposition surgery or middle fossa surgery. Finally, failures occur in spite of proper patient selection, choice of an appropriate procedure, and skillful execution of the procedure because there are so many variables beyond the control of the most experienced surgeon.

Surgeon's Role in Decision Making

The surgeon must take into consideration the eleven factors just discussed, along with his judgment, philosophy, and experience, in formulating a plan to rehabilitate a paralyzed face. In addition, although the physician formulates the plan for management, the patient must have major input into all decisions that are to be made. Priorities to correct functional aspects such as an exposed eye, a collapsed nose, or incompetent oral commissure must be stressed over correcting strictly cosmetic defects. The surgeon is obligated to bring these factors to the attention of the patient. The facial reanimation surgeon should be capable of correcting a variety of problems encountered, should be able to perform the procedure that is best for the patient, and should not be limited to one approach. **The best chance of rehabilitating a paralyzed face comes with the first procedure and at the earliest possible time after injury. This is particularly true when nerve grafting or a hypoglossal-facial crossover is the procedure of choice.** For this reason, it is important that the surgeon not attempt to try out a new procedure on a patient who would benefit from a standard approach that has a predictable outcome.

Facial Reanimation: 30 Years' Experience

The statements in this section are essentially a derivative of the author's (MM) personal experience with the problem of facial paralysis over the past 30 years. They are by their nature limited, opinionated, contemporary, and transitory. The experience, however, has been broad, derived from surgical treatment of diseases involving the facial nerve from the brainstem to the stylomastoid foramen as well as in its extracranial portion. Between January 1963 and June 1996, 3068 procedures were performed in 859 patients. Their ages ranged between 6 months and 93 years, with an average of 34 years; there were 487 females and 372 males. The sites and causes of the facial nerve lesions that led to the need for facial reanimation are listed in Table 1–1. The single most common cause of facial paralysis was posterior fossa surgery, specifically acoustic tumor resection (Table 1–1).

Reanimation Procedures

The procedures used to rehabilitate the paralyzed face following injury to the facial nerve were divided into six groups: (1) facial nerve repair or graft, (2) cranial nerve substitution, (3) muscle transposition or transplant (dynamic), (4) static suspension, (5) eye, and (6) other procedures. The techniques employed, with the indications for and anticipated results of each, are listed in Tables 1–2 and 1–3.

The first three groups noted above (facial nerve repair, cranial nerve substitution, and muscle transposition) are in order of preference based on the likelihood of yielding the best functional results. These groups include the "three basic operations" for reanimating the paralyzed face that are most dependable and reproducible. Our scheme of procedure prioratization is supported by Spector,[41] based upon a review of the results of his surgical experience reanimating 138 patients with facial paralysis. Further, we agree with Spector regarding abandoning techniques that fail to produce consistent, reliable, and satisfactory results. These procedures can be considered under the category "long run for a short slide." The procedures that should be abandoned include the following: spinal-facial anastomosis (see Chapter 3), ansa hypoglossi-facial anastomosis, split hypoglossal-facial anastomosis (see Chapter 3), nerve-muscle pedicle transposition from ansa hypoglossi,[42] free muscle graft implantation, and cross-facial anastomosis[22] except under special considerations (see Chapters 2 and 5).

General Indications for Each Technique

Groups 1 and 2 The procedures listed under groups 1 and 2 involve nerve repair, and the facial muscles are either motored by the appropriate facial nerve or by a cranial nerve substitution. Nerve repair and reinnervation are time-dependent in order to achieve ideal results. Although normal facial function can never be re-established once the facial nerve has been interrupted, it is possible to restore tone, symmetry, voluntary movement with separation of the eye from the mouth, and spontaneous facial expression by hooking up the fibers of the facial nerve extending from the cell body of the pons to the end organ or facial muscles. The best results are achieved when the nerve is reconnected within 30 days of the injury. When repair is delayed beyond that time the results diminish in strength and quality but are still useful when the repair is performed within 6 months. Tone, symmetry, and slight movement might be achieved as late as 1 year. When the proximal stump is not available, then cranial nerve substitution should be considered, particularly when repair can be achieved within 30 days of injury and not later than 2 years. A facial-facial cross-face graft yields the best results when performed within 30 days and has not yielded useful results when performed after 6 months. The neural input provided by the entire 11th or 12th nerve allows useful results up to 2 years following injury.

Although these physiologic procedures provide the best results, they are all limited by a time window. The rest of the procedures under groups 3 through 5 are not time-related and are used primarily in patients with long-standing facial paralysis where the proximal and distal portion of the facial nerve is not available or the facial muscles are either not present as in developmental cases or atrophied as one would expect in long-standing facial paralysis.

Group 3 The procedures listed in group 3 are considered dynamic and were used in patients whose faces had been paralyzed for 2 years or longer following injury. Symmetry of the face at rest and dynamic movement of the face with volitional effort were the goals with these techniques.

Group 4 The procedures listed in group 4 were used to supplement the results achieved with the procedures in

Table 1–1 Sites and Causes of Facial Nerve Lesions Requiring Facial Reanimation, June, 1963–1996.

Location of Lesion (Total patients)	Cause of Lesion (No. patients)	Location of Lesion (Total patients)	Cause of Lesion (No. patients)
Supranuclear (17)	Möbius syndrome (11)	Parotid Segment (148)	Mixed tumor (21†,1)
	Meige's Syndrome (3)		Mucoepidermoid (9,6†)
	Blepharospasm (2)		Facial laceration (14)
	Cerebral palsy (1)		Epidermoid cancer (7,2*,5†)
			Acinic cell (5†,4)
Nuclear (47)	Birth development (39)		Adenocarcinoma (6,2†)
	Brainstem infarction (3)		Temporomandibular joint surgery (7*)
	Arteriovenous malformation hemorrhage (2)		Basal Cell (5,2*)
	Polio (2)		Adenocystic carcinoma (3,3†)
	Cerebellum infarction (1)		von Rechlinghausen's disease (2,3†)
			Hemangioma (3†,1*)
Cerebellopontine angle (275)	Acoustic surgery (215*,2)		Birth trauma (3)
	Meningioma (17*,3)		Warthin's tumor (3†)
	Arteriovenous malformation (5,2*)		Cystic hygroma (3†)
	Primary facial hyperkinesia (5)		Melanoma (2*,1†)
	Vascular decompensation (4*)		Cranial nerve VII Schwannoma (1†,1*)
	Astrocytoma (4)*		GSW (2)
	Congenital cholesteatoma (2,2*)		Facial fracture (2)
	Medulloblastoma (2*,1)		Unknown disease (2*)
	Ependymoma (2*)		Reactive neuroma (1†,1)
	Gamma knife (2)		Branchial cleft (1†,1*)
	Cranial nerve VII Schwannoma (1,1*)		Malignant mixed tumor (1†)
	Aneurysm (1*)		Sialodenitis (1†)
	Epdermoid (1*)		Ductal carcinoma (1)
	Dandy Walker cyst (1*)		Myoepithelioma (1†)
	Epidermoid cancer (1)		Malignant dermal analogue (1†)
	Hemangioma (1)		Malignant mesenchymal (1†)
	Malignant papillary neoplasm (1*)		Lipoma (1†)
			Cyst (1†)
Labyrinthine segment (3)	Cranial nerve VII Schwannoma (3)		Cosmetic surgery (1*)
			Skin biopsy (1*)
Geniculate ganglion (24)	Cranial nerve VII Schwannoma (8,1*)		Submandibular gland surgery (1*)
	Hemangioma (6)		Puncture wound (1)
			Lymphoma (1†)

(continued)

Table 1–1 *(continued)* Sites and Causes of Facial Nerve Lesions Requiring Facial Reanimation, June, 1963–1996.

Location of Lesion (Total patients)	Cause of Lesion (No. patients)	Location of Lesion (Total patients)	Cause of Lesion (No. patients)
Geniculate ganglion (24)	Meningioma (3)	Other (227)	Bell's palsy (149)
	Reactive neuroma (2)		HZO (55)
	Cholesteatoma (2)		Atypical Bell's (10)
	Facial nerve cyst (1)		Melkersson-Rosenthal syndrome (3)
	Arteriovenous malformation (1)		
Tympanic segment (26)	Cholesteatoma (11,3*)		Chickenpox (3)
	Acute otitis media (2)		Mumps (1)
	Cranial nerve VII Schwannoma (2)		Guillian-Barré syndrome (1)
	Traumatic neuroma (at birth) (1)		Chiari malformation (1)
	Chronic OM (1)		INH Toxic Neuropathy (1)
	Tuberculosis (1)		Lyme disease (1)
	Diphtheria (1)		Osteopetrosis (1)
	Unknown infection (1)		Osteogenesis imperfecta (1)
	Cholesterol granuloma (1)		
	Labyrinthectomy (1*)		
	Adenocarcinoma (1)	Temporal bone (48)	Temporal bone fractures (Multiple sites) (45)
			Metastatic (3)
Mastoid (44)	Otologic surgery (9*,2)		Adenocarcinoma: Lung (1)
	Glomus (7*,4)		Adenocarcinoma: Prostate (1)
	GSW (5)		Carcinoid: Thymic (1)
	Cholesteatoma (4*)		
	Cranial nerve VII Schwannoma (2,1*)	**TOTAL**	**859**
	Meningioma (2*)		
	Epidermoid cancer (2)		
	Granular cell myoblastoma (1)		
	Hemartoma (1*)		
	Angioma (1)		
	Arteriovenous malformation (1)		
	Adenocarcinoma (1)		
	Histiocytoma (1*)		

*Iatrogenic injury defined as that which occurred during surgical treatment.

†Iatrogenic injury which occurred during a parotidectomy for treatment.

‡Location of lesion notes most proximal extent of tumor and does not indicate length of nerve involved.

Table 1–2 Procedures Employed to Rehabilitate the Paralyzed Face: Indications and Ideal Results

Group	Procedures	Indications	Results
1. *Facial Nerve (Repair)	End-to-end Interposition Double cable	Ideally within 30 days when proximal and distal segment available	Spontaneous (mimetic) facial language expected in 90% of cases. Synkinesis with mass movement.
2. Cranial nerve (Substitution)	XII-VII XII-VII Jump VII-VII Cross-face	Ideally within 30 days to 1 year when proximal segment not available	No mimetic movement. Voluntary movement learned with activation of central cell body CNN XII (with XII-VII), VII (with VII-VII). Tone may be absent at rest.
3. Muscle transposition or transplant (Dynamic)	Temporalis m. Masseter muscle	Combined with Groups 1 & 2 to augment results	Facial symmetry at rest. Voluntary asymmetrical smile. Better to reanimate eyelids with different approach to separate eye from mouth movement.
	Digastric Sling	Lower lip paralyzed	Holds lower lip down, improves smile symmetry.
	Free muscle neurovascular anastomosis	Distal nerve and muscle not available or developmental (birth) palsy	Facial symmetry at rest. Voluntary asymmetrical smile.
4. Suspension (Static)	Palmaris longus Fascia lata Gore-Tex Face lift Brow lift Blepharoplasty	Improve smile symmetry, lateralize nasal ala to improve nasal airway To supplement other procedures in Groups 1-3	Static support, good results initially, may require revision.
5. Eye	Gold implant	Lagophthalmos upper lid	Excellent for upper lid. Rarely extrusions or adjustments required. Does not result in involuntary blink.
	Spring implants	Lagophthalmos upper lid	Excellent for upper lid; extrusion may occur and adjustments may be required. Restores voluntary blink.
	Bick	Ectropion lower lid, epiphora	Excellent.
	Cartilage to lower lid	To elevate lower lid	Excellent.
	Orbicularis m. resection	Reduce spasm	Substitutes weakness for hyperkinesis.
	Lacrimal punctal resection	Symptomatic epiphora	Some improvement can be expected.
	DCR	Epiphora, after all else fails	70% of the cases successful.
	Lacrimal punctal plugs	Dry eye	Some improvement can be expected.
	Punctal cautery	Dry eye	Some improvement can be expected.
	Parotid duct transposition	Dry eye, after all else fails	Effective in 70% of the cases.
6. Other procedures	Selective myectomy:		
	Platysma	Neck spasm	Complete relief.
	Mentalis	Chin dimpling	Complete relief.
	Depressor labii inferior on normal side	Normal side, lower lip pulls down showing teeth	Improves smile symmetry.
	Zygomatic major/minor	Hypertonicity, deep nasolabial	Partial relief, complete relief causes drooping upper lip.
	Stapes muscle	Ear flutter or spastic noise	100% effective.

*Best results were achieved when surgery was performed within 30 days of lesion. Final evaluation must wait until minimum of 2 years from time of nerve repair.

Table 1–3 Total Reanimation Procedures 1963–June 1996*

1. FACIAL NERVE (REPAIR)		107
End-to-End	15	
Interposition graft	69	
Double cable graft	21	
Triple cable graft	2	
2. CRANIAL NERVE (SUBSTITUTION)		112
XII-VII	11	
XII-VII Jump	69	
VII-VII Cross-face	31	
XI-VII	1	
3. MUSCLE TRANSPOSITION OR TRANSPLANT (DYNAMIC)		350
Temporalis muscle	286	
Masseter muscle	11	
Other	39	
Free muscle neurovascular	9	
Digastric swing	5	
4. SUSPENSION (STATIC)		583
Brow lift	143	
Palmaris longus muscle	35	
Fascia lata	63	
Face lift	54	
Blepharoplasty	71	
Other	200	
5. EYE		1609
Gold weight	482	
Spring implant	325	
Bick/wedge	241	
Cartilage implant	176	
Tarsorrhaphy	21	
Partial lacrimal gland resection	10	
DCR	10	
Parotid duct transposition	7	
Other	337	
6. OTHER		307
Selective myectomy	59	
Neurectomy	15	
Stapes muscle lysis	6	
Other	227	
TOTAL PROCEDURES		3068

*Procedures listed are by order of preference and not by frequency of surgery.

Groups 1, 2 and 3 in patients who had had facial paralyses for 2 or more years. The procedures were considered static and designed to add support to the patients' faces when they were at rest.

Group 5 The procedures listed in group 5 were used to reanimate paralyzed eyelids. In the past, temporalis muscle transposition, either alone or combined with the spring implant, was used in patients in whom paralysis would be permanent. Since 1982, the upper eyelid has been reanimated by implanting a gold weight or inserting a spring without transposing a portion of the temporalis muscle. This creates a voluntary, as well as to some degree an involuntary, blink and separates eye closure and blinking from mouth movement. Canthopexy and lid wedge procedures were employed to correct ectropion of the lower lid. Tarsorrhaphy was used only when the other techniques failed and is recommended as a procedure of last resort because it is associated with limitation of vision, creates a cosmetic blight, and may be responsible for morbidity from lid notching or ingrown lashes. In addition, tarsorrhaphy does not guarantee corneal protection, since two patients were seen who had corneal lesions despite having undergone a medial and a lateral tarsorrhaphy.

Group 6 Group 6 consists of procedures to correct minor defects and problems resulting from faulty regeneration (Table 1–3).

Analysis of Results

Figure 1–12 and Table 1–4 outline the classification system that was used for reporting the results for each group of reanimation procedures. The results of 278 procedures in 132 patients cared for between August 1974 and June 1983

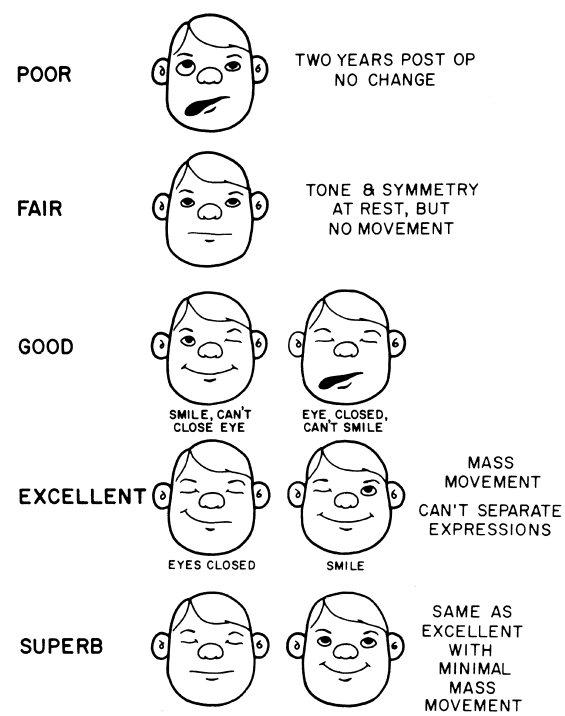

Figure 1–12. Classification system used for reporting success of procedures in Groups 1 through 3. (From May M: Management of cranial nerves I through VII following skull base surgery. Otolaryngol Head Neck Surg 88:560–575, 1980. With permission.)

Table 1–4 Classification System for Reporting Results for Each Group of Reanimation Procedures

Group	Quality of Results	Criteria
1. Facial nerve repair (Physiologic)	Superb Excellent Good Fair Poor	As depicted in Figure 1–12.
2. Cranial nerve (Substitution)	Superb Excellent Good Fair Poor	As depicted in Figure 1–12.
3. Muscle transposition or transplant (Dynamic)	Superb Excellent Good Fair Poor	As depicted in Figure 1–12.
4. Suspension (Static)	Good Fair Poor	Symmetry, static facial expression. Symmetry at rest. Sagging face.
5. Eye	Excellent Good Fair Poor	Volitional eye closure, lids approximate. Lid approximation incomplete, cornea covered. Lack of lid retraction, cornea incompletely covered. No change from preoperative state.
6. Other procedures	Good Fair Poor	Marked relief of complaint. Some improvement. No change.

were reported in the first edition of this book (Table 1–5). The best results were obtained when the procedure was performed within 30 days of the lesion, providing the central stump of the facial nerve could be connected to the peripheral segment either by direct anastomosis or with a graft. Results with the other procedures were successful in the majority of patients that were properly selected based on the guidelines previously enumerated.

The success or failure of a procedure must be measured by the relief of functional impairment as well as by the degree of cosmetic improvement. Some of the more common functional impairments following facial paralysis are listed in Table 1–2. The taking of the preoperative history is directed toward identifying the functional impairments present so that the procedure best designed to overcome these functional deficits may be selected. The evaluation of results of surgical treatment, therefore, must include an assessment of the degree to which these deficits have been relieved. There is no system that addresses this issue; therefore, the present measure of success remains subjective.

The patients treated by the procedures listed in Groups 1 and 2 were not considered eligible for evaluation until a minimum of 2 years after the procedure because the maximum effects of these nerve approximation techniques are not appreciated until after this interval.

The results of the remaining techniques listed in Groups 3 through 6 in Table 1–2 can be evaluated as early as 6 weeks after the surgical procedure when the swelling from surgery has subsided enough to observe movement achieved by these techniques. The results of the palmaris muscle tendon transplant noted at six weeks have been lasting, while the results of muscle transposition when overcorrection was maintained for up to 3 weeks after surgery continued to improve over a period of 1 year.

The long-term effects of the static procedures in Group 4, and some of the reanimation techniques in Groups 5 and 6, cannot be evaluated because these procedures may not give lasting results and on occasion require revision. This factor points up a shortcoming in the system for classifying the long-term results of procedures in Groups 4 through 6.

A serious limitation of any classification system is that most patients require multiple complimentary procedures to achieve the best result, making it difficult to evaluate the results of any one given technique. The multiple procedures that were performed on patients with long-standing facial paralysis and are listed in Groups 3 through 6.

Table 1–5 Summary of Results of 278 Procedures in 132 Patients (August 1974 to July 1983)

Group	Procedures	No. Performed	Results: Superb	Excellent	Good	Fair	Poor
1* (Physiologic)	End-to-end anastomosis	8	1	6	0	0	1
	Interposition graft	27	5	7	2	4	9
	Double cable graft	7	5	1	1	0	0
	Faciofacial cross graft	15	0	0	7	3	5
	Total	57					
2† (Dynamic)	Hypoglossal-facial nerve crossover	11	2	3	5	1	0
	Cervical muscle-nerve	10	0	0	2	3	5
	Temporalis muscle	40	0	27	11	2	0
	Masseter muscle	9	0	2	6	0	1
	Total	70					
3 (Static)	Palmaris longus	19	0	7	7	2	3
	Fascia lata suspension	5	0	0	2	2	1
	Digastric transposition	2	0	0	0	0	2
	Face lift	6	0	4	0	2	0
	Blepharoplasty	6	0	6	0	0	0
	Brow lift	10	0	8	0	2	0
	Total	48					
4 (Eye)	Spring implant	33	0	23	8	0	2
	Gold weight	15	0	13	2	0	0
	Sialastic encircling	4	0	1	0	0	3
	Temporalis transposition	23	0	10	9	1	3
	Canthopexy	4	0	3	0	0	1
	Lower lid tightening	2	0	1	0	0	1
	Total	81					
5 (Other procedures)	Platysma resection	4	0	4	0	0	0
	Neurectomy	5	0	3	1	1	0
	Lacrimal gland resection	4	0	4	0	0	0
	Nasal ala suspension	3	0	3	0	0	0
	Stapes muscle lysis	2	0	2	0	0	0
	Fascia implant	4	0	4	0	0	0
	Total	22					
Total Number of Procedures		**278**					

*Best results were obtained when procedure was performed within 30 days of lesion. Good results have been achieved up to 1 year. After 1 year, results have been disappointing, although some recovery has been noted.

†Results are not available for three patients in the interposition graft group and one patient in the hypoglossal-facial nerve crossover group.

However, with few exceptions the results of nerve repair or grafting and muscle transposition, transplant or selective myectomy could be attributed to these procedures alone. An effort to update our results in the last 10 years was frustrated by the factors mentioned as well as the difficulty achieving long-term follow-up because the majority of patients came from great distances and return visits for re-evaluation were not practical. Even if long-term follow-up was available in every patient and we somehow could take into account the effect of the combined procedures, there are so many variables presented by each patient that there would be no practical way to draw any meaningful scientific conclusions. Therefore, as stated at the outset, our observations must be empirical, anecdotal, and opinionated. However, the unique experience in managing 859 patients and performing 3068 procedures gives us some license to share our impressions.

Summary

This chapter sets the stage for approaching any patient with a facial paralysis following a nerve injury. The time between nerve injury and repair was the most significant factor in determining which procedures are appropriate and whether surgery would be successful. The best results were achieved when the central nerve stump was connected to the peripheral system of the facial nerve performed within 30 days of injury. Once the ideal time window of opportunity of 30 days and up to 6 months has passed, cranial nerve substitution should be considered. The ideal time window is 1 year and not longer than 2 years following injury. Beyond that time, regional muscle transposition should be considered.

The systematic approach and the variety of techniques to reanimate the paralyzed face will be described in detail with ample illustrations in Chapters 2 through 8. These procedures were learned by trial and error over years of wide-ranging experiences. Twenty-five years ago, the learning laboratory for facial reanimation was the operating room. Surgeons interested in mastering these techniques today, should not simply read an article about a procedure before trying it on a patient but rather take an apprenticeship under someone actually working in the field to learn firsthand the various nuances of its performance. In addition to this book, there are videotapes available through the Shadyside Sinus Surgery Center* that show in a step-by-step fashion the technique of the gold, spring, and cartilage eyelid techniques, the T-muscle transposition, XII-VII jump graft, and a comprehensive facial program on clinical problem-solving.

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2

Nerve Repair

Mark May, M.D.

Santiago Ramon Y Cajal (Fig. 2–1) (born in Petilla De Aragon May 1, 1852; died in Madrid October 17, 1934) was known principally for his histologic documentation of the contiguity of the neurons originating in the central nervous system, which was contrary to the common belief at that time (Fig. 2–2). His scientific achievements earned Cajal numerous honorary awards, including the Medal of Helmholtz in 1905 and the Nobel Prize in Stockholm in 1906.

Cajal, with his iron will, continued his scientific pursuit for truth in spite of resistance from his colleagues who initially refused to accept a "new" concept; even the church threatened excommunication if he continued his practice of cadaver dissection. Cajal, an eminent Spanish biologist, philosopher, artist, writer, and clear and insightful observer, was generous with his time, serving as a guide to his students, and was known above all for his simplicity and modesty.

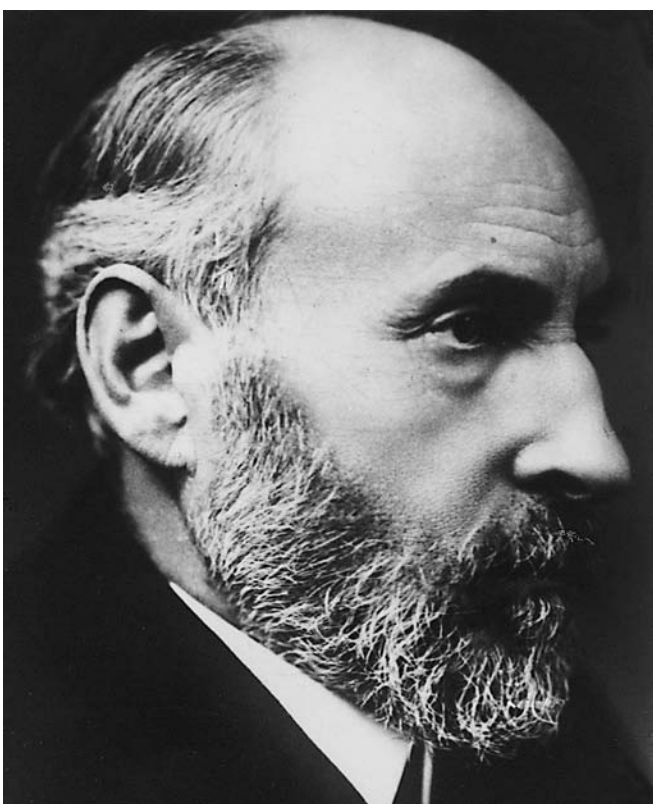


Figure 2–1. Santiago Ramon Y Cajal (1852-1934). Nobel Laureate–1906. Pioneer in the neurohistopathologic mechanism of regeneration.

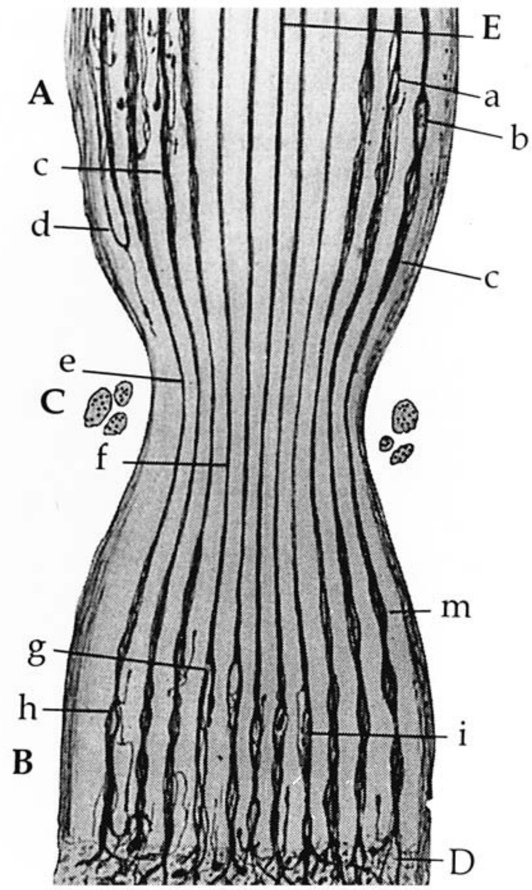


Figure 2–2. Histologic preparation of degeneration and regeneration of peripheral rabbit nerve following ligation. The ligature (C) has been in place 8 days. Note central fibers (E) are undamaged. Multiple axon sprouts form at regenerating distal end (D). (Scientific work by Cajal.)

Introduction

Direct repair of the facial nerve is the most effective method of rehabilitating the paralyzed face. Re-establishing a connection between the facial nerve nucleus in the pons and the facial muscle motor unit end plate by nerve repair or an interposition graft is the only technique that will re-establish spontaneous involuntary (mimetic) facial expression. General principles regarding indications, the importance of timing, and expected results are discussed in Chapter 1.

Nerve repair or nerve grafting has the advantage of re-establishing direct facial nerve continuity, with all of its obvious anatomical and physiologic advantages. This repair is best done at the time of the primary ablative operation when this is realistic or ideally within 30 days. Otherwise, the anatomy, technical facilities, and wound physiology will never present themselves as favorably. Delayed grafting incorporates all the disadvantages of re-entry through a distorted scar tissue bed where identification, dissection, and delicate repair can prove to be exceptionally difficult. The basis for the surgical approach to nerve repair that is to follow is based on established basic fundamentals covered in detail in Section I of this book.

Nerve repair has evolved through rather gross attempts at approximation to the present technique, which incorporates the use of a microscope, specific instrumentation, and 8-0/10-0 monofilament suture material (Table 2–1). Once the ends of the injured facial nerve are identified, the ends are trimmed, the epineurium is peeled back, exposing the endoneurial surface. At this point, the ends of the exposed nerves are stained with 1% methylene blue. This is accomplished with the ends of a wooden cotton applicator dipped in the dye and then touched to the ends of the exposed nerves. This maneuver is quite helpful because the connective tissue component of the epineurial sheath stains dark blue, while the endoneurial surface stains a lighter blue. I have found that using a small amount of dye placed carefully on the nerve endings without allowing the stain to extend to surrounding tissues helps to distinguish the nerve endings from otherwise "look alike" structures such as vessels and connective tissue. Once the ends of the nerves to be repaired are isolated and stained, they are freed up for several millimeters so that a blue background paper can be placed under the nerve thus creating a work platform that stabilizes the nerve and facilitates retrieval of the delicate needle used for nerve repair (Fig. 2–3A). Usually one or two perineurial sutures are all that is required between the main trunk or peripheral branches of the nerve and the donor graft (Fig. 2–3A). One should not lose sight of the fact that the facial nerve has a great capacity for regeneration, and if the nerve endings are approximated and matched without tension in a normal tissue bed, great numbers of axons will sprout and reinnervate the paralyzed muscles (Fig. 2–3B).

A number of suggestions have been proposed to increase recovery of facial function and discourage the development of synkinesis: (1) clipping nonessential branches of the facial nerve,[1] (2) rotating the donor nerve graft so that the distal end is sutured to the proximal end of the facial nerve, (3) orienting the interposition grafts to match the appropriate segment of the facial nerve,[2] and (4) suturing fascicles to fascicles[3] (Fig. 2–4). It is of interest to note that the efficacy of all four of these has been challenged, and it most likely makes no difference whether the peripheral branches are clipped, the sural nerve graft is rotated, the cable grafts oriented,[4] or the nerve repaired by the fascicular technique.[5,6] Further, in the author's experience, the results achieved were the same whether or not these procedures were followed (see Chapter1).

Perhaps there is a *genetic hypothesis* that can explain these observations. I would propose that the same influencing factors present in the embryo that bring about the connection between the facial nerve system to the appropriate muscle group is operative to some extent following the completion of embryogenesis. Therefore, the regenerating peripheral facial nerve fibers seem to be genetically programmed to more or less reach their appropriate muscle territory regardless of the

Table 2–1 Instrumentation for Nerve Repair and Sural Nerve Graft

SPECIAL EQUIPMENT
Operating microscope with 250 mm lens
Bipolar Bovie console
SPECIAL INSTRUMENTATION
Jewelers bipolar tip
Microinstrument set
Padgett* tendon stripper
Long #P1688 (24″)
Short #P210 (18″)
SPECIAL SUPPLIES
Weck-cel spears 00-8680
Background paper
Xomed† Vari-Stim nerve locator 85-62010
Methylene blue 1% 1 cc amp
SUTURE
8-0 Ethilon #2822G for nerve graft
10-0 Ethilon #2822G for nerve graft
DRESSING & DRAIN
7 mm Blake drain
Steri strips
Kerlix super sponges
3″ kling
ANTIBIOTICS
Clindamycin 600 mg + NSS SNS 30 cc to irrigate wound

* Padgett Instruments, 2838 Warwich T.F. WY, Kansas City MO 64108

† Xomed, 6743 Southpoint Drive, Jacksonville, FL 32216

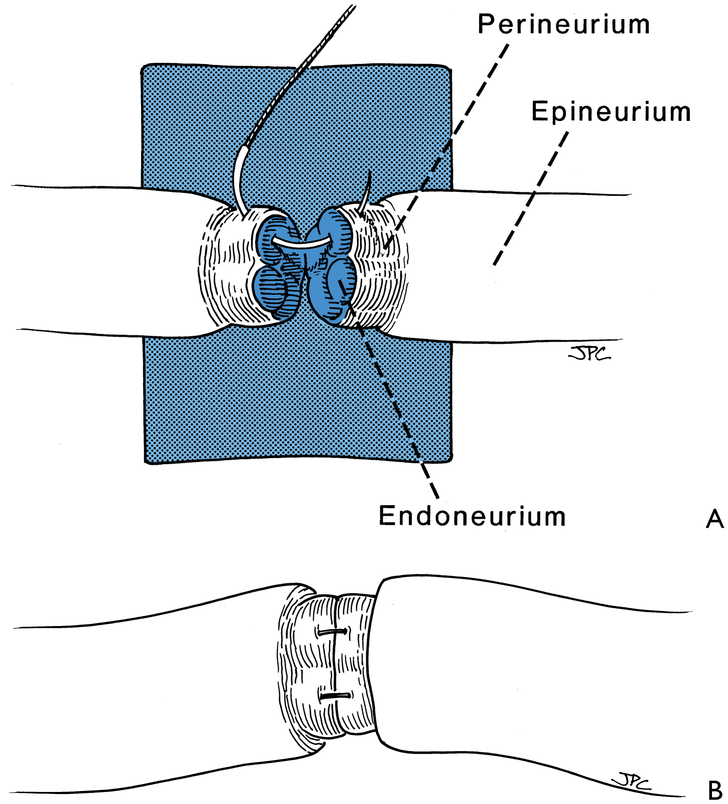


Figure 2–3. **A**, The ends of the nerves to be repaired are placed over a work platform created by blue background paper. The ends are stained with methylene blue (MB). This set-up provides a dry field and makes it easier to identify and to manipulate the ends of the nerves for surgical repair. To suture donor to recipient, the epineurium is peeled back to expose the protruding endoneurial surface. An 8-0 monofilament suture is placed through the perineurium and out the endoneurium of the recipient and then through the endoneurium and out the perineurium of the donor. Three knots are tied in order to prevent the suture from unraveling. Usually one or two sutures are necessary, depending upon the size of the ends of the nerve repaired and whether there tends to be rotation or a need for improving nerve end approximation. **B**, The ends of the donor and recipient nerves should be brought together without tension, and the endoneurial surface of these should match so that a maximum number of axons have an opportunity to pass through the nerve graft.

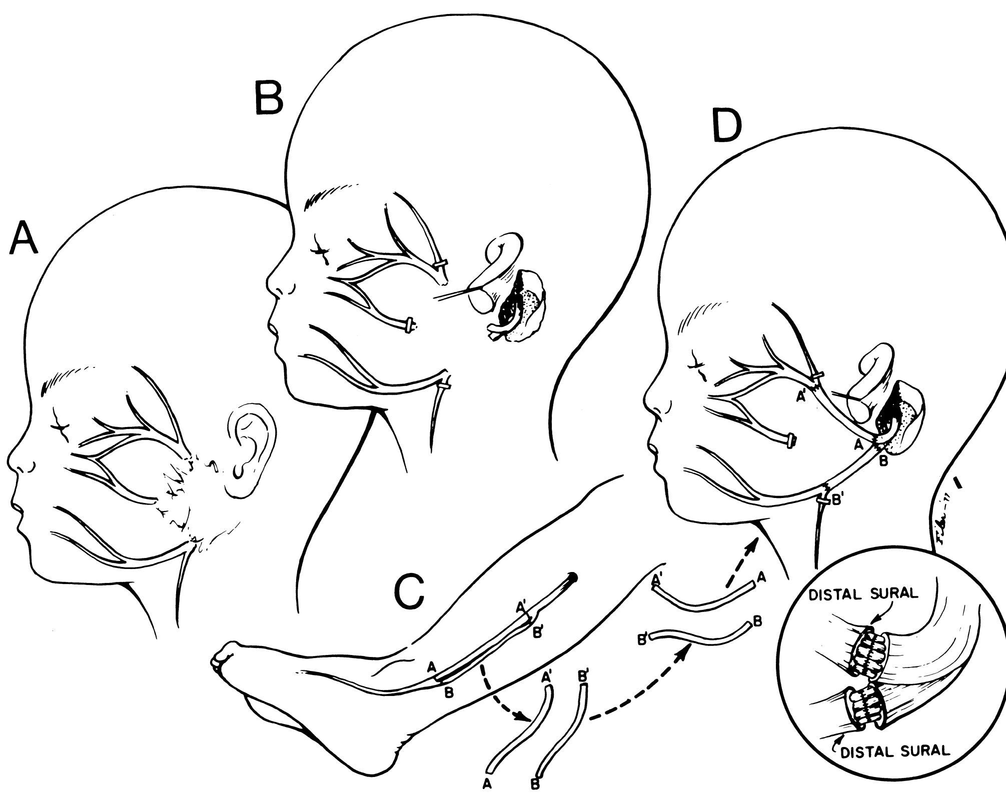
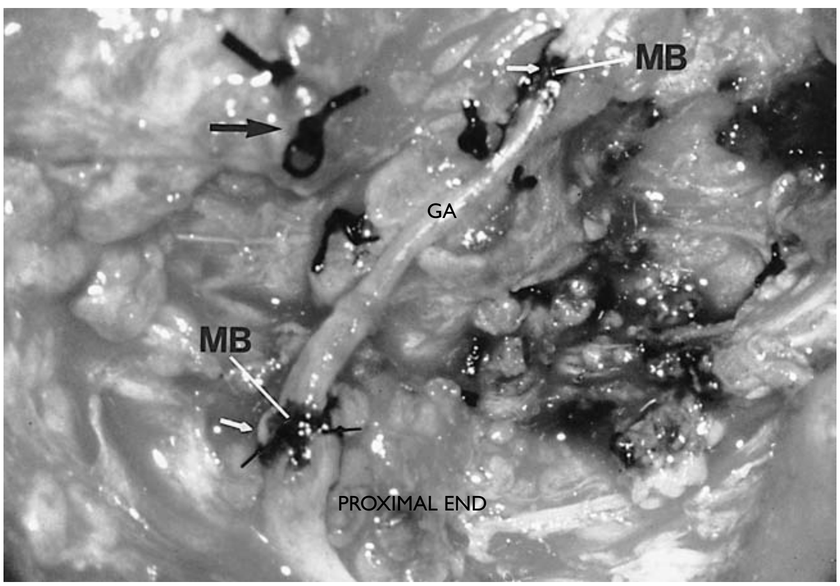


Figure 2–4. Nerve repair strategies intended to improve outcome. **A**, The lesion is resected. **B**, Branches to the forehead and extra branches to midface and neck clipped to discourage faulty regeneration and growth of axons to unessential areas. **C**, Sural cutaneous nerve graft. **D**, Nerve reversed so that the distal end of the graft is attached to the proximal end of the donor nerve. Insert demonstrates fascicular grafting: orienting the fibers parallel to the topographical orientation of the fibers as they leave the temporal bone. In our experience, none of these techniques illustrated in this figure or the insert have improved the outcome of surgery, even though they have been recommended by other surgeons. (From May M.[36] With permission.)

A–C



D

Figure 2–5. This youngster presented 24 hours following an accidental fall through a plate glass window. He sustained a facial laceration that divided the upper division of the facial nerve on the left side. There was paralysis involving the left forehead, brow, eyelids, midface, and upper lip with sparing of the corner of the mouth, lower lip, and neck. **A**, Twenty-four hours after facial nerve repair, raising the eyebrow. **B**, Smiling. **C**, Closing the eyelids tightly. **D**, At the time of surgery, a gap between the upper division of the facial nerve just beyond the pes was repaired with a 4-cm graft taken from the great auricular nerve. A nerve stimulator is useful in finding the ends of the upper division in its distal segment. The ability to electrically stimulate the distal end of the severed nerve up to 3 days after injury is one of the major incentives for early exploration. Further, upon opening the wound and washing away the clot, the anatomical structures are easier to find as opposed to waiting 10 days or more when the stimulator is not useful and scar tissue is beginning to envelop the site of injury. Note: (1) The great auricular nerve (GA) makes a good match to reconnect the two ends of the upper division of the facial nerve. (2) Methylene blue stains the anastomotic sites (MB). This helps identify the endoneurial surfaces. (3) Compare the 8-0 neurorrhaphy sutures (small arrow) to the 4-0 silk sutures used to tie bleeding vessels (large arrow). (For results of nerve repair see continuation of figure on next page.)

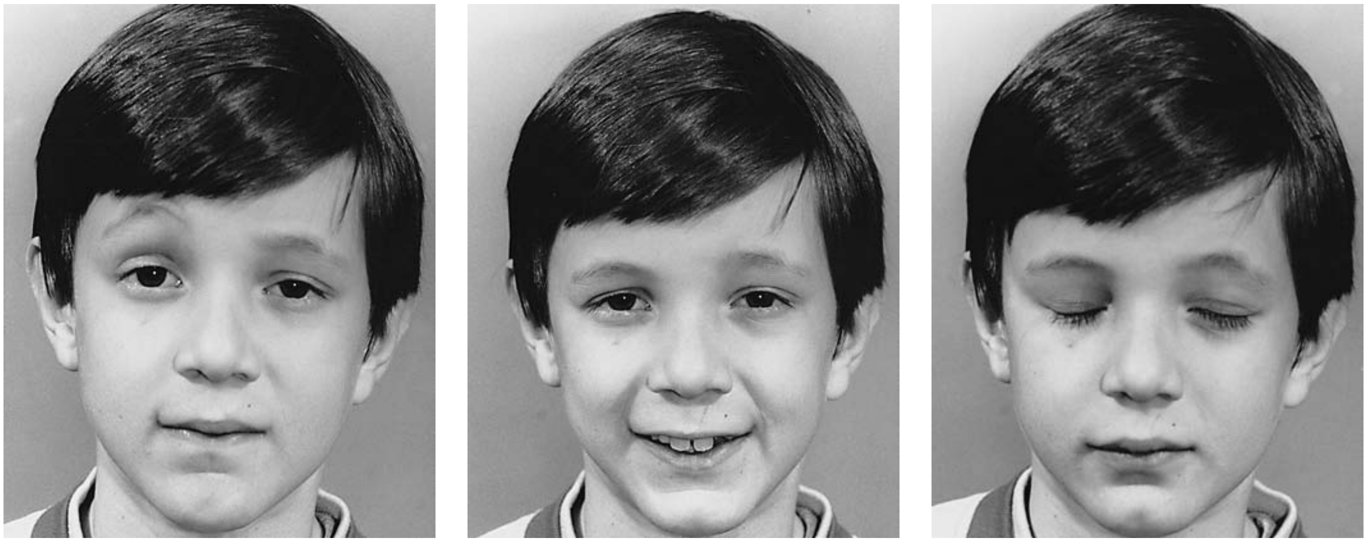
orientation at the repair site. Further, the postregeneration synkinesis-hyperkinesis following facial nerve injury may be related more to regeneration morphologic events that occur in the facial nucleus than what occurs in the peripheral axons[7–9].

Factors That Influence Results

The major factors influencing results involve: (1) the time postonset until repair, (2) the condition of the nerve at the time of repair, (3) the presence of tumor involving the facial nerve and/or reactive scar tissue, and (4) adherence to surgical principles of nerve repair.

Timing

As has been mentioned and stressed in Chapter 1, of all of the factors leading to the best results, timing of the repair is the most important. When the nerve is repaired at the time of injury to within 30 days, the results have been uniformly excellent, yielding mimetic movement, the ability to close the eye with minimal mouth movement, the ability to smile with minimal eye movement, and normal tone and symmetry at rest (Fig. 2–5). The proximal and distal portion of the interrupted nerve between time of onset and 30 days is best suited for repair in terms of its neurobiology as described in Chapters 4 and 8 (Fig. 2–6). Modern neurobiologic techniques have demonstrated that the regeneration



E–G

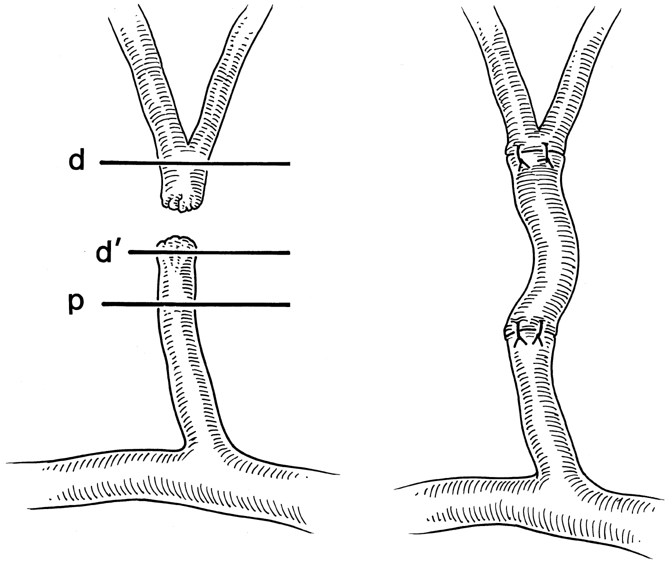
H–J

Figure 2–5. *(continued)* **E**, One year after surgery, raising the eyebrow. **F**, Smiling. Note that there is some synkinesis as the involved upper brow elevates with an effort to smile. **G**, Closing the eyes. **H**, Two years after surgery. There is still inability to raise the brow. This is not unusual following nerve repairs. Upper division repairs frequently do not restore eyebrow function and lower division repairs often leave a lower lip and platysma deficit. **I**, Closing the eyes. Note sykinetic elevation of the brow on the involved left side. **J**, A strong symmetrical smile. (From May M et al.[17] With permission.)

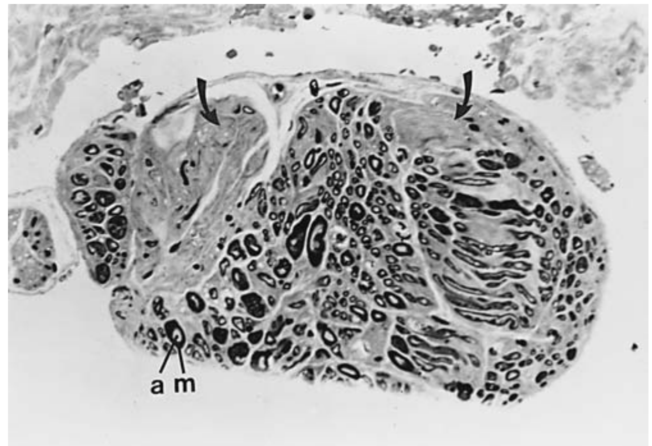
process begins within hours from the time of injury.[9,10] Axon sprouts are being pushed out from the central stump within 4 days[11] and will seek the distal motor unit end plate re-establishing connection between the pons and the facial muscles at a rate of 1 to 3 mm/day. The window of opportunity can be extended to 6 months with a fall-off in the strength of muscle movement recovery due to less axons reaching the motor unit end plates. There is evidence to suggest that the progressive decrease in facial function recovery is related to alterations in the biology of the facial nerve nucleus in the pons as well as shrinking and collagenization of the peripheral system of axons that are distal to the injury (Fig. 2–7). Fisch and Rouleau[12] demonstrated evidence of recovery in patients grafted 18 to 36 months after injury but clearly achieved the best results when the nerve was repaired within a year. Our overall results of facial nerve repairs after 1 year have been so disappointing that other techniques such as the hypoglossal crossover or muscle transposition are preferred (Fig. 2–8).

Condition of the Nerve

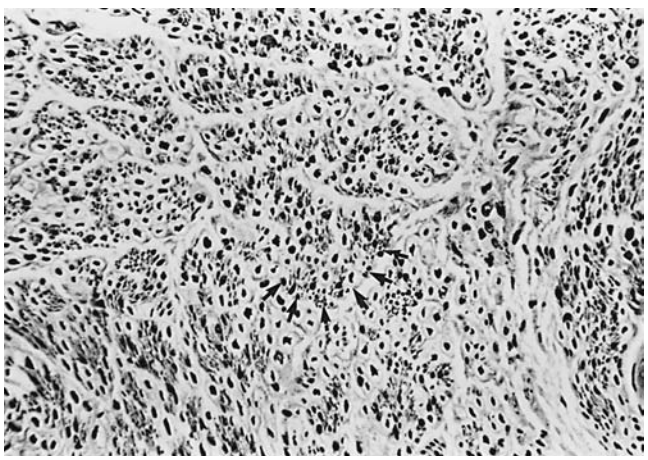
In addition to the time factor, the cause of the injury must be considered in predicting results. Upon histopathologic examination, a malignant tumor may actually show evidence of neural invasion even with little or no clinical evidence of facial weakness (Fig. 2–9).



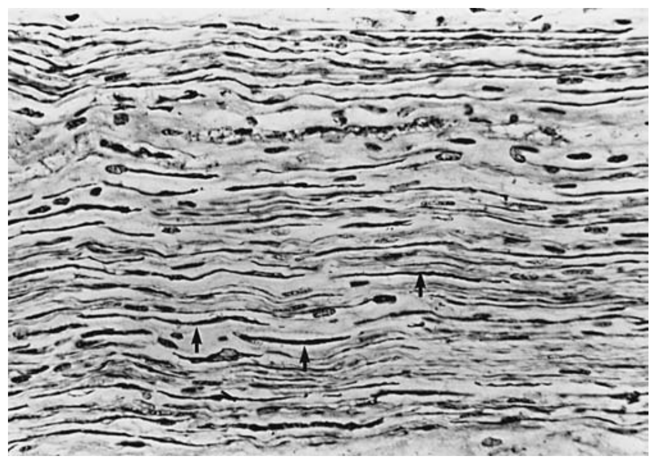
A1, 2



B1

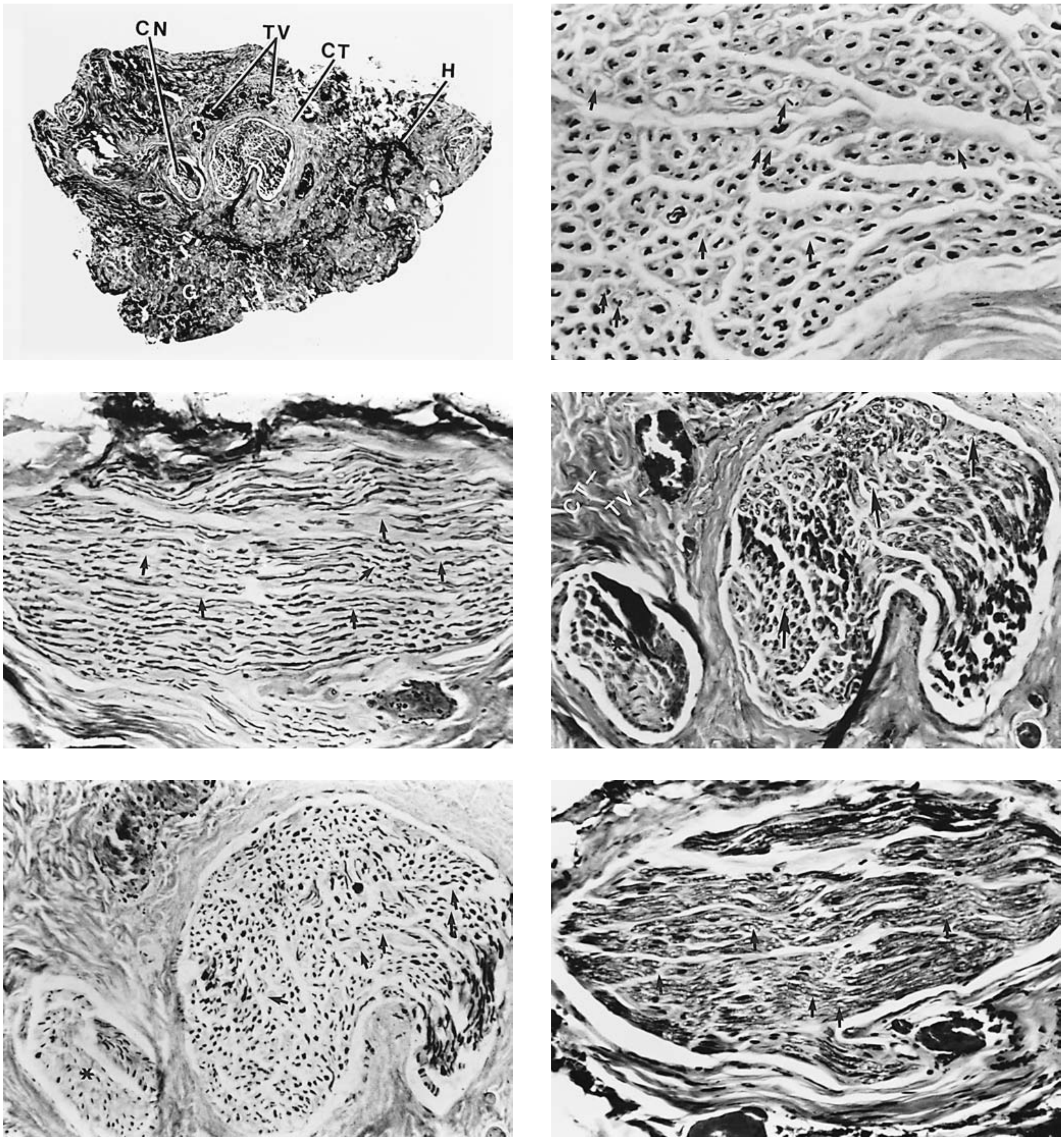


B2



B3

Figure 2–6. **A1**, A schematic of Figure 2–5D indicates that the injured portion of the proximal and distal end were trimmed back to normal-appearing nerve confirmed by frozen section control (p, proximal; d′, section from end of proximal segment; d, distal segment). **A2** demonstrates that a 4-cm graft taken from the great auricular nerve was required to fit between the proximal and distal end without any tension. Note how the small gap becomes significantly larger after the injured proximal and distal segments are trimmed. Prior to placing the graft, frozen section control confirms that following trimming the proximal end shows normal axons and the distal end is beyond the acute injury. **B1**–**3**, Are nerve biopsies taken through the proximal end of the injured upper division. This section is proximal to the injury. **B1**, Cross-section, proximal end (Toluidine blue, ×42). The specimen is completely normal except for the two sections (arrows) with crush artifact or extension of the injury to involve two fascicles of this multifasciculated nerve bundle. Toluidine blue selectively stains myelin. m, myelin; a, axons. **B2**, Cross-section, proximal end (Bodian stain, ×250). Bodian selectively stains axons. Both **B2** and **B3** show a normal axon pattern on cross- and longitudinal section. The arrows point to the axons.
B3, Wallerian degeneration involves the proximal end a very short distance, whereas there is complete degeneration distal to the injury. It is important to trim back the traumatized nerve proximally until normal nerve is demonstrated, as depicted in **B3**. Within 3 days, these axon processes will be extending out the distal end and entering the graft. These processes will be drawn into the graft toward the motor end plate by neurotrophism and guided by the Schwann cell-lined tubes created as the axon and myelin degenerates within the nerve graft and the peripheral neural system to which the graft is attached.



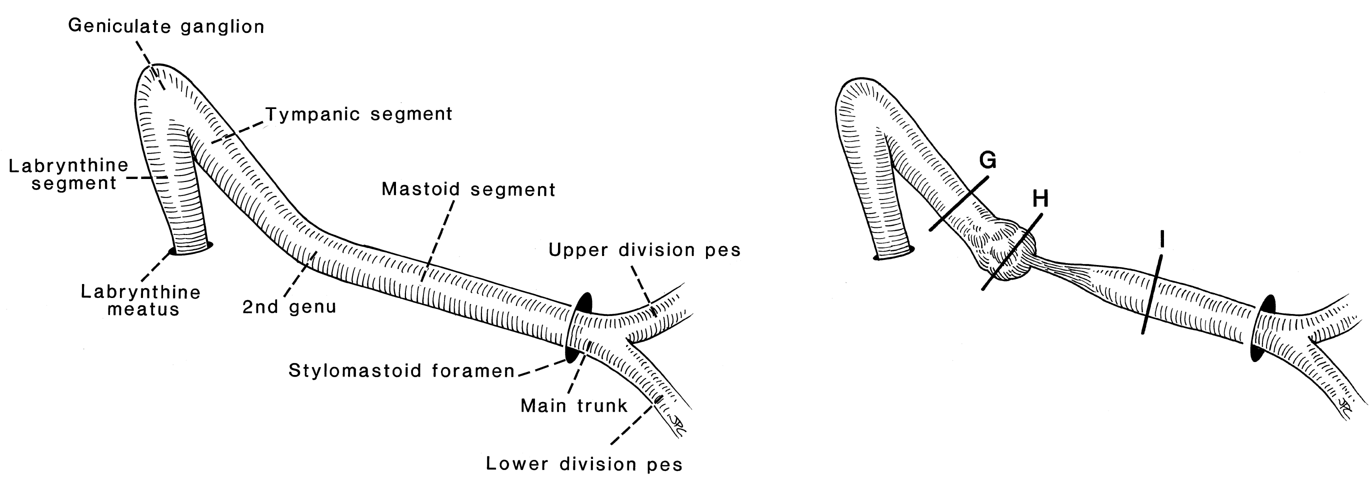
C1 C2 C3 C4 C5 C6

Figure 2–6. *(continued)* **C1**, Cross-section, distal end through injury (Toluidine blue, ×42). This section is through the acute injury just distal to the traumatic transection as depicted in **A1**. Note the hemorrhage (H), increased connective tissue reaction (CT), granulation tissue (G), thrombotic vessels (TV), and crushed nerve (CN). Upon review of this specimen, one can appreciate the importance of removing the area of nerve close to the injury and suturing the graft to a healthier appearing nerve more distally. **C2–6**, These specimens were taken distal to the lesion as depicted in **A1**. **C2**, Stained selectively for axons and shows early Wallerian degeneration has already begun within 24 hours of injury. There is some loss of axons (arrows). **C3**, Clumping and beading of axons indicates early Wallerian degeneration. **C4**, Trichrome stain for myelin shows vacuolization (arrows), while the general morphology and organization is intact. **C5**, Loss of axons (arrows). **C6**, Vacuolization of myelin depicted with the Toluidine blue stain. These histologic specimens demonstrate vividly the favorable situation for nerve regeneration and an anatomicophysiologic basis for early nerve repair.

A, B

Figure 2–7. Patient with right-sided facial paralysis 5 months following self-inflicted gunshot wound to area of right mastoid tip. **A**, Smiling, **B**, Closing eyes. **C**, **D**, One year post-nerve graft, temporalis muscle transposition, and eye spring insertion. **C**, In repose. Note return of tone and symmetry. This is due to the effect of the temporalis muscle as well as nerve regeneration through the nerve graft placed 1 year prior. **D**, Closing eyes. Note with effort to close the eyes, there is some synkinetic movement of the corner of the mouth on the involved right side indicating nerve regeneration. **E**, Smiling as a result of voluntary muscle contraction through nerve regeneration as well as contraction of the temporalis muscle. **F**(left), Schematic representation of the facial nerve within the right temporal bone. **F**(right), Indicates the levels where nerve specimens were obtained for histologic study.

C–E



F

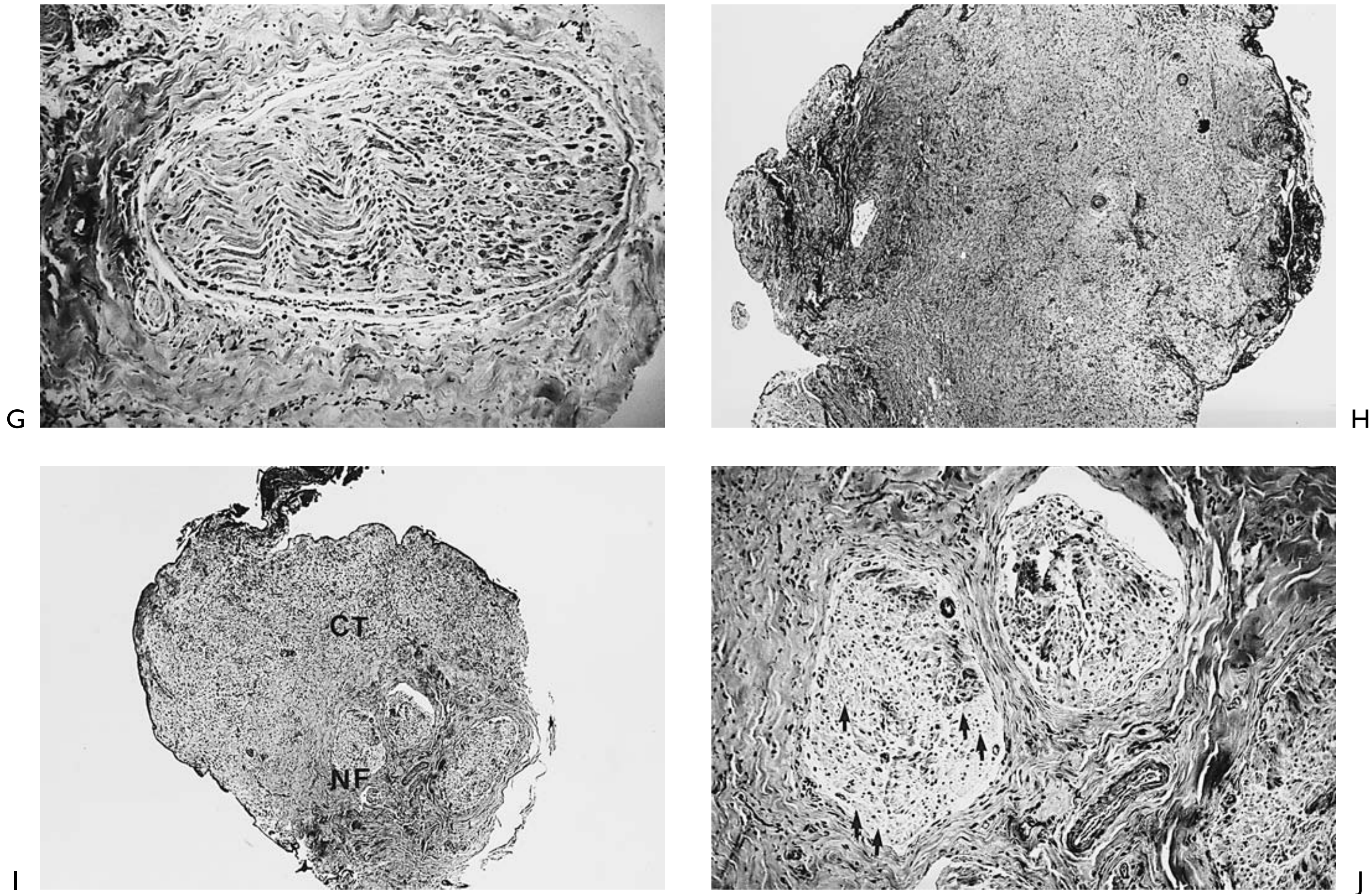
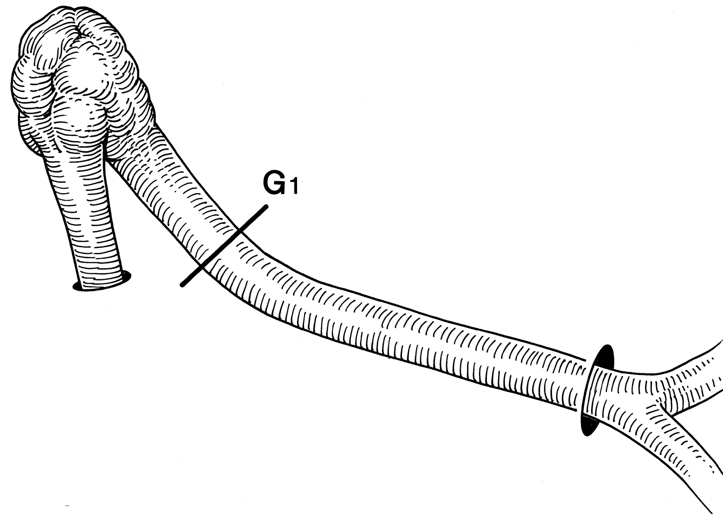


Figure 2–7. *(continued)* **G**, Cross-section through tympanic segment proximal to level of injury. Mason trichrome stain, ×33. The stain specific for myelin shows surviving normal-appearing myelin proximal to the injury. The proximal end of the facial nerve will retain its morphology and remain viable for the life of the individual. This intact proximal nerve has the potential to reinnervate the distal system. Unfortunately, the distal facial nerve system collagenizes and is replaced by scar tissue. **H**, **I**, **J**, This process begins as soon as Wallerian degeneration has been completed within 10 to 21 days and progresses rapidly over 3 months. Although the distal system may not be serviceable for reanimation, certainly the proximal surviving end of the nerve could be used to motor a free muscle graft. This approach has been used effectively in two patients. **H**, Cross-section. Mason trichrome stain, ×8. Section through the traumatic neuroma. There are no identifiable fascicles but rather a haphazard pattern of interdigitating fibrous tissue of a reactive or traumatic neuroma. **I**, Cross-section. Mason trichrome stain, ×8. Specimen was obtained distal to the traumatic neuroma and shows three fascicles with marked increase in connective tissue encompassing these nerve bundles. *CT*, connective tissue; *NF*, neural fascicle. Note the amount of neural shrinkage and increase in connective tissue just 5 months following the injury. **J**, Cross-section. Mason trichrome stain, ×33. High-power view of the area depicted in **I**. There are no surviving axons or myelin. The organization and distribution of the neural elements seem to be constricted by surrounding connective tissue. There is already significant collagenization. These factors interfere with regeneration following nerve repair. Considering the amount of shrinkage and collagenization involving the nerve distal to the injury at 5 months, we do not rely on the nerve graft alone and use combination procedures in such a case. In this particular patient, eye reanimation was critical in order for him to return to work as a truck driver. Based on this, an eye spring was inserted to improve eye closure, and a temporalis muscle transposition for mouth function was performed along with a nerve graft. The amount of recovery achieved with the nerve graft was minimal yet significant in terms of tone and some mimetic movement. The combination of procedures complimented each other.

A–C

D–F

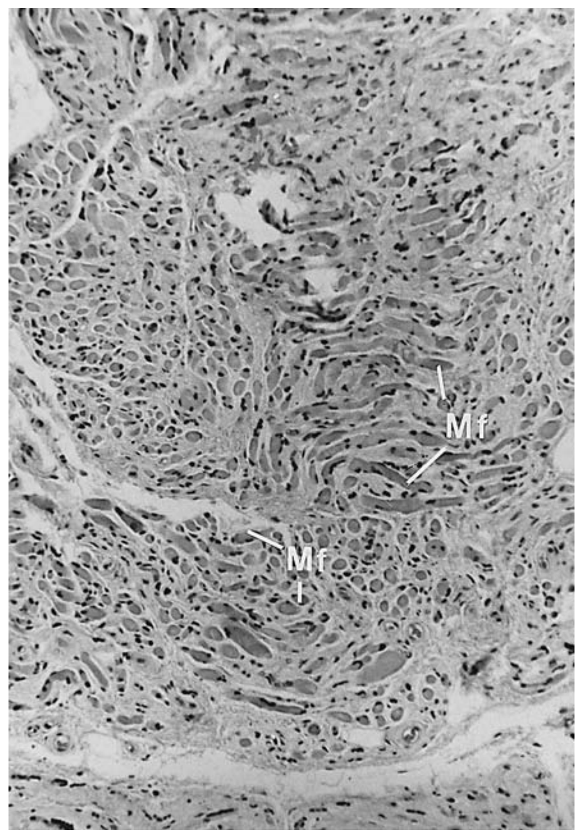
Figure 2–8. Patient presents with an 18-year history of facial paralysis that began slowly over a period of 5 years and then became complete. A meningioma involving the facial nerve at the geniculate ganglion was confirmed at the time of surgery. A temporalis muscle transposition and gold weight implant was used to reanimate the face rather than depend on a nerve graft in a patient who has been paralyzed for 18 years. **A**, Note widened interpalpebral fissure and some sagging of the corner of the involved right side with flattening of the lip cheek crease. **B**, Inability to approximate the eyelids on the involved right side. **C**, No movement of the involved side with smiling. **D**, Six weeks post-temporalis muscle and gold weight implant. Face in repose. **E**, Closing the eye. **F**, Smiling.



G

Figure 2–8. *(continued)* **G**, Schematic of the facial nerve within the temporal bone showing the location of the tumor and the site of the specimen (G1). **H**, A biopsy of the facial nerve was taken distal to the tumor. It shows thickening of the epineurial sheath (eS) with complete collagenization of the endoneurial compartment (f). No viable nerve elements were identified by special staining techniques. **I**, Biopsy of facial muscles in the area of the lip cheek crease shows viable muscle fibers (Mf). The fact that facial muscles survive over long periods of time does not correlate in any way with return of function following nerve repair. A possible explanation for survival of muscle fibers in spite of complete facial nerve denervation may be reinnervation from nerves in the vicinity. It is possible that fifth nerve fibers reanimate the denervated facial muscles. This has been demonstrated by Silverstein et al.[35] in a patient with a teratoma involving the facial nerve in the temporal bone. A teratomatous tumor was removed with the facial nerve. Following this procedure, the patient demonstrated spontaneous recovery. It was established that the recovery was through fifth nerve fibers because the movement could be interrupted by blocking the pathway of the fifth nerve by injecting Xylocaine into the region of the foramen ovale. This finding of muscle survival in the face of long-term facial nerve denervation points out the lack of clinical application of muscle biopsy to determine whether nerve repair is a reasonable option.

H



I


A

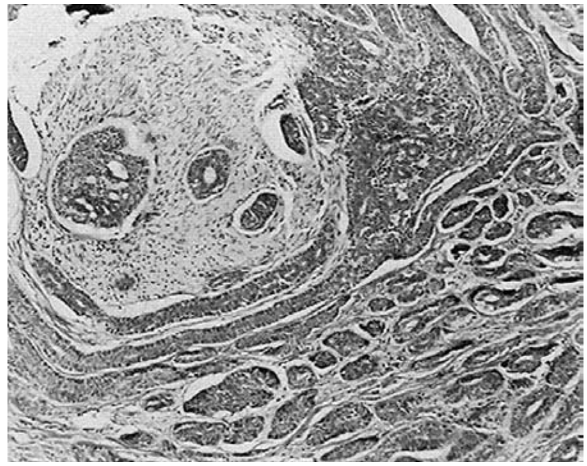

B

Figure 2–9. **A**, Patient with a left-sided facial weakness present 2 months due to occult adenoid cystic carcinoma of the parotid gland.
B, High-power view of the specimens from this patient demonstrating both intra- and perineural invasion of the nerve.

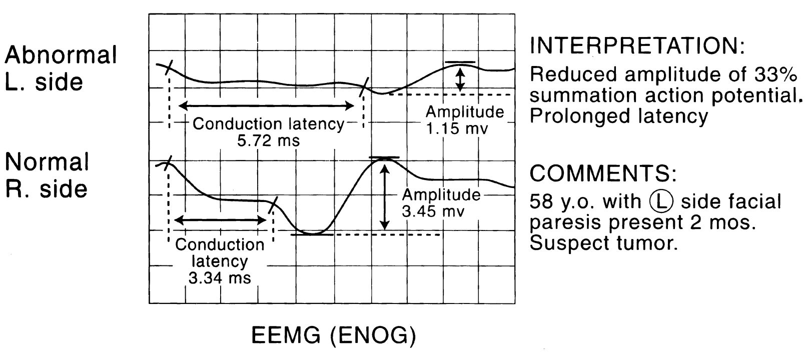


Figure 2–10. EEMG (ENOG) of patient in Figure 2–9. Reduced amplitude and prolonged conduction latency in a patient with a facial paresis that persists beyond 3 weeks without evidence of spontaneous recovery suggests the presence of a tumor. Appropriate imaging studies are indicated. In this case, imaging studies were normal. Based upon the pattern noted by EMG, surgical exploration of the facial nerve in the temporal bone and total parotidectomy was performed. An occult adenoid cystic carcinoma of the parotid gland was discovered.

Evoked electromyography has been quite helpful in predicting cases where the nerve has been affected either by a malignant or a benign tumor. Patients may present with minimal paresis (Fig. 2–9) and yet show marked reduction in the amplitude of the summation action potential and prolonged conduction latency, suggesting that the nerve has undergone degeneration and regeneration due to a slow ongoing process of invasion, replacement, and compression (Fig. 2–10). In patients with a parotid malignancy and facial paralysis or paresis prior to resection, the results of nerve grafting have been disappointing compared to those patients where the nerve was resected but was not involved with tumor. Clearly resection of benign tumors where the nerve was not involved (Fig. 2–11) and the nerve then repaired yielded ideal results much as one would expect if the nerve was transected iatrogenically or accidentally injuried and repaired immediately (Figs. 2–5 and 2–12).

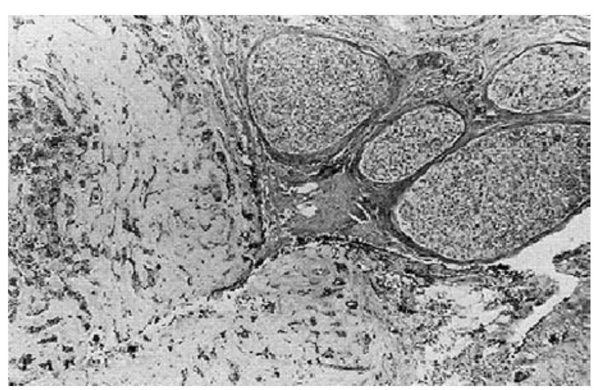
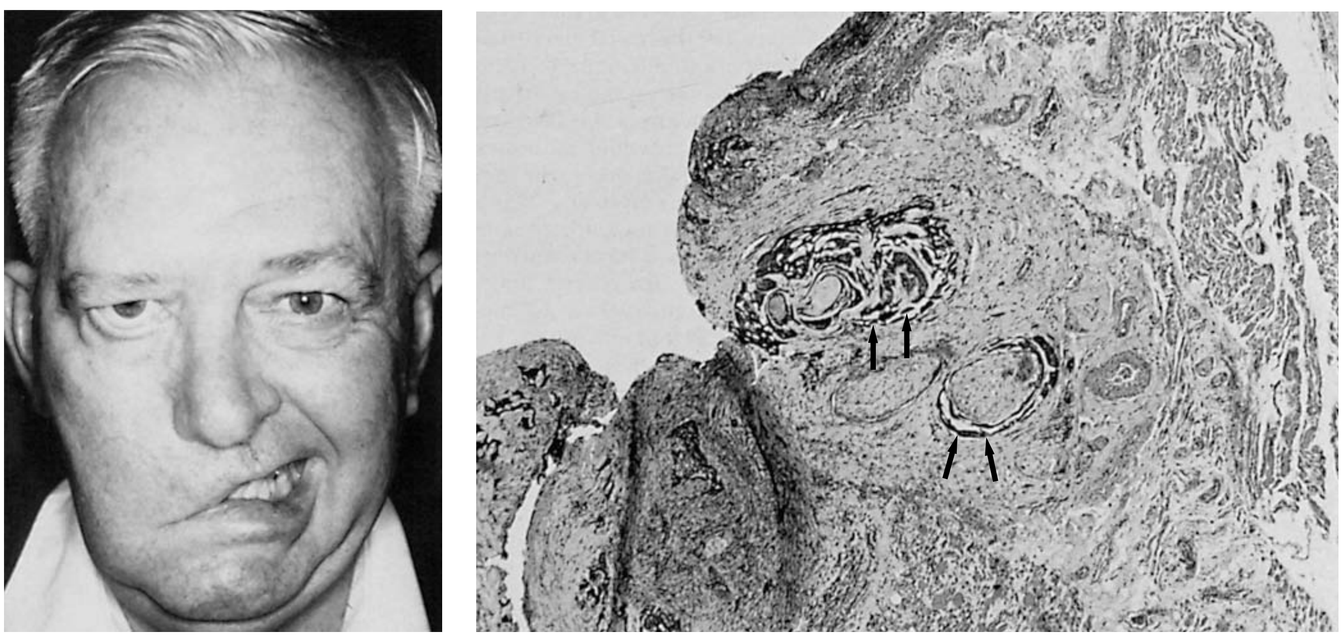


Figure 2–11. Section through tumor specimen taken from parotid of a patient (Fig. 2–12) with recurrent pleomorphic adenoma. The tumor is adherent to the facial nerve, but not invading. In such cases it is not possible to separate the tumor from the nerve and preserve facial nerve continuity.

A–C

Figure 2–12. **A**, Postresection of the facial nerve with the adherent pleomorphic adenoma and immediate nerve graft repair. **B**, **C**, Five years after surgery. Recovery with individual movement, some mass movement, and synkinesis. **B**, Smiling. **C**, Eyes closed.



A B

Figure 2–13. **A**, Patient presents with facial paralysis of 2 years duration diagnosed as "Bell's palsy." A history of radiation therapy for a recurrent basal cell carcinoma in the cheek skin on the same side a year prior to the onset of "Bell's palsy" prompted an exploratory parotidectomy and facial nerve resection. **B**, Pathologic study of the specimen demonstrates basal cell carcinoma with perineural invasion (arrows).

In contrast, patients who preoperatively had a total paralysis with replacement or invasion of the facial nerve noted pathologically rarely showed any recovery following nerve repair (Fig. 2–13). The amount of facial recovery following resection and repair seem to depend on the amount of functioning fibers present at the time of surgery. Therefore, the surgeon can expect the amount of recovery following tumor resection and repair to vary from the most recovery in a patient who presents with normal function, to less recovery in a patient who presents with paresis, and little or no recovery in a patient who presents with total paralysis. This observation is quite helpful in planning reanimation procedures because one could depend solely on the nerve graft for recovery in the most favorable situation, while in the

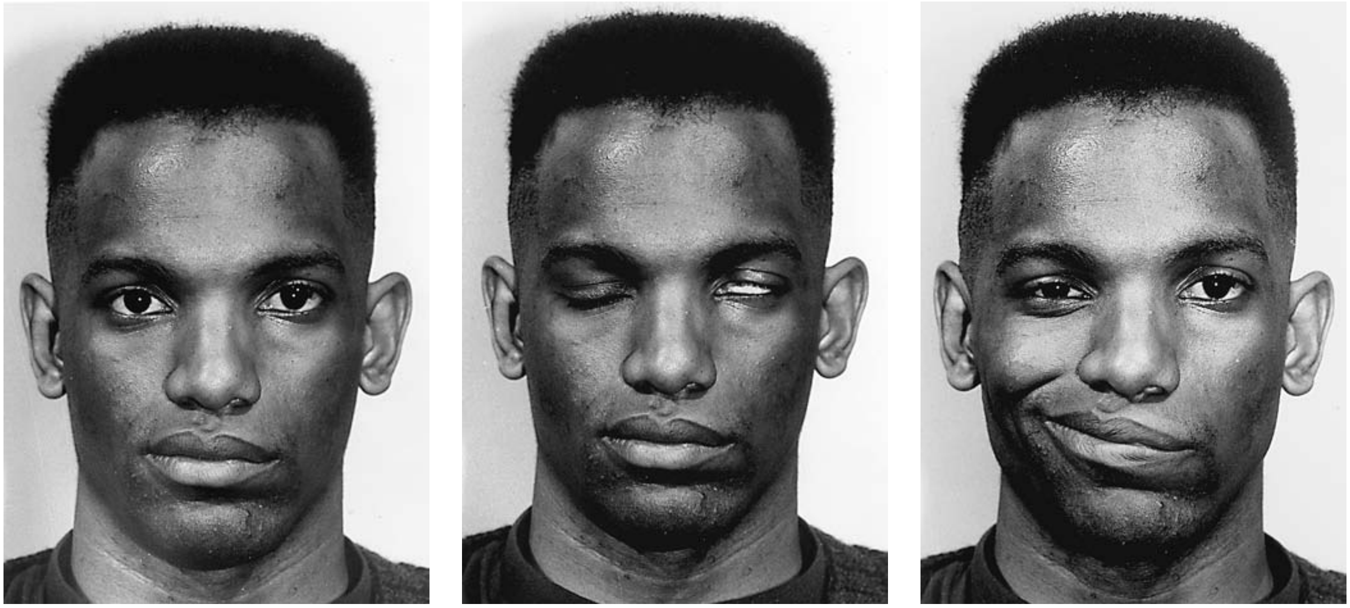
A, B

C, D

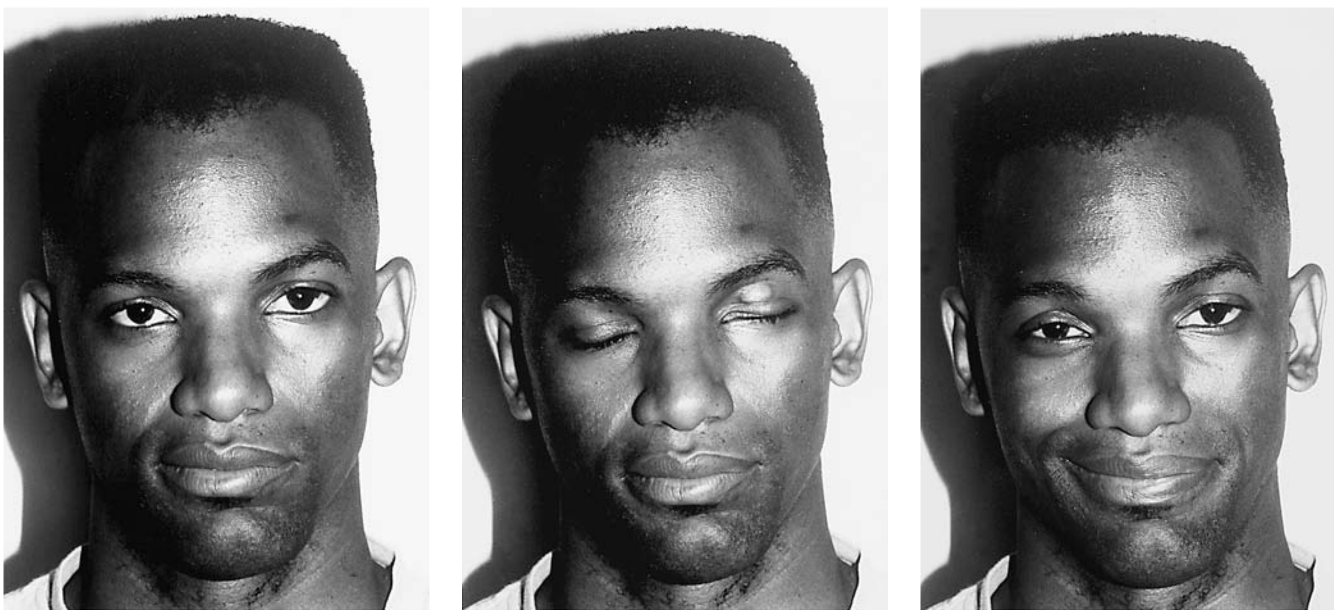
Figure 2–14. Patient with a hard mass involving the left parotid and a total facial paralysis for 6 weeks. Incisional biopsy proved undifferentiated epidermoid carcinoma. **A**, Smiling. **B**, Closing the eye. **C**, Five weeks post-resection with upper eyelid spring insertion, lower eyelid tightening, cartilage implant, and temporalis transposition. Face at rest. **D**, Closing eyes. The animation techiques chosen achieved immediate facial rehabilitation in a patient with an advanced aggressive cancer. The prognosis for long-term survival was poor, and the likelihood of achieving useful facial nerve regeneration with nerve repair is unlikely in a patient with a preoperative total facial paralysis secondary to cancer invading the facial nerve.

worst case, any recovery of facial function with a nerve graft would be unlikely. Further, in the poor prognostic situation, the patient's overall prognosis for survival is questionable. In such a case, nerve repair that takes 2 years for full recovery may not be realistic, and it would be in the patient's best interest to perform a procedure that accomplished immediate reanimation, such as a temporalis muscle transposition (Fig. 2–14). This principle should govern the reanimation surgeon's decisions regarding whether to perform nerve grafts or some other technique. One should not expect to get a better facial recovery following resection and nerve repair than the amount of function the patient had prior to the surgery. In such cases, the distal end of the nerve to be repaired may show extensive collagenization because of the degeneration and regeneration process, and this is the major limiting factor in the amount of regeneration that is possible (Fig. 2–15).

The cause of injury, whether due to a knife, bullet, or shotgun wound, each have different considerations. A knife wound may sharply lacerate or separate the ends of the nerve allowing end-to-end repair (Fig. 2–16). An injury due to a bullet wound presents a different problem. Here the nerve may be disrupted, crushed, stretched, or cauterized by the heat generated as a high-velocity missile courses passed the vulnerable nerve (Fig. 2–17). The surgeon must be prepared to examine the nerve grossly with the aid of the binocular microscope and by frozen section control to be sure the injured nerve segment has been resected so that both proximal and distal stumps are suitable for repair with suture or interposition graft. A shotgun wound inflicted at

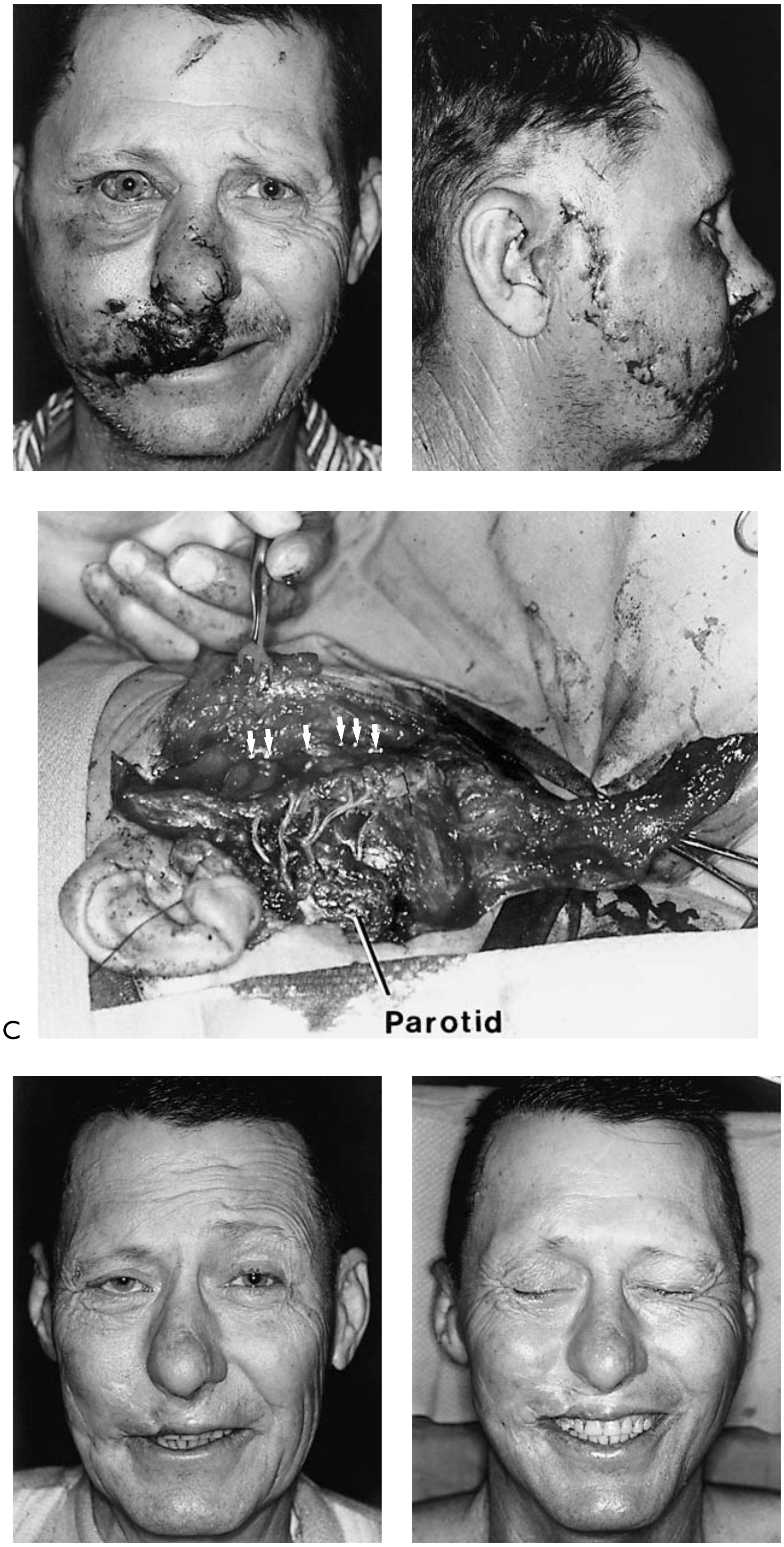


A–C



D–F

Figure 2–15. A 32-year-old man with slowly progressive left facial paresis over a 4-year period. Preoperatively, there is **(A)** tone and symmetry, **(B)** inability to close the eyes, and **(C)** a weak smile. Two years postsurgery with interposition graft from the midvertical segment to the proximal labyrinthine portion following resection of osseous hemangioma, there is return of the preoperative facial function. **D**, In repose. **E**, Eye closure is improved with a gold weight implant. **F**, Smile is asymmetrical but mimetic. The amount of recovery expected with a nerve graft is rarely better than what existed prior to surgery and often is worse. This is an important observation to share with the patient as part of the preoperative discussion regarding risks, options, and alternatives. The patient must not be led to believe that in removing the tumor or resecting the nerve facial function will be restored when in fact the amount of function expected with nerve repair as mentioned may not be as good as what existed prior to surgery. There is always the possibility that there will be no recovery. Based on this, there are cases with a benign tumor where it is better to leave a functioning nerve and observe the natural history of the tumor.

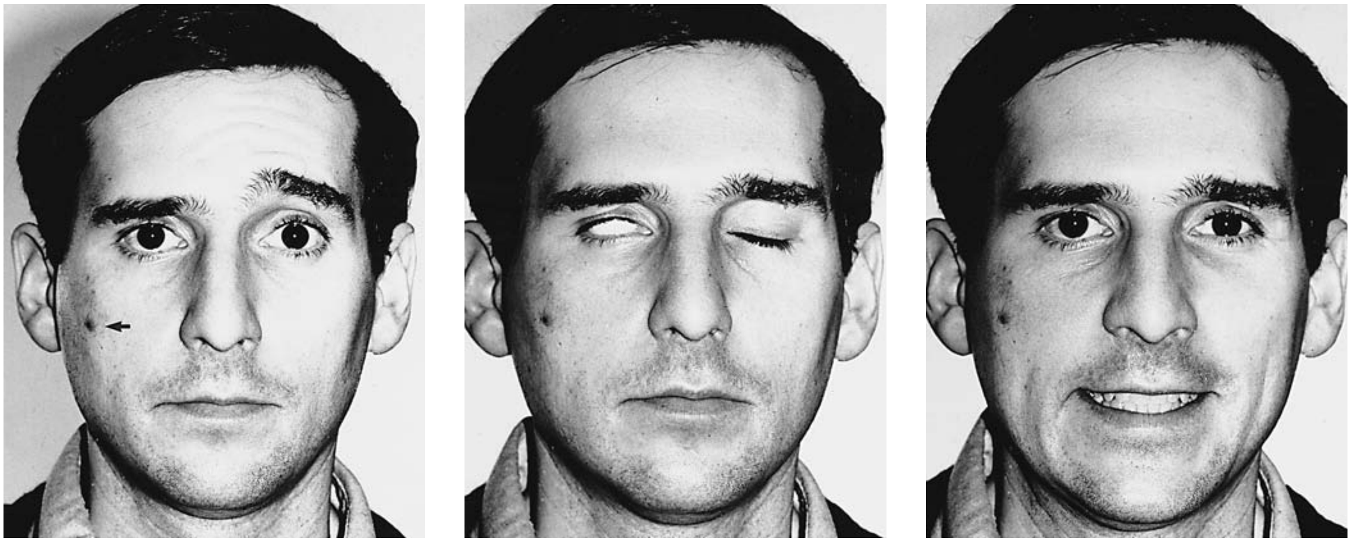


A, B

C

D, E

Figure 2–16. Patient sustained an avulsion of the right side of the face involving the parotid gland and all of the branches of the peripheral facial nerve. He was referred and explored 24 hours after the initial injury and wound repair. **A**, Patient 24 hours after injury with total right facial paralysis. **B**, Prior to referral the wound was closed without an effort to find the ends of the nerve or repair them. **C**, The wound was reopened. The distal ends of the nerve (open arrows) identified with a nerve stimulator and repaired end-to-end to the proximal divided ends. **D**, **E**, The same patient 1 year later demonstrating the best possible recovery one can achieve with an early repair of the peripheral nerves within 24 hours following the injury. **D**, Smiling. **E**, Closing the eyes tightly.



A–C

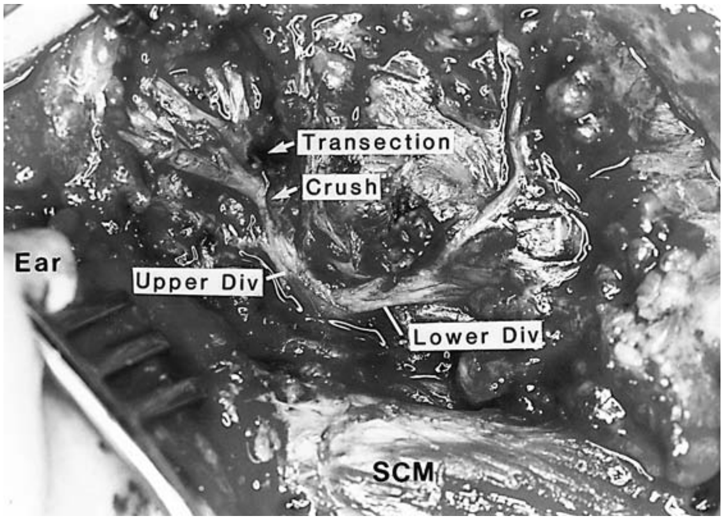
D–F

Figure 2–17. State trooper shot at close range with a 0.22-caliber rifle. **A**, Two and a half weeks post-gunshot wound showing wound of entrance (arrow) and raising eyebrows. **B**, Closing eyes. **C**, Smiling. **D**, Wound of entrance right cheek. **E**, Wound of exit posterior right lateral neck. **F**, Showing trajectory by drawing a line between wound of entrance and exit. Prediction of site of injury to upper division of facial nerve based on the generalized facial nerve pattern drawn on the skin prior to raising the flap. *(Figure continued next page.)*

close range creates a contaminated injury with marked tissue disruption (Fig. 2–18). In such cases, the proximal and distal ends of the facial nerve should be identified and tagged, and nerve repair should be delayed 3 weeks or until the wound is healthy.

Tumor Involving the Facial Nerve

Tumors, especially a schwannoma (neurinoma, neurilemmoma, neurofibroma), involving the facial nerve must be adequately resected, with adequate or with frozen section controlled proximal and distal margins. In one patient with a schwannoma in the vertical segment of the facial nerve, a graft was placed after the tumor had been resected. When no recovery was noted after 1 year, the area was re-explored. Tumor material was found to extend outside the stylomastoid foramen, indicating that the original resection was inadequate. Although some facial movement and tone were restored, the 2-year delay between injury and second repair of the nerve precluded optimal recovery of nerve function. This same situation may be noted with tumors extending to the proximal tympanic segment. In these instances, the tumor may extend proximal and beyond the area available for resection through a mastoid approach; when hearing is intact, a middle fossa approach may be used to resect the tumor, or translabyrinthine exposure when hearing is not serviceable. The proximal and distal ends of the resected nerve must be examined histopathologically to confirm total resection of the tumor before a graft is placed. On occasion, the results of examining frozen sections will not agree with the permanent pathologic preparations. If the frozen section is reported as "ends free of tumor," the graft should be placed. If the permanent section agrees, no further surgery is necessary. However, if



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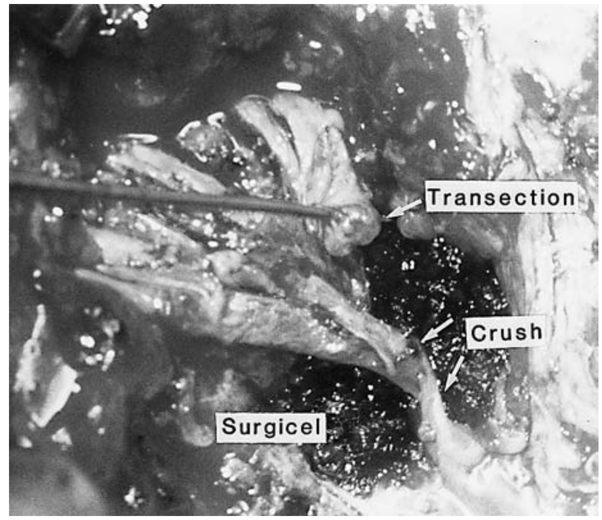

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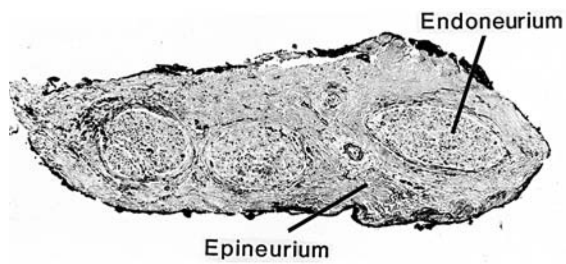
I



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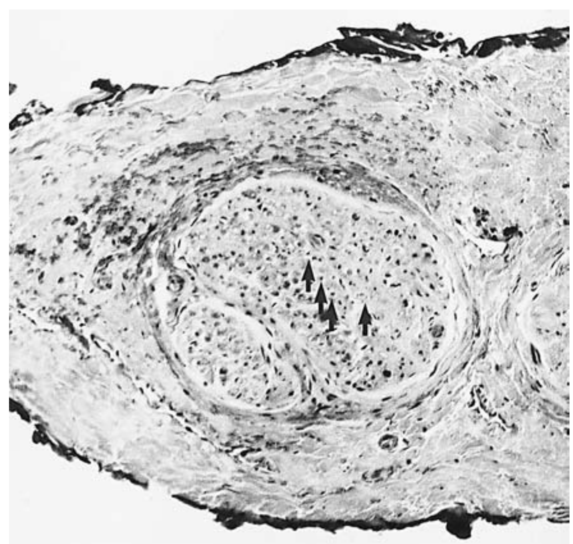


K

Figure 2–17. *(continued)* **G**, Identification of site of injury at time of surgery. **H**, Area of injured nerve resected. **I**, Interposition grafts in place. Note the lack of tension by using grafts (G) that are longer than the gap they bridge. **J**, **K**, **L**, Sections through the proximal **(J**, **K)** and distal nerve **(L**, see next page**)** showing intact proximal nerve and degeneration of the distal nerve without any significant evidence of fibrosis, an ideal distal conduit for nerve regeneration. **J**, **K**, Proximal section. **J**, Cross-section. Shows three fascicles. Hematoxylin and eosin stain, ×8. **K**, Hematoxylin and eosin, ×165. Note intact axons (arrows).

L–N

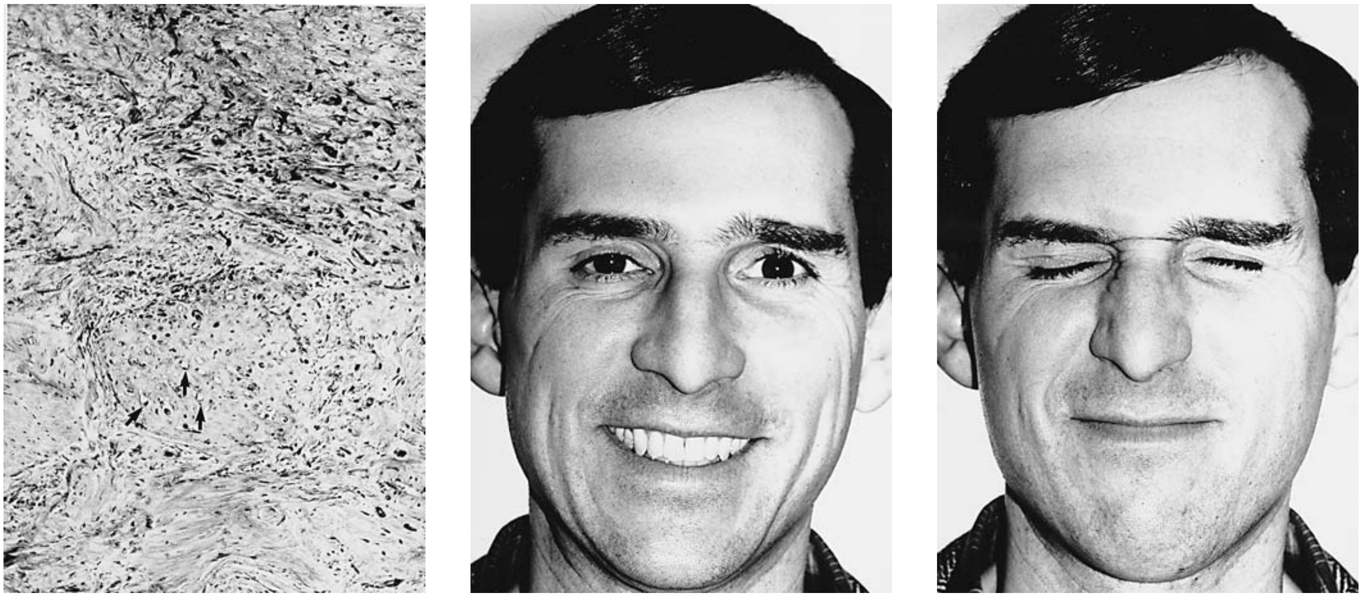


Figure 2–17. *(continued)* **L**, Distal segment, cross-section shows empty neural tubules (arrows). Hematoxylin and eosin, ×100. One year postsurgical neural repair. **M**, Smile (elevation of right eyebrow did not recover, not shown). **N**, Closing eyes tightly. Note mild synkinesis in midface.

Figure 2–18. Disruption of the facial nerve as a result of a shotgun injury.

the permanent section indicates residual tumor, reoperation should be performed as soon as possible and ideally within 30 days of primary surgery.

Following trauma, upon late exploration of the facial nerve 30 days or longer after injury, one may find a neuroma at the proximal end and fibrous tissue at the distal end of the injured segment (Fig. 2–7). The neuroma and fibrous tissue must be trimmed away so that the graft is attached to a healthy axon bearing proximal nerve and peripheral stump containing potential neural tubes. One can usually rely on the appearance of these structures with the aid of the operating microscope to decide if the ends are suitable for grafting. However, there are times when frozen section control taken from the proximal and distal ends examined by an experienced neuropathologist can help determine how much tissue must be trimmed away for the graft to have the highest likelihood for success (Fig. 2–17).

Infection

Infections developed in patients who had combination procedures involving the mouth area. This risk has been reduced by intravenous clindamycin 600 mg just prior to administering general anesthesia and repeated every 8 hours for the first 24 hours following surgery. Further, at the termination of the procedure, the wound is irrigated with clindamycin solution, and suction drainage is applied to all wounds.

Surgical Principles

There are two basic surgical principles of nerve repair: (1) connect the defect between the proximal and distal ends of the nerve without tension and (2) match the endoneurial surface of each end. Tension can be avoided by noting whether the nerve ends meet and hold together without the need for a suture (Fig. 2–19). If the ends tend to pull apart and a gap appears, it is best to place an interposition graft. The bridge created by the graft should form an "S" or "C" shape ensuring that there is extra length and absolutely no tension (Fig. 2–19).

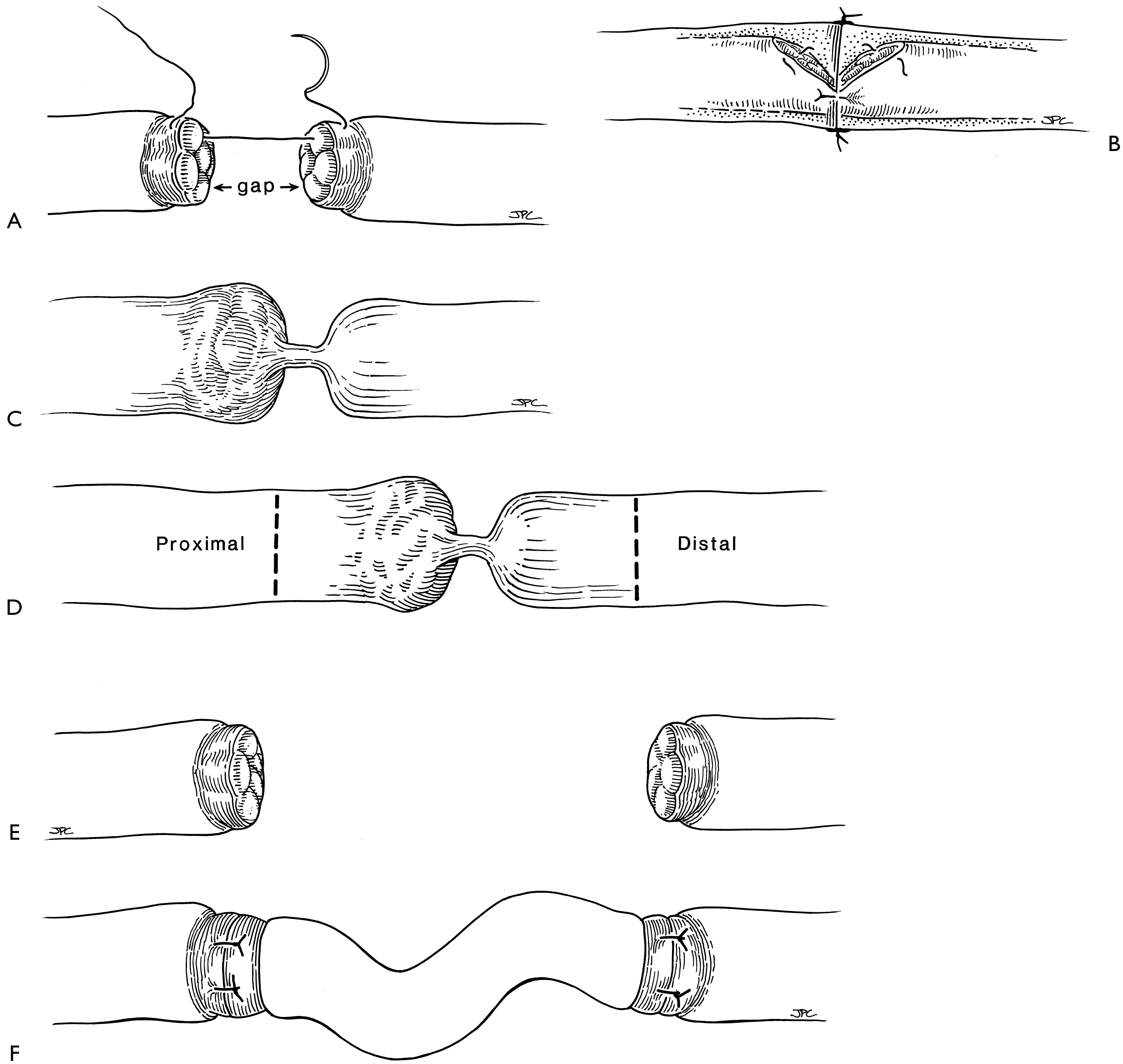


Figure 2–19. Closure without tension. **A**, A gap exists between the two ends of a severed nerve and can not be approximated without sutures. If one tries to close the gap by pulling the ends together and holding them with a suture, the ends will pull apart. **B**, Approximating the loose connective tissue of the epineurium may achieve closure of the gap, but the endoneurial surfaces within the epineural sheath tend to retract and leave a gap that will eventually be filled with connective tissue blocking regenerating axons. **C**, Re-exploration in 30 days or longer after the initial repair, one will encounter a reactive neuroma at the proximal end and a fibrous strand that is collapsed and collagenized at the distal end. If one waits beyond the ideal time window (i.e., up to 30 days and not beyond 6 months), one loses the opportunity for effective nerve repair. **D**, **E**, The proximal and distal ends should be resected, even if it means creating a larger gap since an interposition graft is appropriate in either case. **F**, The graft should form an "S" or a "C" in order to ensure adequate length and a repair without tension thus avoiding the problems depicted in **A**, **B**, and **C**.

The next principle requires matching the proximal and distal nerve ends. The working end of the nerve is the endoneurial surface and not the diameter of the nerve ends (Fig. 2–20A). To make this determination, it is important to trim back the epineurium to uncover the endoneurial surface (Fig. 2–20B). In addition, stripping the epineurium is important to section a peripherial nerve as illustrated in Figure 2–21. Generally the greater the endoneurial surface, the greater the axon volume. However, there are exceptions. This is illustrated in Figure 2–22, where the endoneurial surface is less than expected based on the cross-sectional area of the nerve ending.

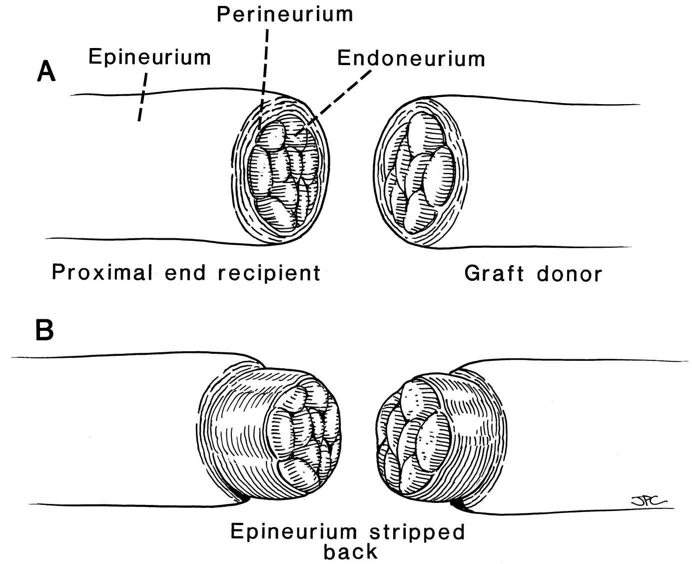


Figure 2–20. Match the endoneurial surface. **A**, The approximated ends of the nerve repair site must match in terms of the endoneurial surface. **B**, In order to ensure that there is a good endoneurial match, the epineurium must be stripped back.

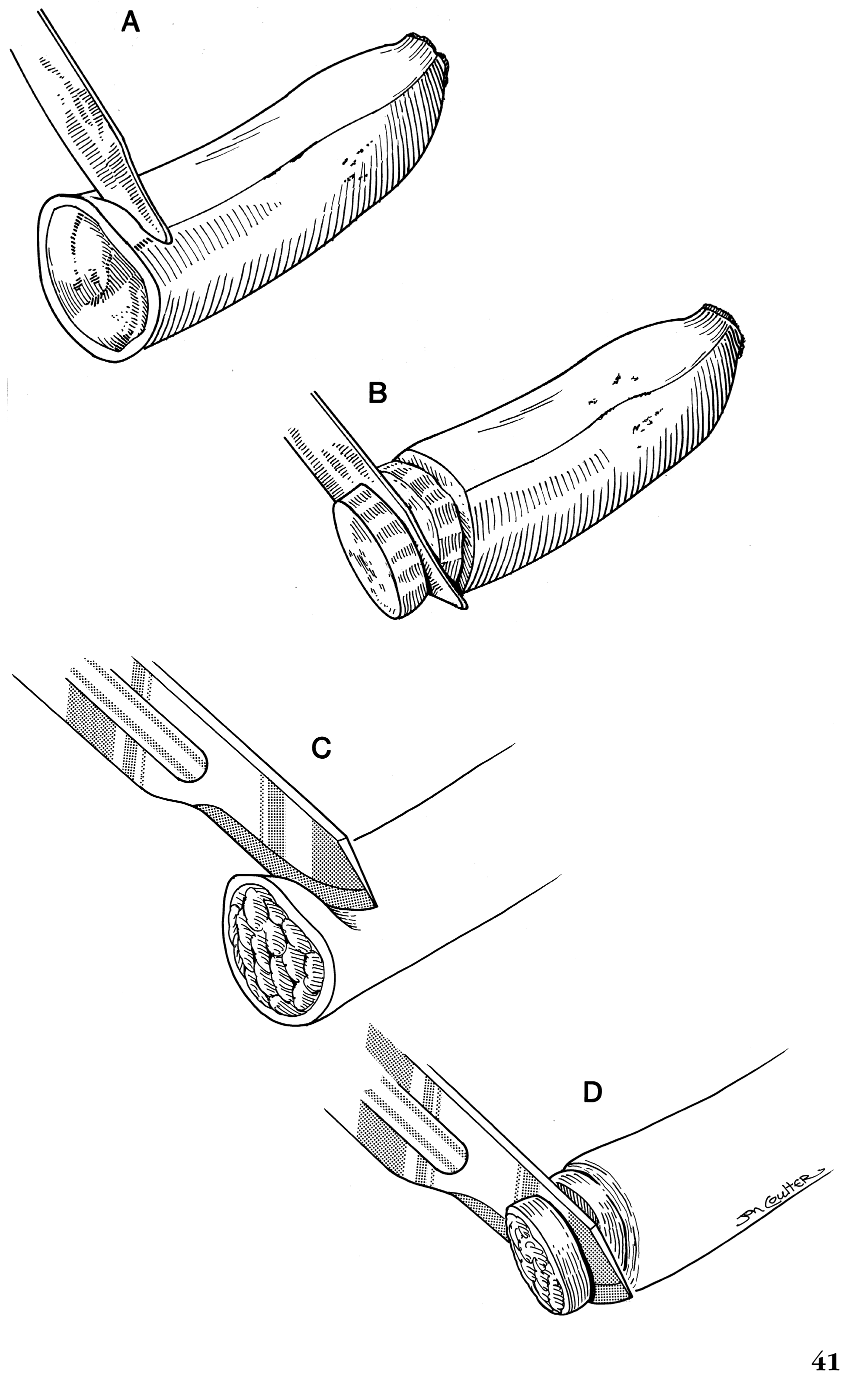


Figure 2–21. The facial nerve is like a banana. The skin of the banana represents the epineurium–a thick, tough covering. Attempting to section the banana with the covering intact tends to crush the soft contents **(A)**. A clean slice without crushing is achieved by peeling back the banana skin **(B)**. Dividing the facial nerve involves the same principles **(C** and **D)**.

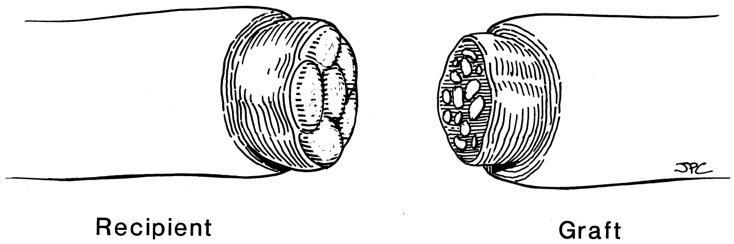


Figure 2–22. Epineurial match and endoneurial mismatch. In this case, once the epineurium was stripped back, it was clearly a poor endoneurial surface match that would not have been detected if the nerve ends were sutured together without stripping back the epineurium.

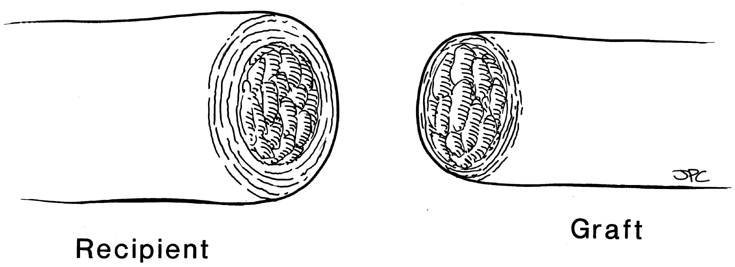


Figure 2–23. Epineurial mismatch and endoneurial match. There are instances where there seems to be mismatch when looking at the cross-sectional surface area of the cut end of the nerves to be approximated. However, once the epineurium is stripped back, it becomes clear that the nerve that had the smaller diameter had a very good endoneurial surface match and the graft was quite adequate.

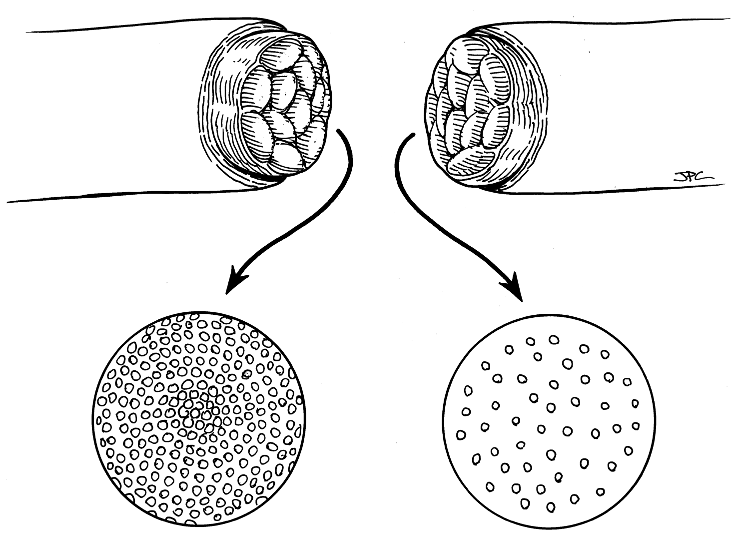


Figure 2–24. Endoneurial match with histologic mismatch. In this case, the cross-sectional diameter of the nerves to be approximated seem to match quite well, even upon stripping back the epineurium the endoneurial surface appears quite adequate. Nevertheless, there are times when the endoneurial surface seems to be adequate but the actual axon content is not in proportion to the endoneurial surface when the end of the nerve is studied histologically. Histologic study shows the graft does not contain high concentration of axons and would not be ideal to serve as a donor.

In Figure 2–23, the gross diameter of the graft is clearly smaller than the diameter of the recipient degenerated facial nerve. However, upon stripping back the thickened epineurial covering of the distal facial nerve, it becomes clear that there is a good endoneurial match between graft and recipient. One may find, for example, a nerve branch that seems very thin next to one that is clearly larger, but on stimulation of the smaller branch, there is a brisk response to a large area of the face, whereas on stimulation of the larger branch, there is a very limited response, indicating that the smaller branch contains greater "fire power" or a greater axon concentration. We might refer to this as "axon packing" (Fig. 2–24). Generally the more proximal part of a peripheral nerve will have a greater concentration of axons per surface area than the distal end. As the peripheral nerve courses from proximal to distal, the monofunicular cross-section becomes multifunicular as branches form and are separated from each other by an increase in connective tissue. This is true for the facial nerve as well as the donor grafts. However, there are exceptions. For example, there is an increase in the connective tissue/axon ratio in the case of the facial nerve as it exits the stylomastoid foramen. Clearly there is more connective tissue at the stylomastoid foramen than at the extracranial common facial nerve just before it divides into the upper and lower division. Peripheral nerves usually have a greater amount of connective tissue in areas where they make a bend or have to stretch as in the region of the elbow or knee. At these sites, the gross diameter of the nerve does not reflect the number of axons carried (Fig. 2–24).

This principle is particularly important when matching the main trunk of the facial nerve to peripheral branches of the facial nerve (Fig. 2–25A). A nerve graft may match the peripheral segment but be smaller than the main trunk of the facial nerve (Fig. 2–25B). In such a case, we would place two grafts or a double cable graft (Fig. 2–25C). Both grafts would approximate the main trunk of the facial nerve and

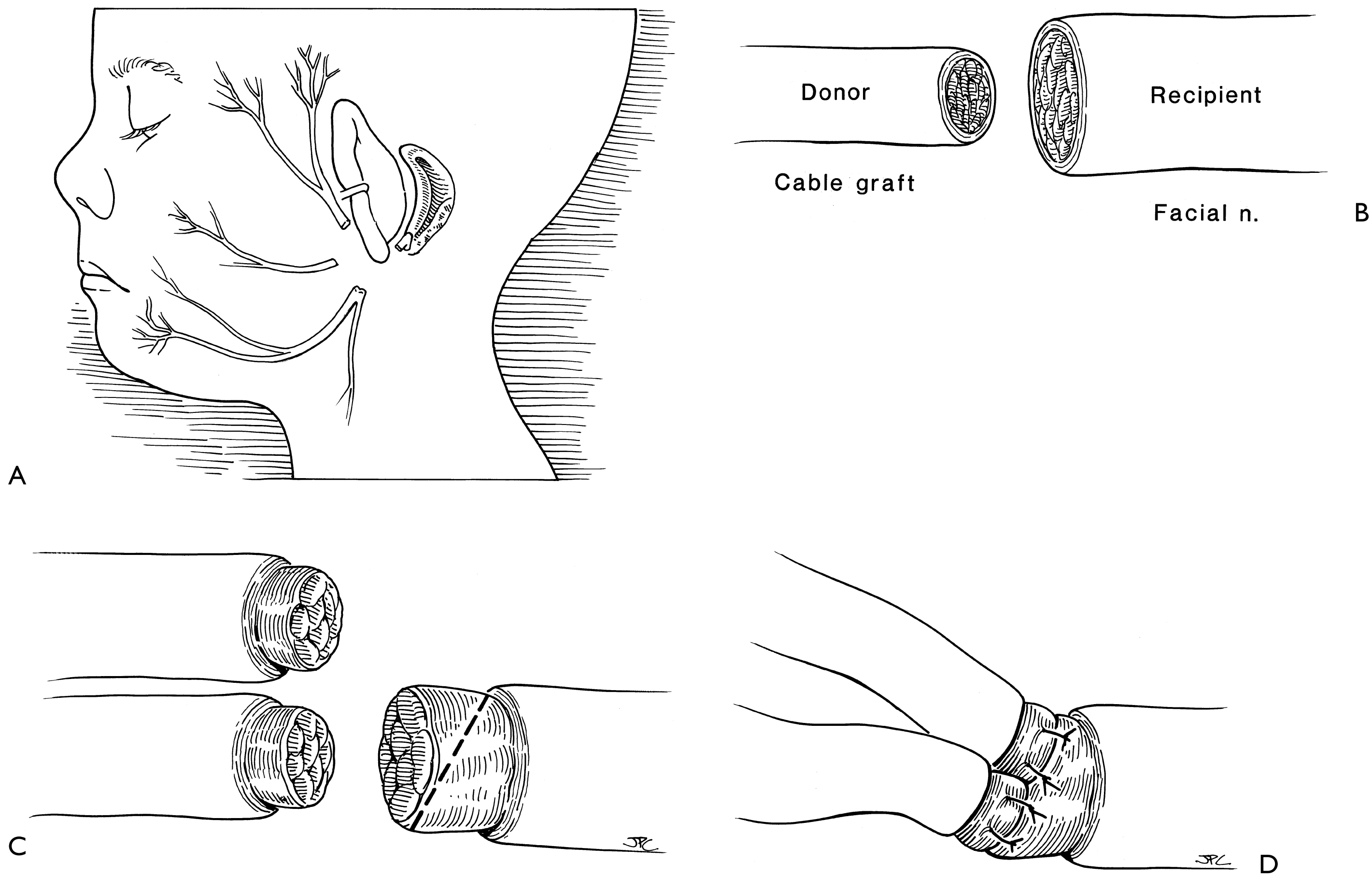


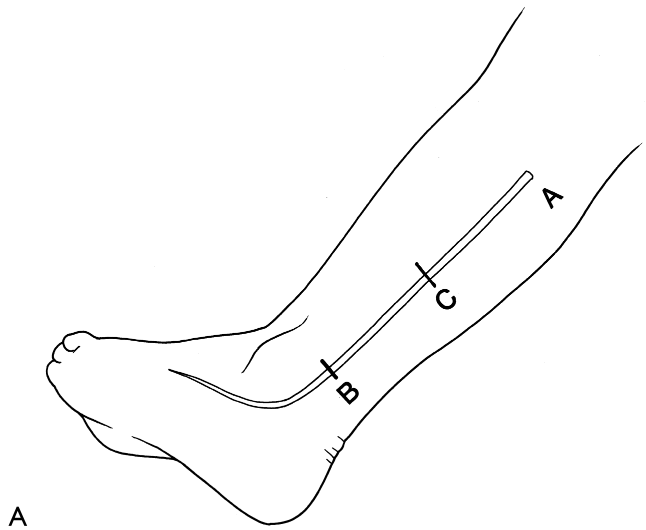
Figure 2–25. Double cable grafts are useful to carry axons from the proximal end of the facial nerve to the periphery using two grafts. Axons can be directed to the upper and lower division and create a better axon surface match with the proximal end of the facial nerve. **A**, The facial nerve has been resected from the vertical segment within the temporal bone to the peripheral branches. It is important to bridge the defect between the main trunk and the periphery with a graft that is of adequate length and matches the endoneurial surface of the proximal and distal recipient nerves. **B**, Shows one cable graft as a mismatch for the proximal end of the facial nerve. **C**, Shows the cable grafts present a mismatch for the facial nerve. This is corrected. The stump of the facial nerve is cut on a bias or bevel, and the epineurium is stripped back. **D**, Now the endoneurial surface match is adequate.

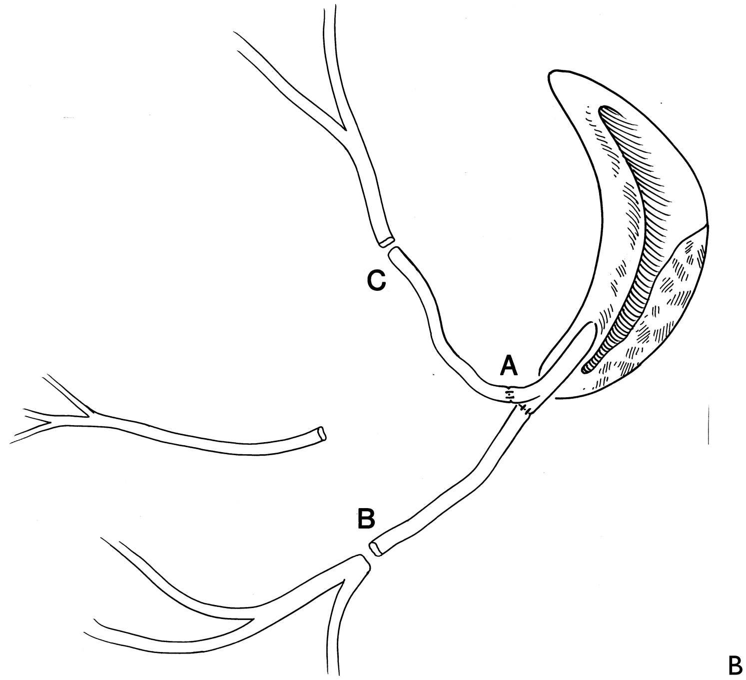
then extend to connect the main trunk to the cut ends of the peripheral branches with one to the upper division and the other to the lower division. On occasion, the two grafts are larger than the distal end of the main trunk of the facial nerve. In that case, at the distal stump of the facial nerve trunk, the available endoneurial surface is enlarged by peeling back the epineurium and cutting the exposed distal end of the facial nerve on a bias or bevel, thus increasing the endoneurial surface (Fig. 2–25D). This technique (Figs. 2–25 and 2–26) has produced reliable and reproducible excellent results (Fig. 2–27).

Another place where neural matching is important involves cranial nerve substitution as with the twelfth nerve. If the twelfth nerve is hooked to the facial nerve within 30 days after injury there is an excellent neural match (see Chapter 3). This match of the endoneurial surface explains why the anticipated results with a XII-VII hook-up is so much better than a VII-VII crossover. The number of axon fibers borrowed from some selected peripheral nerve branches on the normal side in a VII-VII crossover cannot compare with the population of axons provided by the twelfth cranial nerve (see Chapter 5).

Nerve Graft

A nerve graft is a specialized conduit with tubes containing schwann cells. They are used to connect a defect or gap between the proximal and distal ends of a disrupted facial nerve. The nerve graft must be long enough to bridge a gap without tension, and it must match the proximal and distal endoneurial surfaces to allow maximum opportunity for proximal axons to sprout down this conduit and reach the distal system. **Because length and axon volume are the most critical features of a nerve graft, it is these features that help the clinician choose the proper graft for the proper situation.**





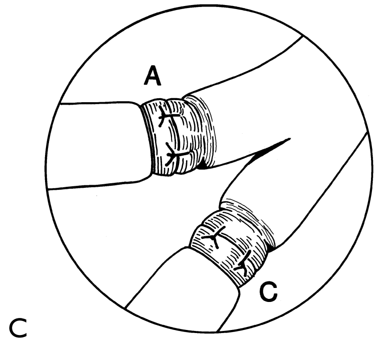


Figure 2–26. Double cable graft technique. The lesion has been resected, and the defect between the vertical segment of the facial nerve within the temporal bone will be connected to the upper and lower divisions of the peripheral portion of the facial nerve using a double cable graft taken from the sural nerve. **A**, Approximately 24 cms of graft is obtained. The graft may have two separate portions, or the nerve can be divided into two 12 cm segments. The orientation of the graft does not seem to alter the outcome. The major consideration is matching the endoneurial surface of the donor nerve to the recipient nerve. The largest endoneurial surface with the greatest axon density (usually the proximal end of the donor nerve) should be used to approximate to the distal end of the central stump of the facial nerve. The endoneurial surface and axon content are more compact in the proximal end of the graft than in the distal end where the fascicles are separated by an increase in connective tissue (Fig. 2–24). **B**, The graft is placed with the proximal end of the sural nerve (A) to the proximal end of the facial nerve and brought to the upper division of the distal end of the facial nerve. Once it is determined that there is adequate length to the graft, the nerve is divided at C and then the length that remains (C-B) is interpositioned between the end of the facial nerve in the temporal bone to the lower division of the facial nerve in the face. **C**, Once again the proximal end of the graft (C) is placed to the stump of the facial nerve in the temporal bone. The distal end of the graft (B) is attached to the lower division. The distal ends are sutured, while the facial nerve in the temporal bone is secured with a layer of Surgicel over the anastomosis. Sutures are not necessary to hold the approximated surfaces of the donor and recipient in this location since there is no tension and the graft bed (the temporal bone) is stable. The blood products normally present in the operative site weld the nerve endings together.

Many donor nerves are available for nerve repair (Table 2–2), but the great auricular and sural nerves are ideal to repair the facial nerve in terms of their availability, axon content, and length, and are most commonly used. Once the grafts are taken, they are prepared by trimming back the epineurium from the proximal and distal ends in order to expose the endoneurial surface. The length of the nerve graft obtained must be of sufficient length even after this trimming in order to bridge the gap without any tension. Therefore, the length of the graft should be at least 1 or 2 cm longer than the gap it is to bridge. The incisions required to obtain the great auricular or sural graft can be accomplished without creating unsightly scars. The area of numbness created by removing these nerves leave an acceptable sensory deficit.

Great Auricular Nerve Graft

The great auricular nerve, the largest of the ascending branches of the superficial cervical plexus (C-2 and C-3), is found by drawing a line between the angle of the jaw and the mastoid tip (Fig. 2–28). This line is bisected at right angles by the great auricular nerve as it passes from behind the posterior border of the sternocleidomastoid muscle and runs just behind the external jugular vein, at a point half way between the mastoid tip and the clavicle in an oblique course toward the parotid gland. In an adult patient, approximately 7 to 10 cm of nerve can be dissected free and used as a nerve graft. Additional length can be obtained by dissecting the proximal end of the nerve behind the posterior border of the sternocleidomastoid muscle and by dis-

A–C

Figure 2–27. Results of double cable graft. **A**, Facial paralysis present 1 year after incomplete resection of low-grade myxomatous carcinoma of the parotid. Double cable graft from sural nerve was placed. Return of function began at 4 months. **B**, Three and a half years after nerve repair, closing eyes without mouth movement. **C**, Smiling without eye closing. The excellent result seems to break the rule of the time window since the repair was performed a year after onset of paralysis. There are two factors that played an important role in this case. First, we have observed that children have stronger regenerative potential than adults. This is based on clinical observations and is supported by the fact that there is a natural attrition of nerve fiber population with age. Another possible explanation is the genetic memory for appropriate regeneration that plays a crucial role in gestation is carried over after birth to some extent and then is lost with aging. In this case, the nerve was not completely divided, but probably injured during the initial removal of the tumor. The surgeon was confident that the nerve was actually in continuity at the completion of the resection. Most likely there was incomplete degeneration with some sparing of fibers and evidence of regeneration because at the time of the second procedure there was response to direct electrical stimulation of the peripheral branches of the facial nerve. This was in spite of the fact that the patient could not demonstrate any voluntary movement prior to the second procedure. Of the two factors, age and incomplete injury, it is felt that the latter was the most important in contributing to the excellent result in spite of the fact that the nerve repair was performed outside the ideal time window. (From May M.[36] With permission.)

Table 2–2 Donor Nerves Available for Facial Nerve Repair

Nerve	Length	Donor Site	Numbness
1. *Great auricular (C 2,3)	7-10 cm	Upper neck	Ear lobe
2. Supraclavicular[33] (C 3,4)	10-15 cm	Lower neck	Lower neck
3. Medial cutaneous[34]	10-15 cm	Upper arm	Upper forearm
4. Lateral cutaneous	15-20 cm	Thigh	Lateral thigh
5. Saphenous leg	25-40 cm	Medial knee	Medial lower
6. *Sural cutaneous	Up to 40 cm	Lateral ankle	Lateral foot

*Most common donor nerves used for facial nerve repair.

secting the distal aspect into the subcutaneous area over the parotid. Often, after dissecting the great auricular nerve to its origin behind the sternocleidomastoid muscle, other branches can be freed up with it and used as a group with its common origin at its proximal stump. A maximum number of available axon tubes can be provided for the ingrowth of axon sprouts by connecting the proximal end of the great auricular nerve to the proximal end of the facial nerve. Usually, this graft is of sufficient length and appropriate diameter for most nerve grafting procedures for facial nerve repair and is conveniently located in the general region where it might be needed.

However, there are sequelae associated with removing the great auricular nerve. Patients should be advised of numbness of the ear lobe because this almost always follows sacrifice of this nerve. An uncommon sequelae is

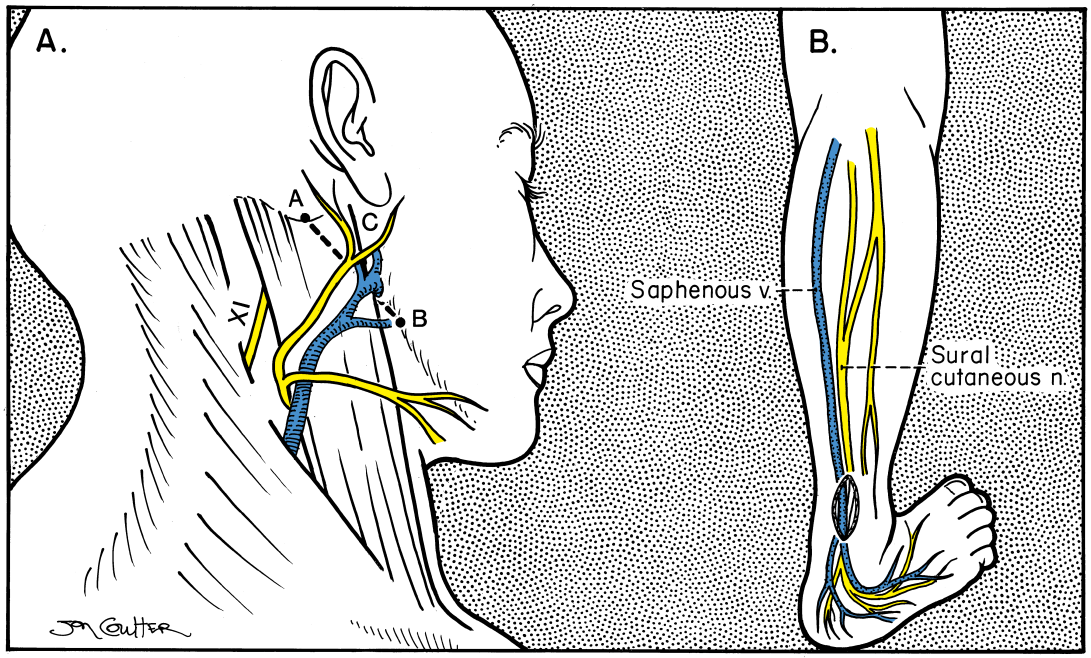


Figure 2–28. Donor nerves for grafting facial nerve. **A**, A cervical plexus graft from the ipsilateral side of the neck is preferred (the contralateral nerve is used in case of cancer if nodes are involved, or the cancer is near the tail of the parotid). Usually a 7- to 10-cm graft can be obtained with a main trunk and four or five branches. Landmarks for finding the great auricular nerve to be used as a graft. A line is drawn between (A) the angle of the jaw and (B) the mastoid tip. That line is bisected at right angles by the great auricular nerve (C) as it passes from behind the posterior border of the sternocleidomastoid at a point halfway between the mastoid tip and the clavicle and courses obliquely towards the parotid gland. Just anterior to the great auricular nerve and running parallel to it is the external jugular vein. Just posterior the great auricular nerve, emerging from the posterior border of the sternocleidomastoid muscle, is the eleventh cranial nerve. Care must be taken not to injure this nerve when removing the great auricular nerve. A 7- to 10-cm length of great auricular nerve can be dissected free and used as a nerve graft. **B**, For cross-face nerve grafting, a sural nerve graft from 30 to 40 cm in length is obtained.

injury to the eleventh cranial nerve. Dissection of the proximal end of the great auricular nerve places the eleventh nerve in jeopardy, and the surgeon must take care not to injure this nerve because injury can cause shoulder drop. The eleventh cranial nerve courses on the undersurface of the sternocleidomastoid muscle in a direction parallel to the great auricular nerve. The eleventh cranial nerve is one finger's width above the point where the great auricular nerve passes behind the posterior border of the sternocleidomastoid muscle (Fig. 2–28A). In the event of the eleventh cranial nerve is inadvertently divided, it should be repaired primarily. The same principles described for facial nerve repair hold for the eleventh cranial nerve as well as for other motor cranial nerves.

Sural Nerve Graft

The sural nerve has some advantages over the great auricular nerve: (1) greater length can be obtained (up to 40 cm) and (2) the sural nerve has a greater number of neural fascicles. The sural nerve can be located between the lateral malleolus and achilles tendon and deep, or just posterior to the saphenous vein (Fig. 2–28B). The sural nerve leaves the tibial nerve in the popliteal fossa and descends between the two heads of the gastrocnemius, and pierces the deep fascia in the middle or upper part of the back of the leg. At this point, it is joined by the sural communicating branch of the common peroneal nerve (Fig. 2–29).

Harvesting the sural nerve requires either one long incision from ankle to popliteal fossa or multiple transverse incisions to achieve maximum nerve length. Transverse incisions decrease postoperative pain on ambulation and avoid an unsightly scar that follows the long incision. A number of techniques have been described to obtain the graft through one long vertical incision or with one or two stepladderlike incisions using some type of a stripper.[13–15] We prefer to use a fascia stripper to harvest the sural nerve through an incision just posterior to the lateral malleolus (Fig. 2–30). The stripper is inserted up the back of the leg to the area where the sural nerve is joined by the communicating branch. At this point or where the sural nerve pierces the fascia, the stripper "hangs up" and does not make easy progress (Fig. 2–29). At that juncture, an incision is made over the stripper, and the common sural nerve is identified. The communicating branch is located and divided, allowing the stripper to enter the defect in the fascia (Fig. 2–30). The stripper can then be passed superiorly between the heads of the gastrocnemius toward the popliteal fossa. Just before reaching the popliteal fossa, tension is placed on the nerve as the stripper is pushed for-

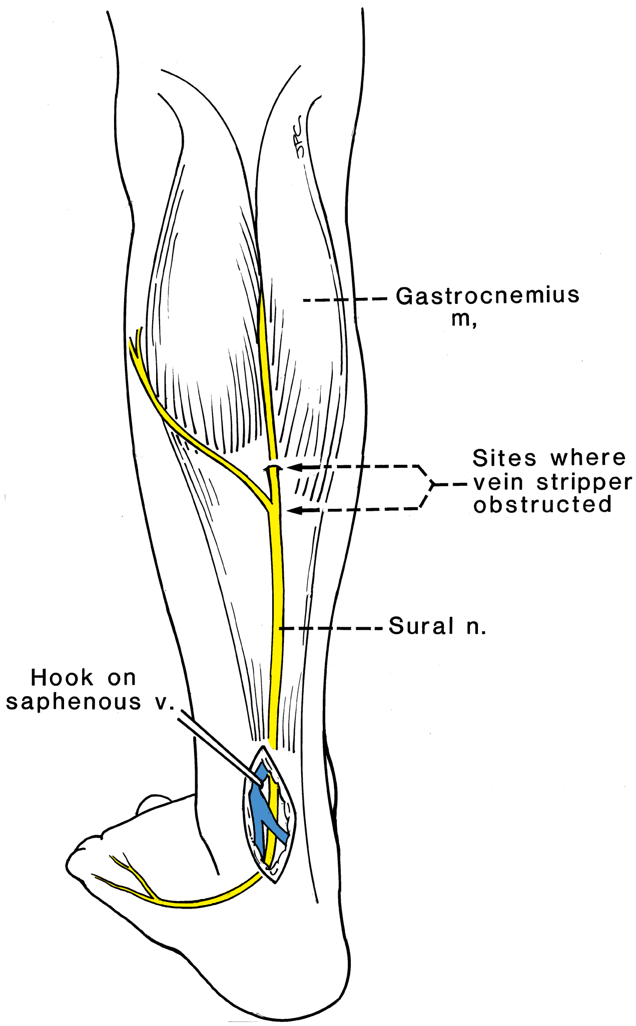


Figure 2–29. Surgical anatomy of the sural cutaneous nerve. Note the anastomosis between the communicating branch of the common perineal nerve to the sural nerve. The communicating branch joins the sural nerve just before the sural nerve penetrates through the fascia between the two heads of the gastrocnemius. These anatomical findings are important in harvesting the sural nerve.

ward. This action divides the nerve, and the intact common sural cutaneous nerve is withdrawn (Fig. 2–30). Coert and Dellon[16] caution against using a vein stripper technique because in about 80% of the cadavers they studied, the communicating branch was the main contributor to the graft; therefore, they suggested the long incision as the preferred approach in order to determine the exact site of the union between the communicating branch and the sural nerve. In spite of this admonition, we have been able to get adequate length (up to 40 cm) and demonstrate histologically that there has been no damage noted when studying the samples of the proximal and distal ends of the graft (Fig. 2–31) as well as confirming the viability of the graft by the functional clinical results obtained (Fig. 2–27).

Sequelae have been noted with the sural nerve graft. A common and unavoidable problem is numbness of the lateral aspect of the foot. Another is irritation of the incision site from the shoe top. This can be avoided if the inferior aspect of the incision is not extended beyond the top of the lateral malleolus. An infrequent problem is postoperative infection and wound dehiscence. A meticulous layered closure reinforced with a running subcuticular 4-0 monofilament permanent pull-out suture is left in place for 14 days. A rubber-band drain removed on the second postoperative day and perioperative antibiotics tends to discourage infection. Incisions in the lower extremity remain unsightly for 6 months to a year until the redness begins to fade.

Surgical Repair of the Extracranial Facial Nerve

Total or segmental facial nerve paralysis is most often seen following extracranial trauma. Such trauma may be accidental, may occur as an unintended complication of surgery, or may result from an operation to resect a life-threatening tumor. The importance of early repair of injuries to the facial nerve trunk as well as the need to repair peripheral nerve branch injuries has been stressed. The principles governing the management of segmental peripheral facial nerve injuries is the same as for management of proximal (truncal) injury. These principles include accurate and early recognition of the injury, determination of the extent of injury, and evaluation for the necessity and timing of repair.

Regional deficits, such as brow ptosis, midfacial weakness, or lower lip palsy, that result from injury to a branch of the facial nerve may be disfiguring and disturbing to many patients (Figs. 2–32, and 2–33). Injury may follow facial lacerations and blunt trauma during face-lift or parotid and submandibular gland, temporomandibular joint, mandible, and skull base surgery through a frontotemporal approach. Knowledge of the anatomy and course of the facial nerve in the different regions of the face will help to prevent and manage such injuries. Figures 2–34 and 2–35 illustrate the anatomical position of the facial nerve at points in the face where injury is likely to occur.[17–21]

Injuries over the cheek region usually require a parotid approach for complete identification of proximal and distal branches of the facial nerve. In complex injuries, the nerve may be disrupted at more than one point in its course. More distal injuries occurring at or above the lateral orbital rim or lip-cheek crease may require microdissection techniques for accurate identification and nerve repair. In the past, such injuries occurring just proximal to the nerve's entry into the muscle were left to recover spontaneously; however, even in these cases, it is possible to find disrupted nerve branches that can be repaired. In such cases, recovery of facial function is more likely following repair than when left to chance[22] (Fig. 2–36).

When a total or regional nerve deficit is recognized postoperatively, the surgeon must decide whether there is reasonable likelihood that the nerve has been transected. If transection is likely, exploration and repair of the nerve

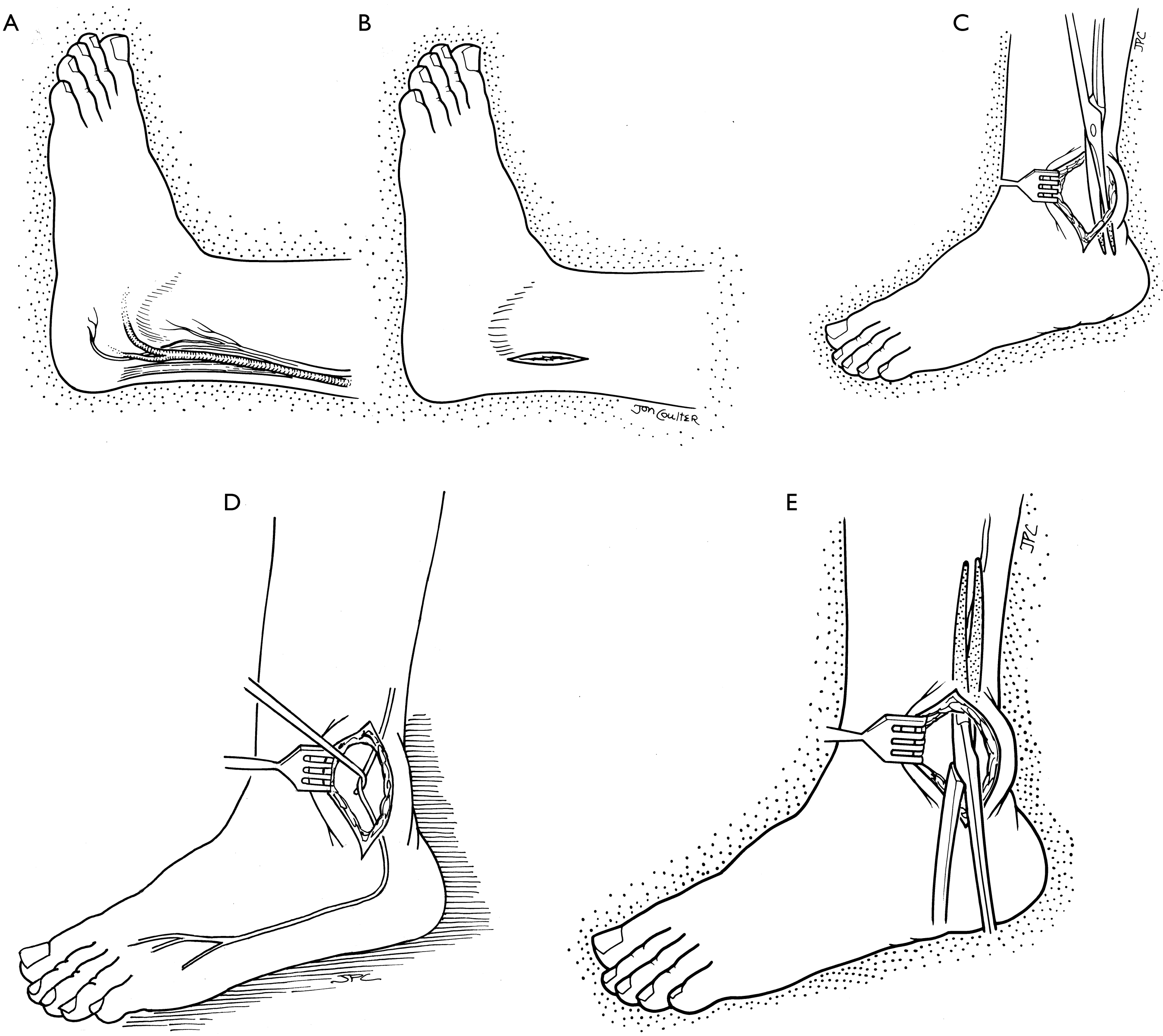


Figure 2–30. Harvesting the sural nerve. **A**, The sural nerve is identified between the achilles tendon and the lateral malleolus. **B**, An incision is made behind and above the lateral malleolus. **C**, The nerve is freed up distally. **D**, A nerve hook places the nerve on stretch, and it is cut with a serrated scissors. **E**, The nerve is dissected superiorly with a blunt scissors separating the nerve from the surrounding connective tissue.

should be undertaken as soon as possible. When the surgeon is confident that transection has not occurred and that traction-induced neuropraxia is the cause of paresis, electrical tests of nerve function can be of value. The situation is similar for blunt trauma resulting in a segmental facial nerve injury.

If voluntary motor unit action potentials (MUAPs) can be detected by electromyography (EMG) in the first 24 hours postinjury, transection is unlikely, and some spontaneous recovery is probable[17]. This test is particularly useful when there is no response to evoked electromyography (EEMG) because once the EEMG response is lost, this test becomes useless in following the course of recovery. If MUAPs were not present initially but appear on retest between 10 and 21 days after injury, surgical exploration is not indicated unless periodic reevaluation for facial movement shows no return of function for 4 months. At this point, surgical exploration should be undertaken regardless of electrical test results.

EEMG performed distal to the site of suspected injury is most helpful for evaluating peripheral injuries within the first 5 days. Loss of the evoked response to stimulation along the injured segment within the first 5 days indicates severe nerve injury, but not necessarily transection. Only surgical exploration can determine if there is nerve transection. Conversely, as long as the response to EEMG remains

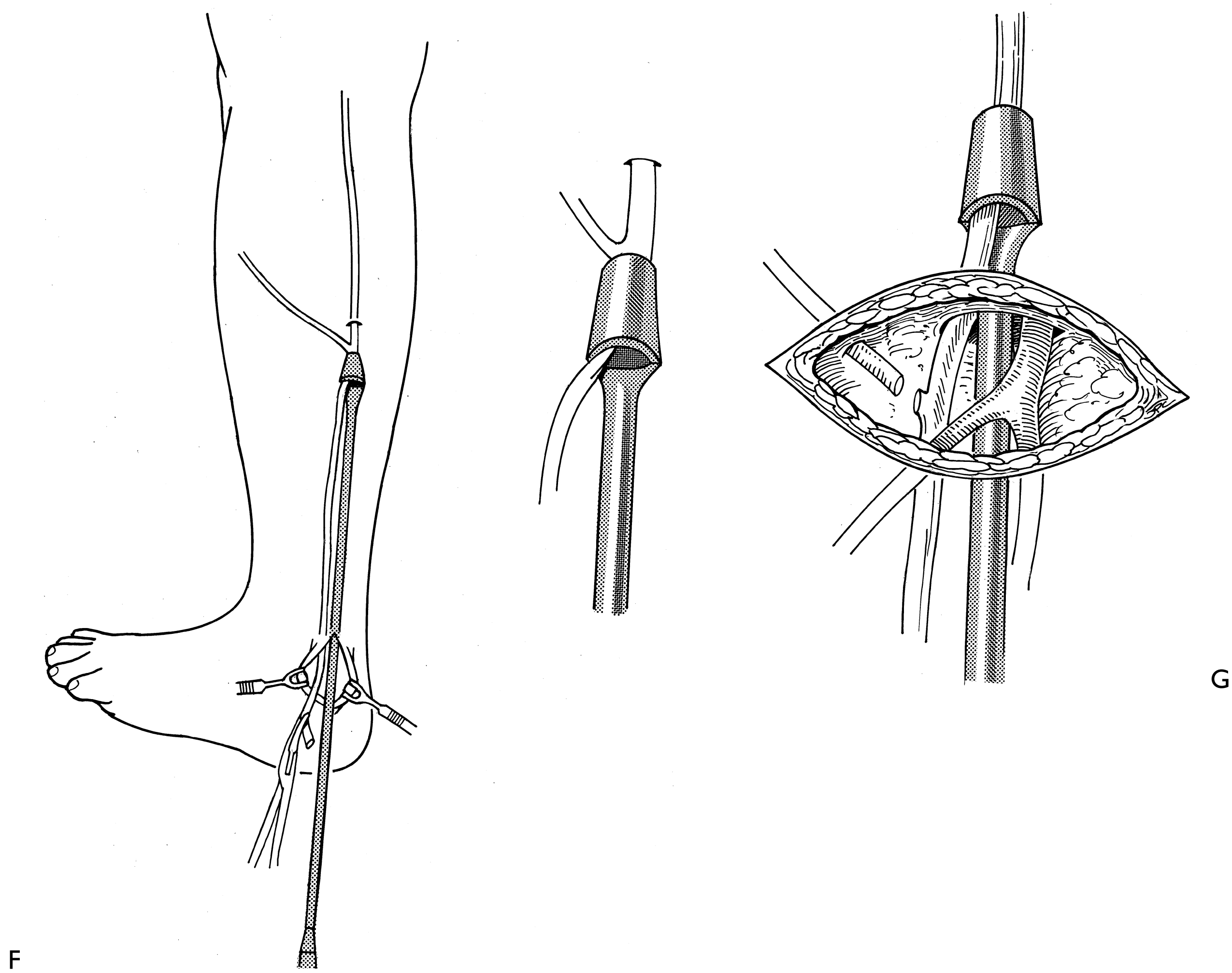


Figure 2–30. *(continued)* **F**, The fascia stripper is then placed in the wound, and the distal end of the nerve is brought through the opening in the stripper. The stripper is then inserted up the leg until it reaches resistance, usually at a place in the vicinity of the defect in the fascia and before the lateral communicating branch joins the sural nerve at that point. **G**, A counter incision is made and the lateral communicating branch is divided. The fascial foramen is enlarged, and the passor is placed deep to the fascia through the opening between the gastrocnemius muscle towards the popliteal fossa where the nerve is put on tension and the stripper is advanced in order to divide the nerve and remove it. Forty centimeters of nerve can be obtained in this way.

in the normal range, the nerve has not been irreversibly injured, and recovery should begin within 4 months.

In some cases, the response to stimulation will be significantly reduced or even disappear during the first 14 to 21 days. This indicates damage to the axons sufficient to block neural transmission. Delayed recovery is likely over several months. There is no evidence that exploration, resection, grafting, or nerve repair is beneficial under these circumstances.

The decision to operate becomes more difficult when patients with facial nerve injuries present after the first and before the fourth month postinjury. This is beyond the ideal time for nerve repair, yet spontaneous recovery may occur at any time. It is our opinion that when there is no visible voluntary movement, no response to EEMG, or no evidence of regeneration by needle EMG, exploration for repair or grafting should be considered when the functional deficit warrants it.

Our recommendation to explore the facial nerve under these circumstances is based on the following facts: (1) spontaneous recovery is unlikely without repair if the nerve has been completely transected, (2) there is no sure way to determine the nerve's status without exploration, and (3) the longer the interval between injury and repair, the worse the results. Beyond 1 year, the results of repairing the peripheral facial nerve have been poor, perhaps due to progression of collagenization that occurs in the nerve segment distal to transection.[23,24] Early repair of the extracranial facial nerve should be associated with low morbidity and can allow more complete recovery of facial function.

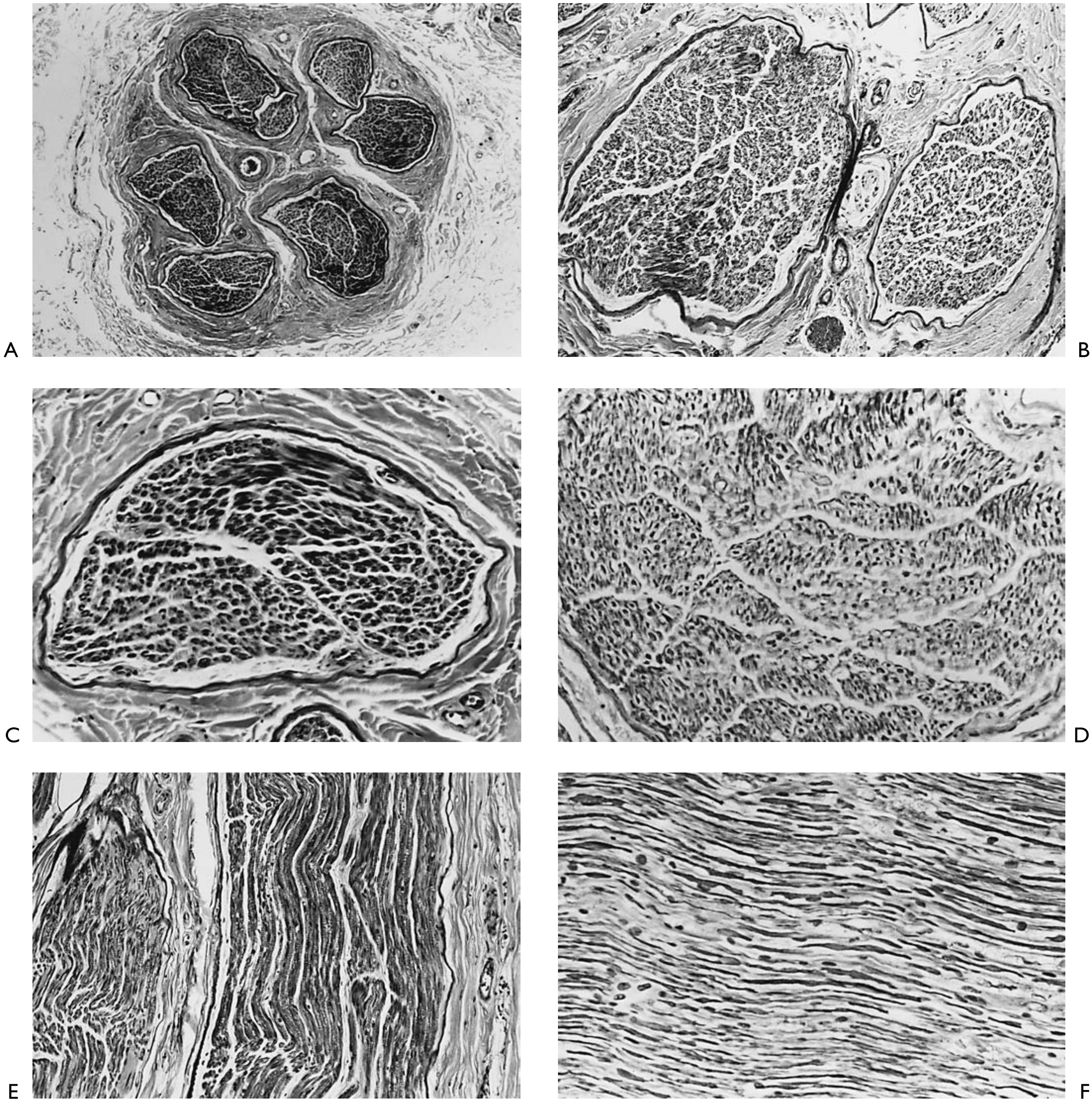
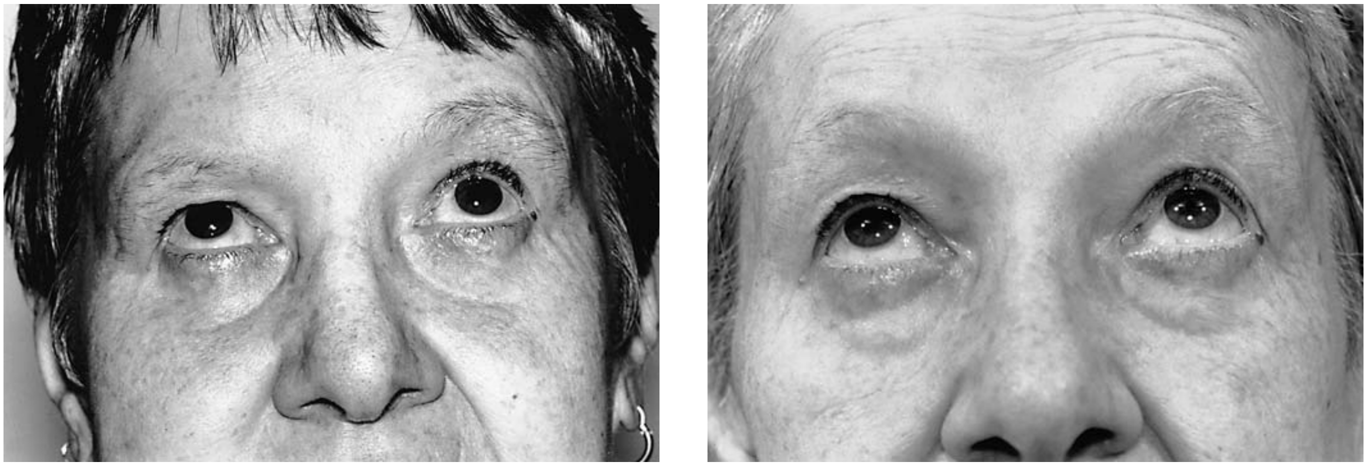


Figure 2–31. The sural nerve taken with stripper was sampled to determine if there was any evidence of histological damage. Samples were taken from the distal end of the sural nerve. **A**, Six large fascicles noted. Trichrome stain, ×8. **B**, Bodian stain for axons. Cross-section, normal nerve. ×40. **C**, Cross-section, normal nerve. Trichrome stain, ×120. **D**, Cross-section, normal nerve. Bodian stain, ×240. **E**, Longitudinal section, normal nerve. Trichrome stain, ×240. **F**, Longitudinal section, normal nerve. Bodian stain, ×500. There was no evidence of damage to the sural nerve in spite of the fact that the stripper was used to harvest the nerve.



A B

Figure 2–32. Upper division injured and repaired during parotid surgery. **A**, After patient was operated on for parotid tumor. Inadvertent transection of the frontalis branch of the facial nerve resulted in brow weakness. **B**, Two years after immediate repair by end-to-end anastomosis, there is good elevation of the eyebrow. (From May M et al.[17] With permission.)

A B C

Figure 2–33. **A**, After inadvertent sectioning of the marginal mandibular nerve during parotid surgery, weakness of the lower lip and platysma is evident. **B**, Two years after immediate repair by end-to-end anastomosis, recovery is complete. **C**, Suture repair of the marginal mandibular nerve at time of parotid surgery. (From May M et al.[17] With permission.)

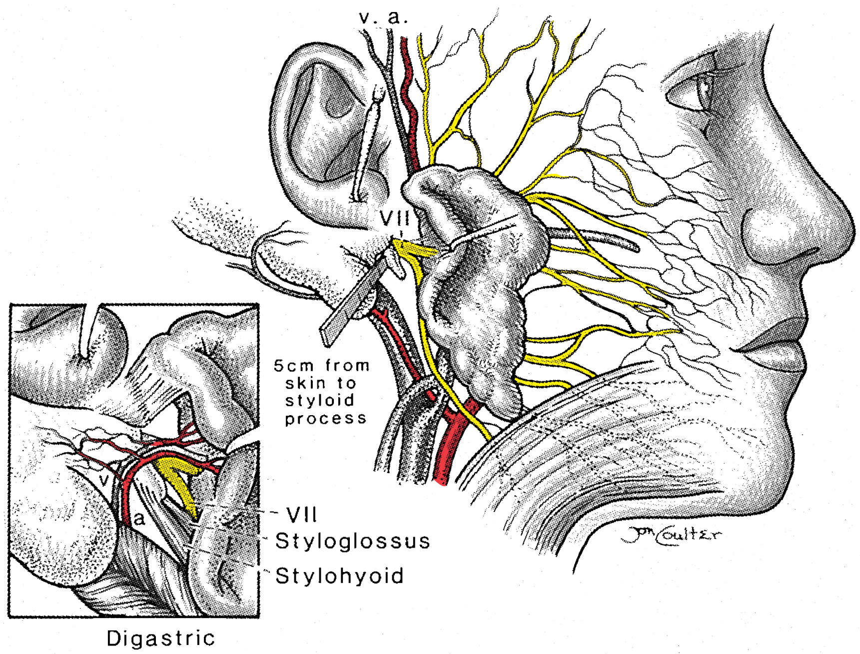


Figure 2–34. Topographical surgical anatomy of the peripheral facial nerve. Landmarks to help identify the facial nerve at the stylomastoid foramen (artery and vein coursing across the nerve), upper division (superficial temporal artery and vein courses behind the facial nerve), buccal branch (courses in close proximity to the parotid duct), and lower division (deep to the platysma).

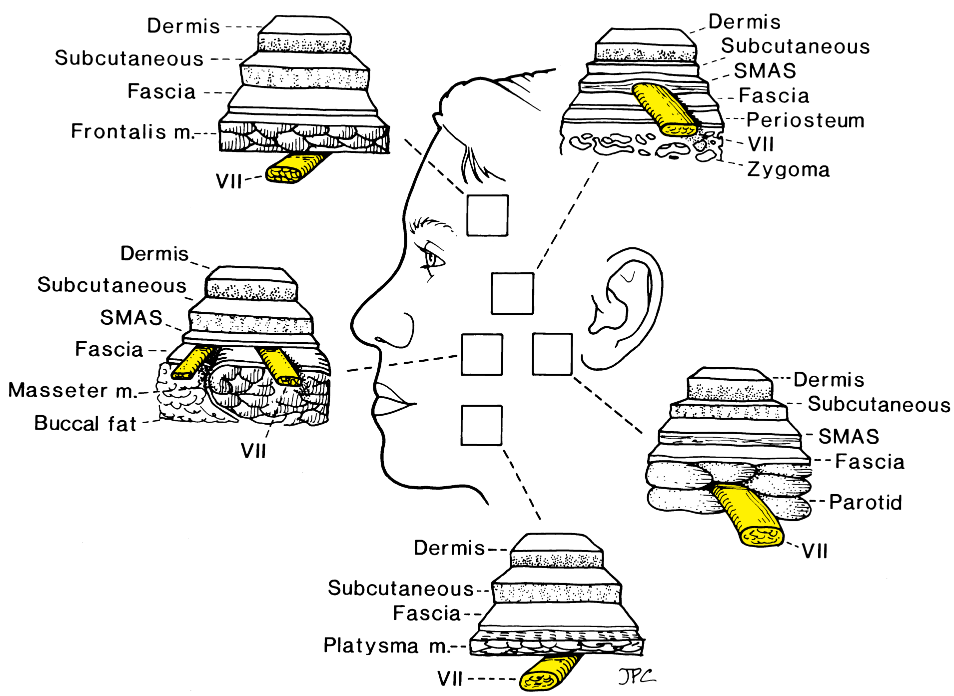


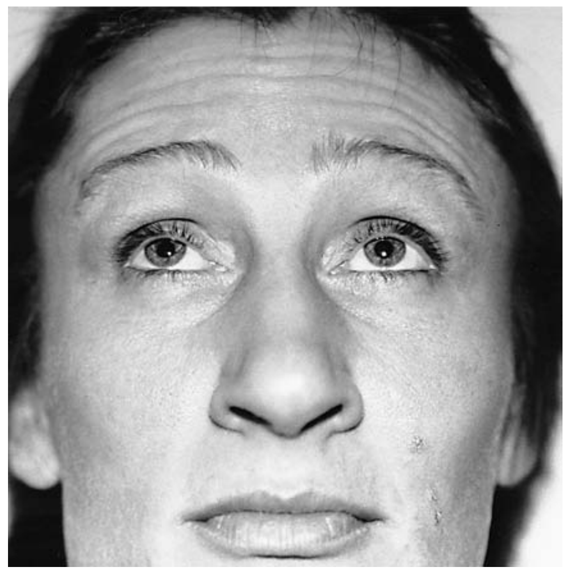
Figure 2–35. Topographical surgical anatomy of the facial nerve showing the relationship of the facial nerve to the deep tissue plains, especially the superficial musculoaponeurotic system.

Surgical Repair of the Intracranial Facial Nerve

The facial nerve may be interrupted intentionally or inadvertently during procedures to remove tumors from the posterior or middle fossa. Such interruption occurs most frequently during removal of large acoustic schwannomas or during resection of facial nerve schwannomas. Although it is possible to preserve the facial nerve in most cases of acoustic schwannomas when microsurgical techniques are used, if the tumor is large, the facial nerve often must be sacrificed in order to remove the tumor mass completely. In addition, in some cases the facial nerve must be sacrificed because the tumor has invaded the nerve directly or because the nerve itself is intimately involved with the tumor.

Until recently, facial paralysis that occurred in association with intracranial surgical procedures was managed by nerve substitution techniques such as hypoglossal-facial or

A B



C

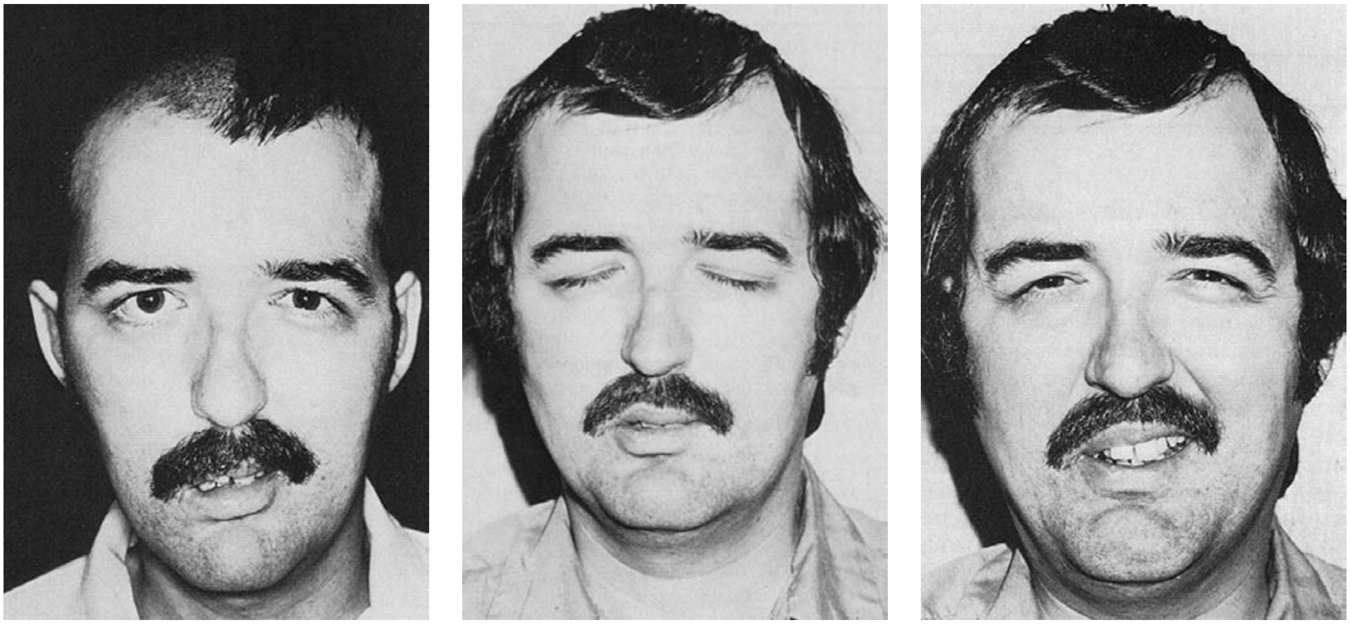
Figure 2–36. **A**, Patient was kicked by a horse and sustained a laceration in the lateral temporal region and paralysis of the forehead and brow. **B**, Note the nerve stimulator being used to identify the most distal aspect of the frontalis branch. Such stimulation can only be performed during the first 3 days following injury, after which time no response can be recorded. **C**, Two years after injury and repair, there is good eyebrow movement. (From May M et al.[17] With permission.)

facial-spinal accessory nerve anastomosis. However, microsurgical techniques have permitted restoration of the continuity of the facial nerve either by direct end-to-end anastomosis or placement of an interposition graft (Fig. 2–38) either intracranially or from intracranially to just beyond the stylomastoid foramen (Figs. 2–39 and 2–40). Such nerve grafting has been done as a primary procedure when possible but has also been performed as a delayed technique for rehabilitation. Excellent results have been achieved when the graft was placed as a delayed procedure, as long as the procedure was performed within 30 days of the initial surgery (Figs. 2–37, 2–38, and 2–40).

The intracranial to extracranial graft technique employed is a modification of a procedure originally described by Dott,[25,26] who was the first to repair the facial nerve successfully after acoustic tumor removal. Dott used an intracranial to extracranial graft that bypassed the temporal bone. Drake[27,28] used this technique to restore function in a patient in whom the facial nerve had been interrupted during removal of an acoustic tumor. Drake[29] was the first to report an intracranial anastomosis of the seventh cranial nerve following acoustic tumor surgery.

Once the seventh nerve has been interrupted in the course of management of lesions in the cerebellopontine angle, intracranial repair can be carried out if the proximal nerve stump at the brainstem is clearly identifiable. If the nerve is inadvertently interrupted and there is a long peripheral segment, an end-to-end anastomosis may be carried out. If the two ends cannot be approximated without tension, either an intracranial-to-intracranial or an intracranial-to-extracranial graft can be used to bridge the gap. The intracranial-extracranial technique is used when the distal end of the facial nerve is within the internal auditory canal, as occurs with removal of an acoustic tumor through the posterior fossa approach. This technique allows bypassing of the temporal bone segment altogether (Fig. 2–39).

These principles have been applied to the management of 10 patients in whom the facial nerve was interrupted in the course of removing large posterior fossa tumors and in patients in whom the defect was too great



A–C

Figure 2–37. Results of end-to-end repair through middle fossa approach. **A**, One week following transmastoid middle fossa resection of a congenital cholesteatoma. Facial nerve was divided and repaired end-to-end. **B**, Two and a half years postoperatively. Recovery began 8 months following surgery. Eyes closed lightly with minimal mouth movement. **C**, Controlled smile without eye closure. (From May M.[36] With permission.)

A–C

Figure 2–38. Results of placing an interposition graft between posterior fossa and tympanic segments of facial nerve. **A**, Three days following translabyrinthine excision of an acoustic schwannoma. Facial nerve was transected at the porus acusticus. A 3-cm interposition graft was sutured between the proximal and distal segments. Recovery began 6 months after surgery. Two years postoperatively, patient closing eyes tightly **(B)** and smiling **(C)**. (From May M.[36] With permission.)

for primary end-to-end anastomosis of the nerve. In 3 of the 10 patients, a secondary procedure was performed within 30 days of the initial operation to re-explore the posterior fossa, identify the central stump of the seventh cranial nerve, and place a sural nerve graft.

The length of the graft and the number of fascicles provided by the graft are the two most important considerations in choosing between the great auricular and the sural cutaneous nerves for such purposes. While the great auricular nerve usually has an adequate number of fascicles to be used as a graft, the sural nerve always has an ample number of fascicles, matching the cross-section of the facial nerve very well (Fig. 2–31). The great auricular nerve may be used to bridge defects up to 7 cm in length and is adequate for placing an interposition graft intracranially. Because 12 cm or more is required for a brainstem-

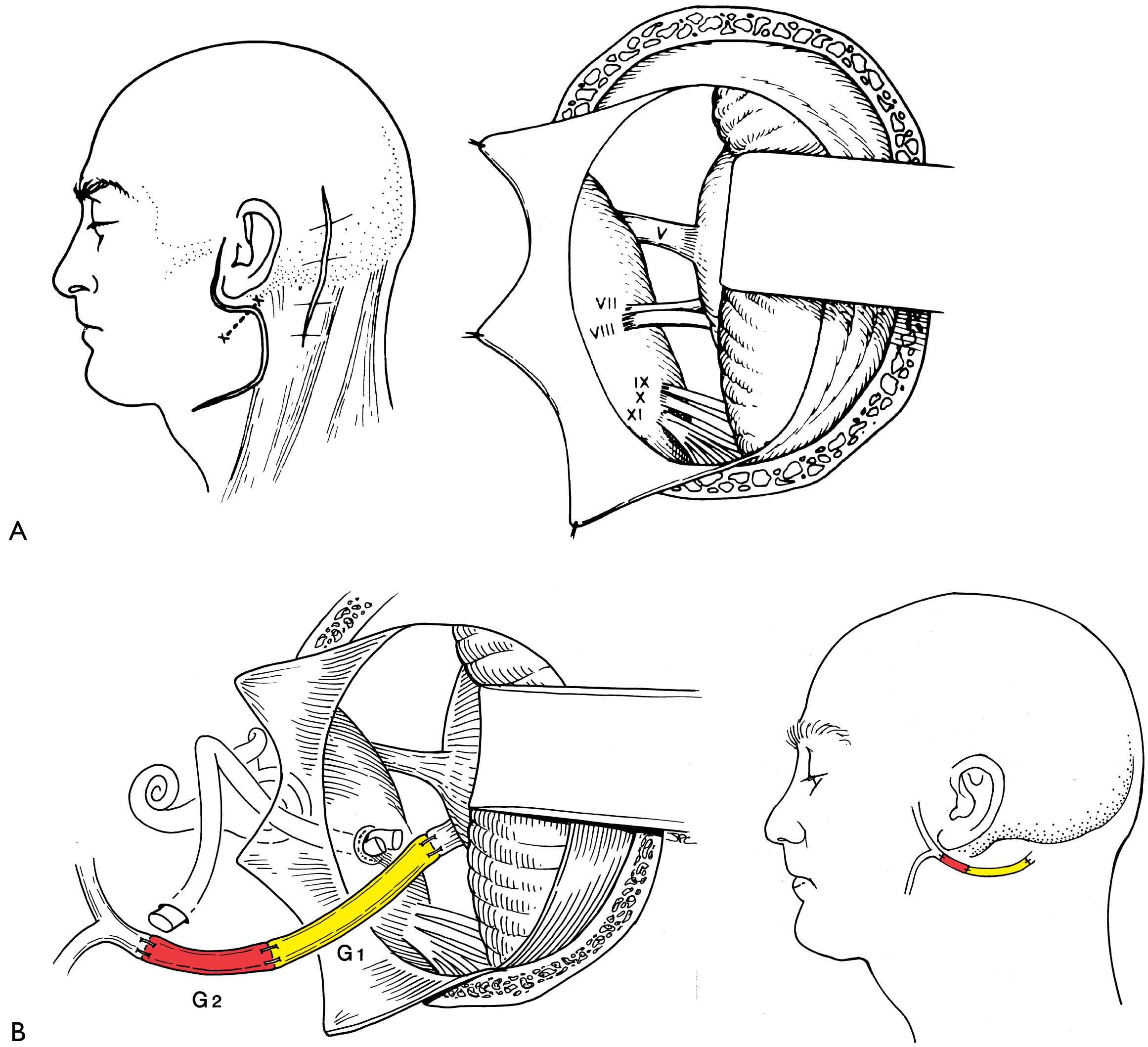
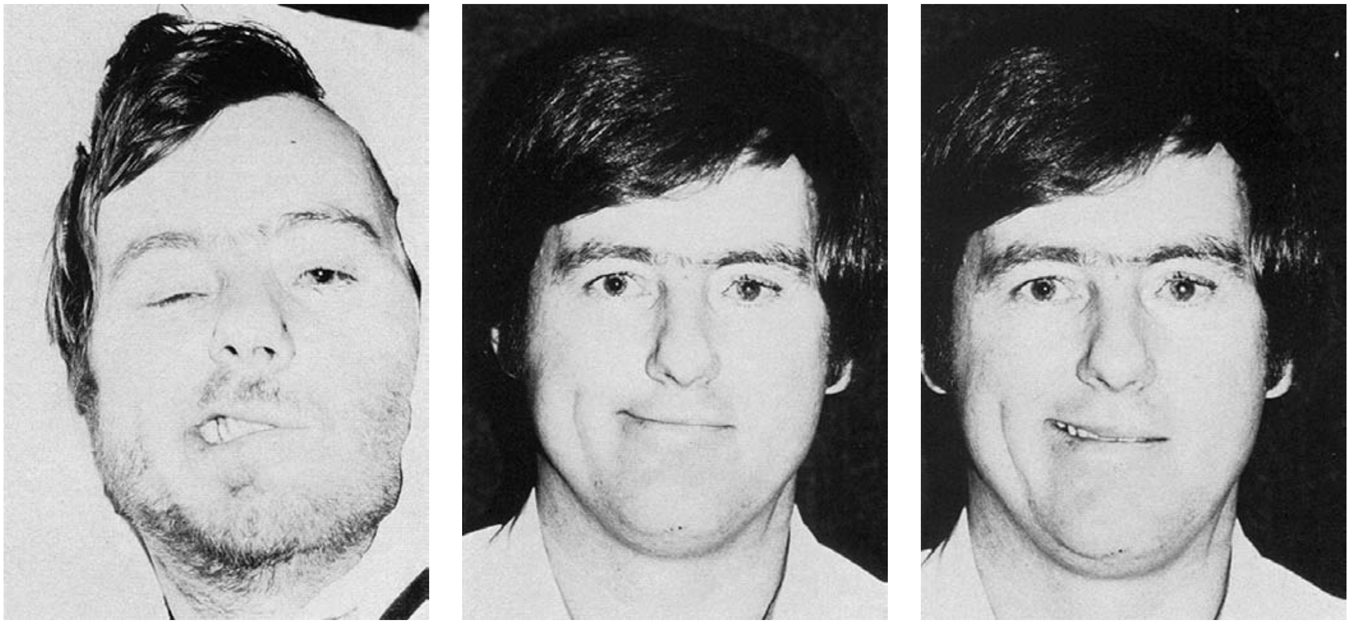


Figure 2–39. Technique used for intracranial-extracranial facial nerve repair with great auricular nerve and sural nerve as donor graft (patient illustrated in Fig. 2–40). **A**, Incision to approach the posterior fossa. The S-shaped incision starts in front of the ear and extends down into the neck to expose the main trunk of the facial nerve as it exits the stylomastoid foramen. The dotted line connecting the two Xs (from the mastoid tip to the angle of the jaw) helps to locate the great auricular nerve which runs perpendicular to and bisects this line. In the lower portion of this figure, the cranial nerves are seen coursing from the brainstem toward the temporal bone as viewed through the posterior fossa approach. **B**, Placement of graft from the brainstem to the extracranial segment of the facial nerve bypassing the facial nerve portion that courses through the temporal bone. G1, Great auricular nerve (10 cm) not long enough for intracranial-extracranial connection. G2, Sural nerve graft (4 cm) to provide adequate length. Ideally the sural nerve would be a better choice because 14 cm is required to connect the brainstem stump of the facial nerve to the extracranial main trunk. **C**, The 10-cm great auricular donor graft leaves the posterior fossa through a small opening in the dura and is passed through the splenius capitis muscle. The great auricular nerve is attached to the sural nerve graft, which in turn is attached to the facial nerve, making three anastomotic sites and a total of 14 cm of nerve graft.

extracranial nerve graft, the sural nerve is more suitable for this application (Fig. 2–39).

The proximal intracranial segment of a nerve graft is technically more difficult to suture and is more tenuous than the distal anastomosis because the nerve at the proximal stump has no epineurium. Thus, when a brainstem-extracranial nerve graft is to be placed, once the central stump is identified, the graft is sutured to the central segment first and then to the distal portion. The ends are sutured in the posterior fossa with long, bayonetted instruments and 10-0 Ethilon sutures. For intracranial-extracranial grafting, the interpositioned nerve is brought through the inferior aspect of the posterior fossa and led through a perforation in the dura. The distal component is pushed through a tunnel created under the head of the splenius capitus to a point below the mastoid process. The distal end is sutured to the extracranial main trunk of the facial nerve (Fig. 2–39). The results of this surgery are demonstrated in Figure 2–40.

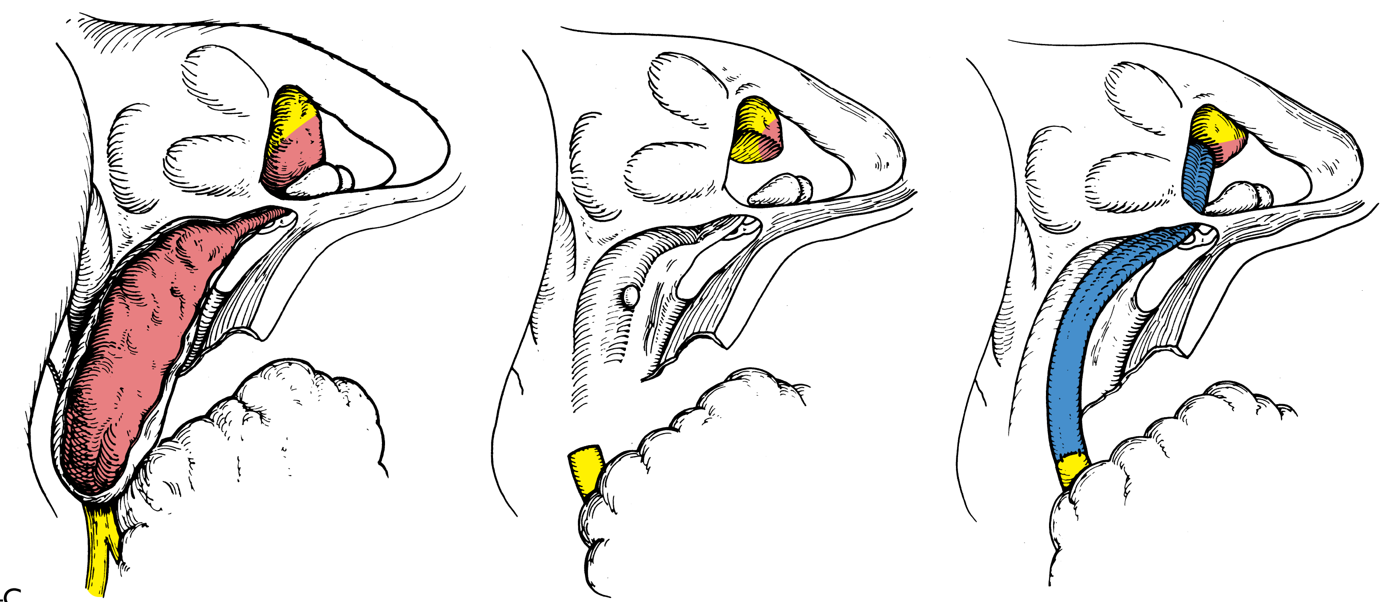
Figures 2–41 through 2–43 show an intracranial interposition graft placed through a middle fossa approach to



A–C

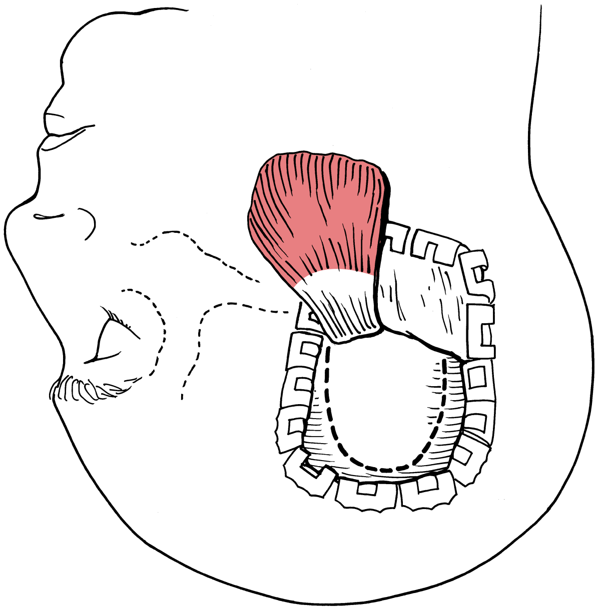
Figure 2–40. **A**, A patient with a total left facial paralysis 1 week following removal of a large posterior fossa tumor. **B**, Voluntary smile 9 months following placement of a 14-cm graft from the brainstem to extracranial facial nerve. **C**, Spontaneous smile. Two cable grafts, total length 14 cm, three anastomotic sites. Excellent results were achieved because the repair was performed within the time window of 30 days. From this case, we learn that results are dependent more on the time of repair postinjury than the length of the graft or the number of anastomotic sites.

reanimate the face of a patient who had undergone resection of a facial schwannoma that had extended from the pes in its extracranial segment to the labyrinthine portion in the middle cranial fossa. Two separate grafts were placed in a two-stage procedure, with surgery being performed at two different times approximately 1 month apart. The first graft was placed from the extracranial segment of the facial nerve to the geniculate ganglion. The second graft was placed through a middle fossa approach used to remove the remainder of the tumor that could not be reached through the mastoid. The second graft was placed from the internal auditory canal segment of the facial nerve to the first graft. Figure 2–43 demonstrates the results.

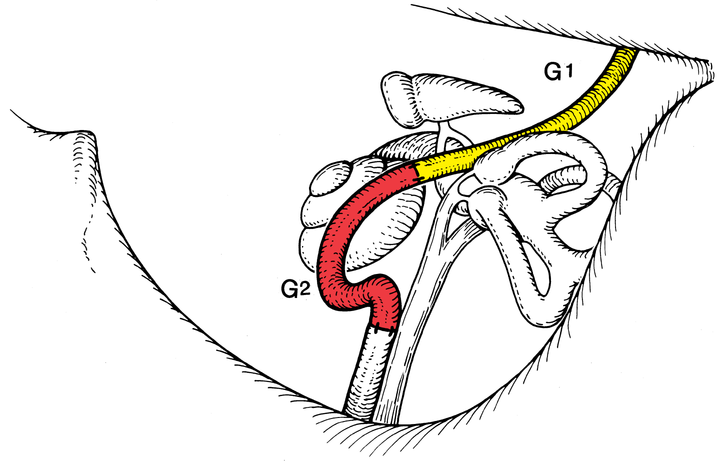


A–C

Figure 2–41. A patient presented with slowly progressive facial palsy, due to a facial nerve schwannoma extending from the extracranial segment of the facial nerve to the labyrinthine portion. **A**, Sausage-like tumor within the temporal bone. **B**, The tumor within the temporal bone was resected through a transmastoid approach; it extended from the extracranial segment just proximal to the pes to the geniculate ganglion. **C**, An interposition graft was placed from the extracranial segment of the facial nerve to the area of the geniculate ganglion.

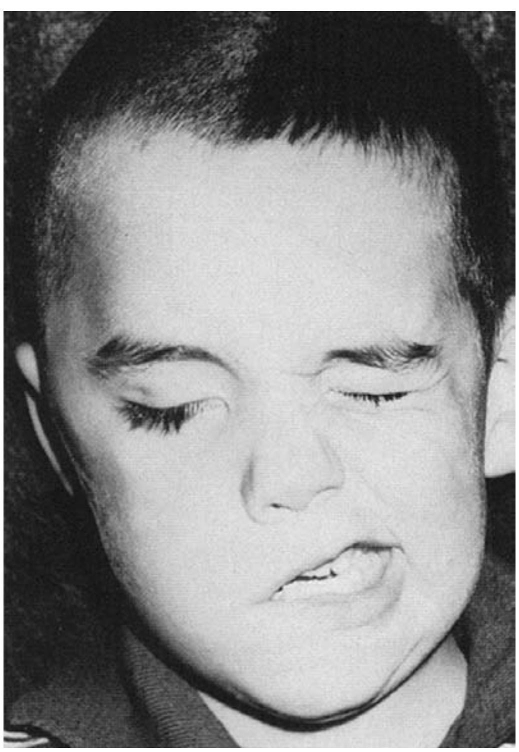


A

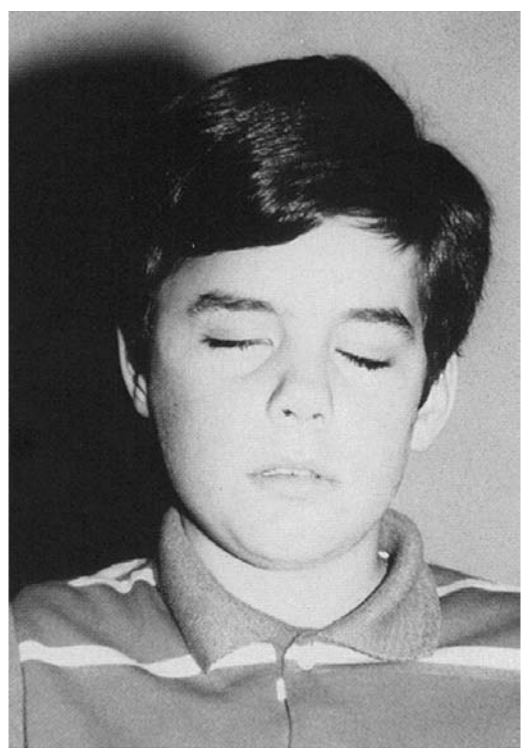


B

Figure 2–42. A, Patient shown in Figure 2–41 was reoperated upon 30 days later after the first procedure to remove the proximal portion of the schwannoma which involved the labyrinthine segment. Patient in the operative position showing the incision made to approach the middle fossa. Muscle was elevated and the bone flap removed. **B**, The facial nerve viewed through the right middle fossa. G1 indicates the first graft and G2 the second graft. The schwannoma that extended to the labyrinthine segment was resected, and a second interposition graft was placed from the internal auditory canal to the previously placed graft which extended to the level of the geniculate ganglion.

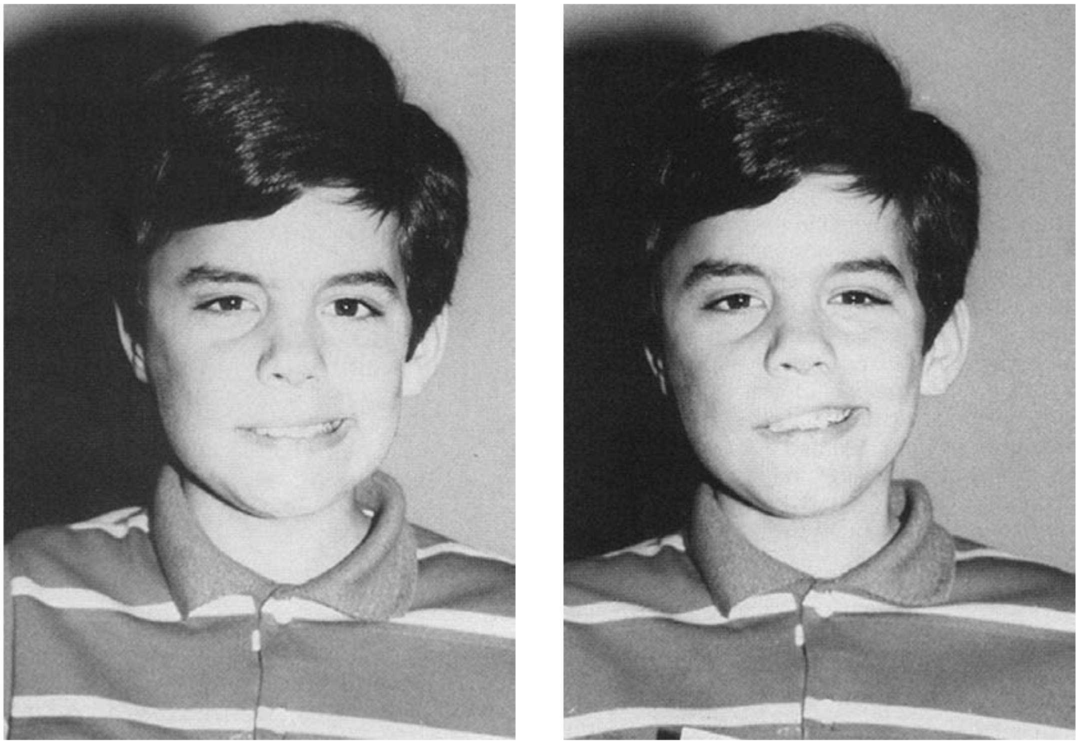


A



B

Figure 2–43. A, Patient with total paralysis following resection of schwannoma from the pes to the geniculate ganglion. **B**, Patient 9 months following placement of a double cable graft from the pes to the internal auditory canal. The graft was placed in two stages, with procedures being performed 1 month apart. Nine months after graft placement, the patient is able to close the eyes without mouth movement. *(Figure continued next page.)*



C D

Figure 2–43. *(continued)* **C**, Voluntary smile with minimal synkinesis in the region of the eye. **D**, Spontaneous smile with less synkinesis. This case demonstrates the best possible result that can be achieved for nerve repair in spite of the fact that there were two grafts, three anastomotic sites, and delay between one procedure and another. The experience in this case supports our observation noted in patient depicted in Figure 2–40. The time window between injury and repair is more important than the location of the injury, the length of the graft, the number of anastomotic sites, or even a delay between procedures. Reproducible and reliable, excellent results have been achieved consistently, providing nerve repair has been performed within the time window of 30 days, and the repair has been achieved without tension and by matching endoneurial surfaces of the connected ends.

Our limited experience as well as reports of others[30–32] has shown that the results achieved with intracranial nerve grafting performed immediately or within 30 days of injury are superior to the results achieved with nerve substitution techniques such as facial-hypoglossal nerve anastomosis. Facial symmetry at rest and spontaneous and voluntary facial movement (although weaker than the normal side) have been restored by grafting with a minimal amount of synkinesis and mass movement (Figs. 2–37, 2–38, 2–40, and 2–43). Luxford and Brackmann[32] reported their experience with intracranial facial nerve repair in 23 patients following cerebellopontine angle tumor surgery. Acceptable function was achieved in approximately half of their patients. They were able to identify some of the factors that may lead to a poorer recovery. These included: (1) the proximity of the nerve injury to the brainstem, (2) tumors involving the facial nerve as with neurofibromatosis Type II, (3) revision cases where the nerve may have been manipulated by a previous procedure, and (4) when the facial nerve was markedly displaced by the tumor. Because facial nerve re-anastomosis can provide superior reanimation compared to alternative techniques, they recommended facial nerve repair at the time of primary surgery. However, if facial motion has not returned within 1 year, alternative reanimation techniques, such as the facial-hypoglossal anastomosis should be considered.

The undertaking of primary repair or interposition grafting of the facial nerve instead of nerve substitution is the result of a cooperative effort between neurosurgeon and otolaryngologist. Because tumors involving the facial nerve often extend from the extracranial segment through the temporal bone into the middle or posterior fossa, such cooperation is natural, especially as refinements in technique have enabled otologists and neurosurgeons working together to undertake more complex procedures in which the function of the cranial nerves may be spared or restored.

Summary

Reproducible excellent results following facial nerve repair or grafting can be expected providing: (1) the repair is performed within 30 days of injury, (2) there is no tension at the anastomotic site, (3) there is a good match between the endoneurial surfaces at the anastomotic sites, (4) all tumor and remnants of reactive scar tissue are removed from the proximal and distal ends of the nerve to be repaired, and (5) there is strict adherence to surgical principles of nerve repair.

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3

Nerve Substitution Techniques: XII-VII Hook-Up, XII-VII Jump Graft, and Cross-Face Graft

Mark May, M.D.

There are a number of approaches that qualify as cranial nerve substitution procedures. These include XII-VII crossover, XII-VII jump graft, VII-VII cross-face graft, and XI-VII crossover. Ideally these procedures should be performed when the proximal segment of the facial nerve is not available and within 30 days to 1 year after injury. Although mimetic movement is not possible with these procedures, the majority of patients demonstrate voluntary facial movement with tone and symmetry at rest. Of all the procedures, the "gold standard" is the XII-VII crossover because it gives the most reliable consistent results. For this reason, the XII-VII crossover will be presented with greater detail than the other cranial nerve substitution techniques. However, the general concepts regarding the XII-VII crossover, for the most part, are relevant to the other procedures.

Hypoglossal Facial Anastomosis

History

Approximately 120 years ago, Drobnik[1] (1879) attempted the first cranial nerve substitution procedure, an accessory-facial-end-to-end neurorrhaphy to rehabilitate a patient with an otogenic facial paralysis. In 1895, some 16 years later, Ballance attempted an end-to-side without success. For the next 30 years, there were several isolated reports of attempts to reanimate the paralyzed face using nerve crossover procedures, using predominantly the accessory, glossopharyngeal, and hypoglossal nerves, with only limited success; indeed, the majority of the world was focusing on the accessory nerve as the nerve of choice. In 1932, Ballance and Duel[2] summarized the experience with accessory-facial anastomosis stating that the technique invariably gave rise to mass-associated movements of the shoulder and face and that dissociated movements were distinctly unusual and required considerable re-education of motor control. Moreover, they recognized the problems of the functional deficit created by accessory nerve sacrifice. In 1901, Korte[3] is perhaps the first to be credited with performing a hypoglossal-facial anastomosis on a woman suffering with a facial paralysis secondary to an infectious petrositis. Two years after the operation, Korte reported a favorable outcome of the surgery.

Since Korte's observation, and certainly for the first third of the 20th century, most surgery for facial paralysis centered around some type of nerve anastomosis, regardless of the site of injury or etiology. During the past 50 years, advances in neuroanatomy, physiology, and surgical technology have permitted more scrutiny in selecting the most appropriate method of reanimation, so that the role of nerve crossover procedures such as hypoglossal-facial anastomosis has become more clearly defined.

Hypoglossal-Facial Anastomosis (XII-VII Crossover)

General Concepts

The idea behind a hypoglossal-facial anastomosis is best summarized metaphorically by the adage, "rob Peter to pay Paul." Fundamentally, the hypoglossal nerve is sacrificed in order to transfer its motor "fire power" to the facial nerve. The essence of the procedure is to attempt to improve a devastating neurologic deficit at the expense of an iatrogenically created deficit of lesser consequence. The basic question then becomes: how much improvement for what cost? In order to answer this question, one must have an understanding of the clinical and neurophysiologic aspects of hypoglossal-facial anastomosis. This requires a study of the following issues:

1. What are the indications and contraindications to nerve crossover procedures?
2. What is the anatomical basis and functional relationship between the facial and hypoglossal nerve that has made this technique so popular?
3. What are the advantages and disadvantages of this technique?
4. Can we predict which patient will be afforded the best results with this technique?
5. Can XII-VII crossover be combined with other techniques of facial reanimation?

In addition to reviewing the operative technique of hypoglossal-facial anastomosis, we will attempt to address these issues so as to place this technique in proper perspective.

Indications, Timing, and Considerations

Hypoglossal-facial anastomosis is most appropriately performed for complete and permanent facial paralysis when the central stump of the facial nerve is unavailable for repair or grafting and when performed up to 2 years after injury. This situation is most commonly seen following cerebellopontine angle tumor surgery in which the nerve is irreversibly injured and not grafted; it also is seen following radical temporal bone, parotid, and skull base surgery for tumors, and following severe temporal bone-brainstem trauma.

The requirements for the successful performance of hypoglossal-facial crossover are an intact extracranial facial nerve, an intact mimetic facial muscles, an intact donor hypoglossal nerve, and a patient who can physiologically and psychologically accept the neurologic deficit created by sacrifice of the twelfth nerve. Contraindications to the procedure occur when these criteria are not met. Patients with developmental facial paralysis lack a sufficient population of extracranial facial nerve fibers and facial muscles capable of accepting reanimation, and thus are not candidates for this procedure. Similarly, patients who have undergone massive resections with sacrifice of the extracranial twelfth nerve, including the muscles of expression, would not be candidates. Patients with tumors that notoriously involve nerves such as neurofibromatosis (Type II) or adenoid cystic carcinoma are at risk for bilateral and multiple cranial nerve involvement. These patients would be poor candidates for nerve substitution procedures because of the risk for multiple cranial nerve deficits. Thus, sacrifice of an intact twelfth nerve may compound future functional deficits. A similar situation may occur in patients with a tenth nerve deficits, in whom the loss of one hypoglossal nerve may create an intolerable and potentially crippling problem with swallowing.

The significance between time of injury and repair is supported by physiologic, experimental, and clinical data. Physiologic evidence of this concept comes from our understanding of distal nerve degeneration following nerve injury. Nerve biopsy may provide some useful information concerning the potential for success of a nerve crossover procedure, although this is not indicated for most patients. Ylikoski et al.[4] studied biopsy specimens of distal facial nerves prior to performing XII-VII anastomosis at time intervals varying from 2 weeks to 2.5 years in five patients. He suggested that success of reanimation correlated with histologic findings in that no recovery of facial function was seen when complete neurofibrosis had occurred in the distal facial nerve prior to anastomosis and varying degrees of functional return were seen in those patients demonstrating Büngner bands (Schwann cell derived tubular structures within a degenerating distal nerve segment that provide guides for regenerating axons). When the time following the injury exceeds 4 years, collagenization and fibrosis of the distal facial nerve is likely too advanced to permit functional axonal regrowth after a nerve crossover procedure. While the state of the facial muscles also plays a role, complete atrophy and myofibrosis likely takes longer to occur than distal neurofibrosis and thus is less of a limiting factor (see Fig. 2–8).

Clinical data lend further support to this concept of timing. Gavron and Clemis,[5] for instance, found in their review of 36 patients that an interval of more than 1 year significantly affected the outcome of hypoglossal-facial anastomosis. In Conley's review of 122 patients following hypoglossal-facial anastomosis, the largest single series reported, the quality of recovery also was time dependent.[6] Based on the results of their study of 29 acoustic neuroma patients, Kunihiro et al.[7] reported hypoglossal-facial nerve anastomosis can be delayed up to 2 years with only minimal effect on the recovery of facial movement. Although it is possible to expect some recovery 2 years after paralysis, recovery after 4 years is unexpected, assuming there was complete separation of the facial nerve and evidence of complete denervation.

It is particularly important to differentiate complete, permanent paralysis from partial or reversible denervation. It would be an error to sacrifice a potentially intact or recoverable facial nerve with nerve substitution. The clinician must use all available information such as history, operative records, evoked and spontaneous electromyography, and, most importantly, clinical observations regarding tone and volitional movement in making this determination.

This type of dilemma might occur following acoustic tumor surgery where the facial nerve is not transected, but rather is injured by crush, stretch, or cauterization. In such a case where spontaneous recovery is likely, sectioning the facial nerve for nerve substitution should be delayed. Facial nerve regeneration may take as long as 12 to 15 months before any significant sign of recovery is noted. In some cases, the number of facial nerve fibers regenerating through the injured segment is too small to effectively contribute evidence of some recovery. In such cases, the decision of whether to re-explore the proximal facial for grafting, as opposed to performing a nerve substitution, or augmenting existing function with other reanimating techniques that do not impair further functional recovery becomes more problematic. These are types of situations in which nerve substitution performed past the 4 year cutoff might still prove somewhat successful, as the distal facial nerve has not completely neurofibrosed.

Anatomical and Physiologic Aspects

From a functional and phylogenetic standpoint, it seems plausible that there is a preformed synergism between the facial and hypoglossal nerves, which would therefore justify the selection of this nerve for reanimation.[8] Practically, the facial and hypoglossal nerves must cooperate quite closely during speech, mastication, and swallowing.

Articulation requires subtle coordination of these two motor nerves for proper motion of the tongue and lips. During food intake, sensory input via the trigeminal nerve must be converted into coordinated motor activity mediated through the facial, trigeminal, vagus, and hypoglossal nerves for effective mastication and deglution to occur.

Although the anatomical proximity of the cortical representation of tongue and facial control is well known, anatomical evidence for interneuronal connections at the central level has only recently been published.[9]

Electrophysiologic experiments on the trigeminofacial reflex and its correlate following hypoglossal-facial anastomosis, the trigeminohypoglossal reflex, provide further support for the existence of preformed connections via interneurons from the facial afferent trigeminal fibers to both the facial and hypoglossal nuclei. These data regarding linkages between the facial and hypoglossal mononeurons have significant theoretical implications of facial movement following XII-VII crossover.[10]

Expectations and Results of Hypoglossal-Facial Anastomosis

Improved facial tone and symmetry occurs in over 90% of patients following XII-VII anastomosis. It is predominantly seen in the midface and to a lesser degree in the lower face, while it is seen least in the frontalis region. Improved facial tone and symmetry is usually seen within 4 to 6 months following neurorrhaphy; however, this is somewhat dependent on time from injury to anastomosis, with better results occurring in earlier repairs.[11] Figure 3–1 shows a patient with a complete left facial paralysis following acoustic tumor removal 1 year earlier and postoperatively following XII-VII anastomosis.

Voluntary facial movements begin sometime after tone develops and progressively improve over 18 months, although continued improvement has been observed up to 5 years following repair. Voluntary motion is best noted in the midface, and less so in the lower and upper face. The precise reason for this phenomenon has not been demonstrated conclusively, but probably relates to more potential axon pathways destined for the peripheral facial muscles in the midface and less in the forehead, lower lip, and neck. Clipping some of the "excess" midfacial fibers in an effort to redirect regenerating axons to the periphery has been suggested by Fisch[12]; however, in the author's experience this has not been substantiated.

True spontaneous reflexive facial function or emotional expression is rare, although with training many patients will develop spontaneous animation with speech. Indeed, motor sensory re-education and practice will assist the patient to more effectively learn to use the new system; this is accomplished by teaching the patient to push the tongue against the incisor teeth or palate when attempting to voluntarily smile. Further, they are taught to suppress the normal side while balancing it with the less controlled and weaker abnormal side to improve symmetry. With practice, concentration, and motivation, roughly 10% of patients evolve a behavioral response that habituates and simulates normal smiling[13].

Although uncommon, true segmental separate regional facial movement control (i.e., eye from mouth) may occur. Conley suggested that this was seen more often following immediate repair.[6,10,11,13] Extensive training and motivation can improve the patient's chances of achieving such an excellent result. Unfortunately, as with any nerve grafting procedure including XII-VII, synkinesis of some degree occurs in virtually all patients. Moreover, mass movement complicates voluntary expression in upward of 80% of patients. Excessive facial tone, hyperactivity, and/or spasm may occur in up to 15% of patients, but this is rarely sufficiently severe to warrant a patient's request to have the anastomosis undone.[6] While not all agree, some suggest that this phenomenon occurs more following early or immediate nerve crossover, thus allowing the overly powerful twelfth nerve axons to maximally reinnervate the face.[6]

Qualitative and quantitative assessment of overall improvement in facial function is necessary with any technique of facial reanimation. Table 3–1 provides a grading system suitable for evaluation of nerve substitution procedures. Clearly, some degree of synkinesis will be seen with even the best result. A review of the literature shows that not all authors utilized a common grading system; thus an accurate comparison of results is not entirely possible.

Conley reported good or excellent results in 65% of 122 patients, fair in 18%, and poor in 17%. He noted that good results increased when nerve substitution was performed immediately (74%) as opposed to delayed (41%). These data were again updated and corroborated by Baker who reviewed Conley's and his experience with more than 200 patients.[13]

In 54 patients undergoing 12-7 anastomosis, Luxford and Brackmann reported excellent results in 22%, good in 31%, fair in 28%, and poor in 7%. Six were not available for follow-up.[14]

In their series, Pensak et al.[15] reported good to excellent results in 42%, fair in 48%, and poor in 10%. Further, they demonstrated that most patients (42%) showed signs of reinnervation within 6 months and that 76% manifested signs of reanimation with 1 year. Virtually all of their patients underwent nerve substitution immediately or shortly after nerve sacrifice.

Gavron and Clemis[5] reported good to excellent results in 61%, fair in 17%, and poor in 6% of 36 patients who underwent hypoglossal-facial anastomosis. They noted that fair to poor results occurred more often in patients over the age of 60 and in patients whose interval to repair was over 1 year.

Our own experience with 11 patients agrees with the results reported with these larger series.

Disturbance of Tongue Function

Sectioning of the hypoglossal nerve unequivocally leads to hemitongue paralysis. However, according to Conley, the degree of hemitongue atrophy varies: 22% minimal, 53% moderate, and 25% severe. Functional disability is also variable. Conley noted that patients undergoing immediate

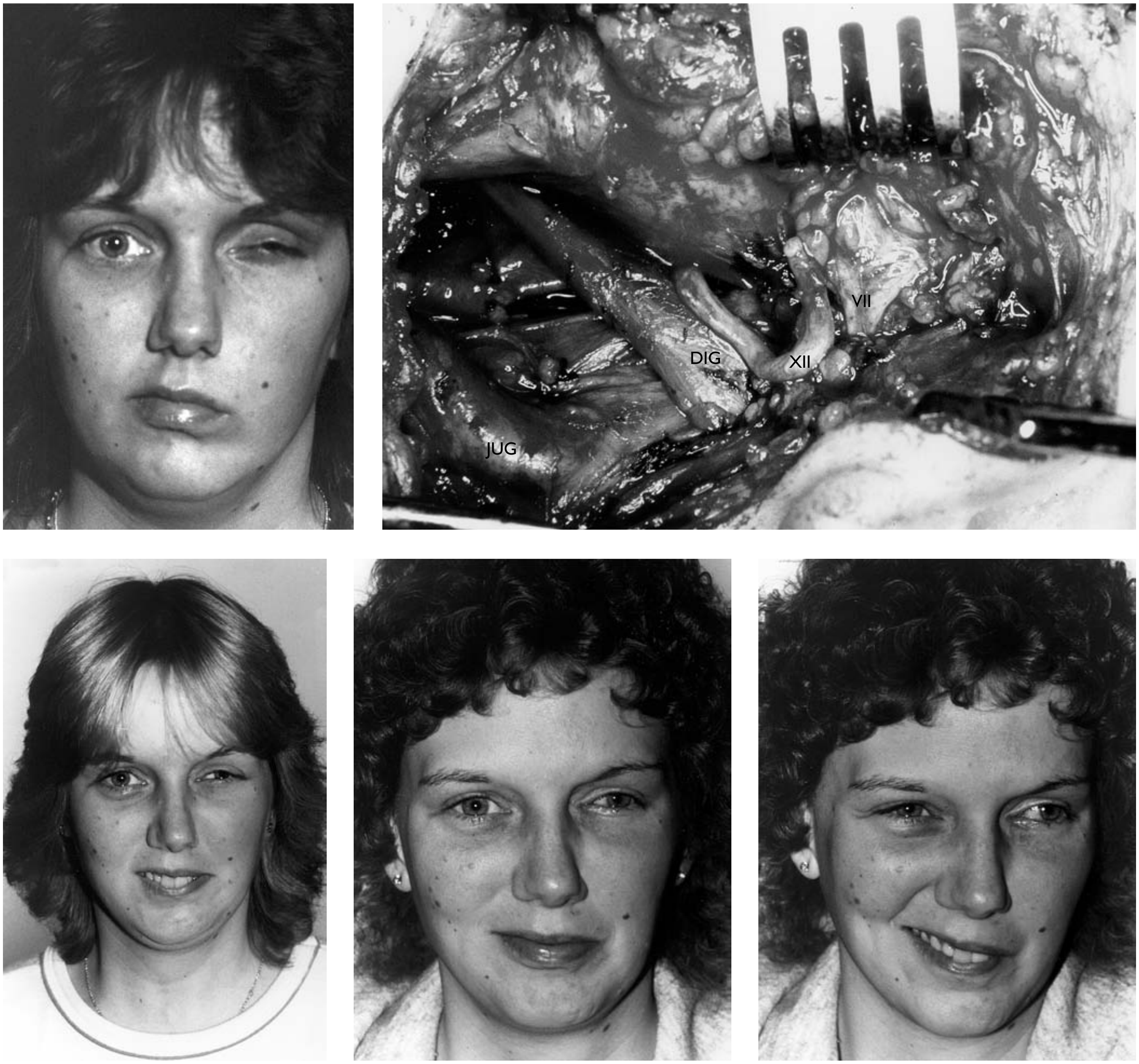


Figure 3–1. Results of hypoglossal-facial anastomosis. Repair was performed 1 year after acoustic tumor resection. **A**, There was no facial function on the paralyzed left side and vision was limited by the medial and lateral tarsorrhaphies. **B**, Hypoglossal-facial nerve anastomosis was performed. *DIG*, digastric muscle; *JUG*, jugular vein; *XII*, hypoglossal nerve; *VII*, facial nerve. **C**, Six months following the hypoglossal-facial crossover, eye closure improved so that the medial tarsorrhaphy was lysed. Patient regained facial symmetry in repose. **D**, With the tongue protruding against the teeth, the patient is able to produce a voluntary smile. **E**, Mimetic or spontaneous smile. Note there is no movement on the involved side. Mimetic facial expression is rarely restored with a nerve substitution procedure.

anastomosis rarely complained of dysfunction, whereas those with long-standing paralysis with flaccidity experienced some disability from food lodging in the buccal sulcus or difficulty moving the bolus posteriorly. This usually improved as facial function improved. Postoperative difficulty in swallowing that was attributed to tongue dysfunction was a complaint of 10 to 12% of patients. Articulation is affected in all patients initially, but is rarely disabling and usually improves over time. In studying perceived oral dysfunction following XII-VII anastomosis, Pensak et al.[15] noted that 74% of patients reported some difficulty with eating, while only 21% found it debilitating. Rarely was swallowing significantly disturbed.

In an effort to reduce the likelihood of postoperative tongue atrophy and dysfunction, Rubin suggested interdigitating the midline tongue musculature using a Z-plasty technique.[16] Presumably, this increases the likelihood of muscle-to-muscle neurotization. Conley tried suturing the descendens hypoglossi branch to the distal stump of the hypoglossal nerve in two patients. No recov-

Table 3–1 Classification System for Reporting Results of Complete Lesions Treated by Reanimation Techniques.*

Grade	Definition
I - Superb	Some mimetic (spontaneous emotion) movement. Individual movement. Complete eye closure and asymmetrical smile with maximal effort.
II - Excellent	Mimetic movement absent. Otherwise same as Grade I.
III - Good	Mass movement. Eye closure complete and asymmetrical smile with maximal effort.
IV - Fair	Incomplete eye closure and/or very weak mouth movement.
V - Poor	Symmetry only. Tone intact.
VI - Failure	Flaccid. Tone lost.

*Reanimation techniques performed less than 2 years posttreatment. Recovery results noted 2 years or longer after onset.

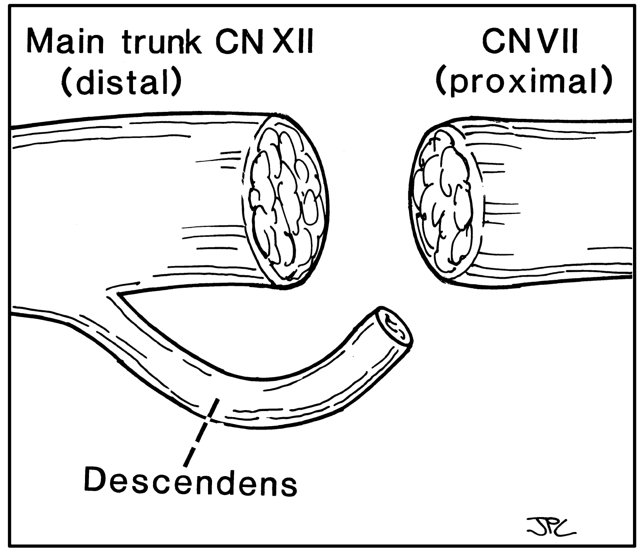


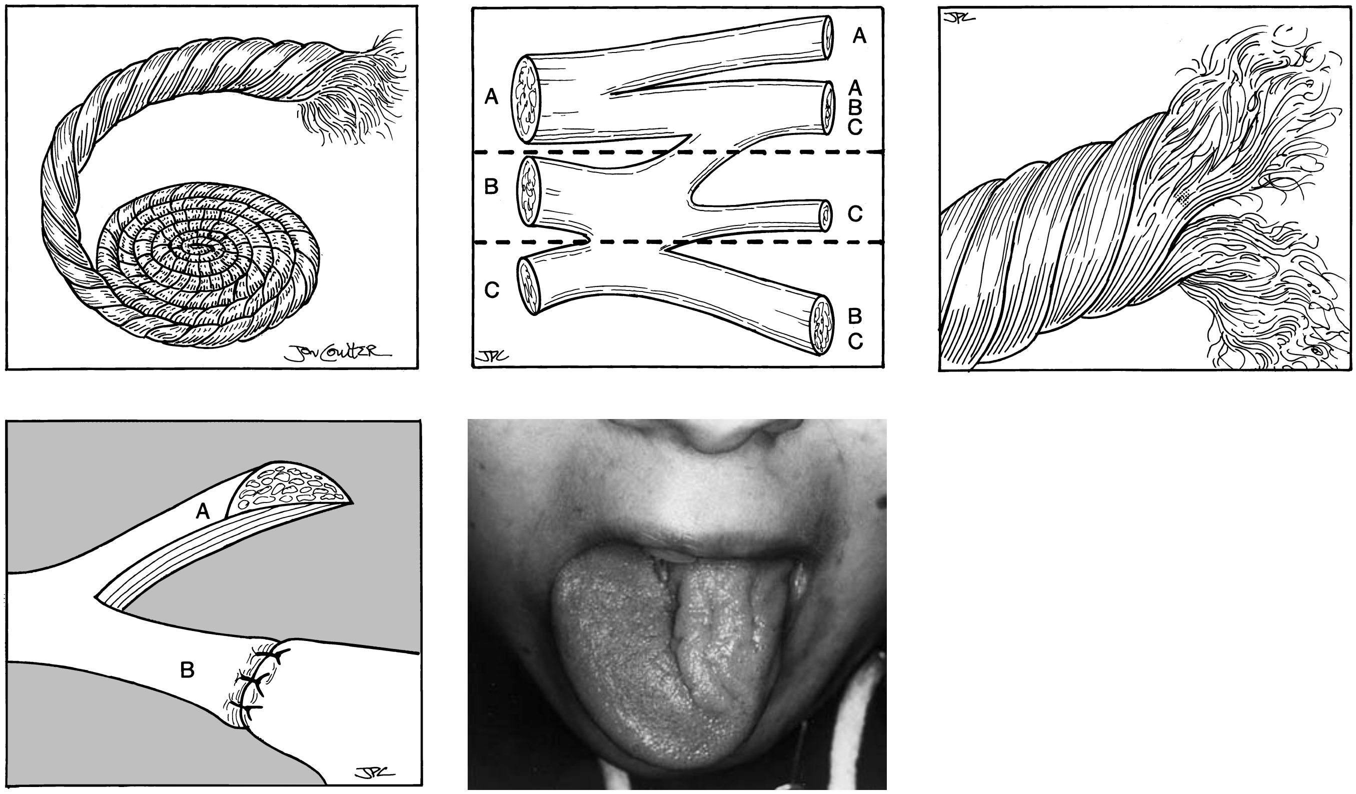
Figure 3–2. Descendens hypoglossi-facial anastomosis. The cut ends of the twelfth nerve, descendens hypoglossi, and distal end of the facial nerve at its extracranial main trunk are depicted approximately to scale. Note that when the facial nerve is sectioned within 30 days following injury, the cross-sectional endoneurial surface of the facial nerve in this circumstance makes a very close match with the end of the hypoglossal nerve. The surface area offered by the descendens hypoglossi is significantly smaller. If the descendens instead of the hypoglossal nerve was used to innervate the facial nerve, there would be a mismatch. The endoneurial surface of the descendens provides inadequate number of axons or "fire power" to expect any useful facial recovery from this procedure (see Chapter 2).

ery occurred in these patients.[11] The number of axons available with the descendens hypoglossi is far to few to expect any meaningful recovery (Fig. 3–2). The possibility of splitting the hypoglossal nerve by a microseparation and retrodissection technique and performing a split XII-VII anastomosis was also suggested by Conley who performed the procedure in 12 patients. None of the patients achieved useful facial recovery, and all had tongue deficits.[11] Splitting the hypoglossal nerve arbitrarily across a funiculus where fascicles cannot be separated denervates the part that is to serve as the donor as well as part of the nerve that is to be spared (Fig. 3–3). The result is decreased viable fibers available to reinnervate the face as well as the tongue. Ueda et al.[17] described a technique using a part of the hypoglossal nerve to motor a free muscle transplant. The hypoglossal nerve in its terminal course divides into three branches. The central branch is large, and Ueda and coworkers reported splitting this branch by microdissection and using half of it to motor the free muscle transplant. They were able to show useful reinnervation with serviceable contraction of the free muscle motored by this branch, but tongue atrophy was more or less seen in all the patients. The authors noted that patients had changes in speech and difficulty with handling food and swallowing. In two of their patients, the functional disturbance was severe. The authors commented that functional disturbance caused by resection of the hypoglossal nerve is unpredictable. In two of the patients, they tried the longitudinal division approach described by Kesseler et al.[18] The functional recovery in those cases was so poor that they have abandoned the technique. We have observed this procedure performed by a colleague and studied three of these patients immediately and up to 2 years postoperatively. Two patients had tongue paresis, and one had hemiatrophy. The recovery was only fair in these patients in spite of surgery performed within 3 months of injury. The concept of splitting the hypoglossal to spare the tongue is flawed, and the use of the procedure is discouraged.

Surgical Anatomy-Hypoglossal Nerve (Fig. 3–4)

The hypoglossal-facial crossover technique requires the identification of the facial as well as the hypoglossal nerve. The course of the hypoglossal nerve can be divided into vertical descending, horizontal, and ascending segments. The anatomical relations of the vertical descending portion of the hypoglossal nerve are relatively constant. Hollingshead[18] notes that the twelfth cranial nerve emerges from the hypoglossal canal medial to the internal jugular vein and the carotid artery. It runs laterally and inferiorly to lie behind the tenth cranial nerve, then courses more inferiorly to pass between the internal jugular vein and the internal carotid artery (Fig. 3–4A). In 8% of individuals, the twelfth cranial nerve passes behind the internal jugular vein.[19] Another variation is that the nerve may be fused by fibrous adhesions to the nodose ganglion of the tenth cranial nerve

A–C



D, E

Figure 3–3. Hypoglossal nerve split for facial reanimation. Splitting the hypoglossal nerve in an effort to spare the tongue and reinnervate the face is a flawed concept. The hypoglossal nerve, like all peripheral nerves, is not oriented in parallel channels but rather is random and interwoven much like a rope **(A)**. **B**, A wax reconstruction of serial sections of a peripheral nerve shows the random mixing of fibers.[39] A split between A and B would leave only A fibers; a split between B and C would leave only C fibers. **C**, Demonstrates the effects of splitting a rope where the fascicles are in a random pattern; therefore, splitting injures the upper and lower part of the nerve separated by the split. In this fashion, the viable axons that would course to the tongue are diminished as well as those to the face. This pattern is more characteristic of the anatomy of the twelfth nerve as opposed to **D** where it suggests that all the fibers are parallel. In such a case, it would be conceivable that splitting the tongue would achieve the surgical goal of getting maximum innervation to the face without paralyzing the tongue. Unfortunately the rope concept is valid. Thus, a hypoglossal split is a flawed concept and should not be performed. **E**, Shows a paralyzed and atrophic left hemitongue as a result of splitting the nerve. This is the same effect as one frequently observes with a formal XII-VII where the twelfth nerve is sectioned completely.

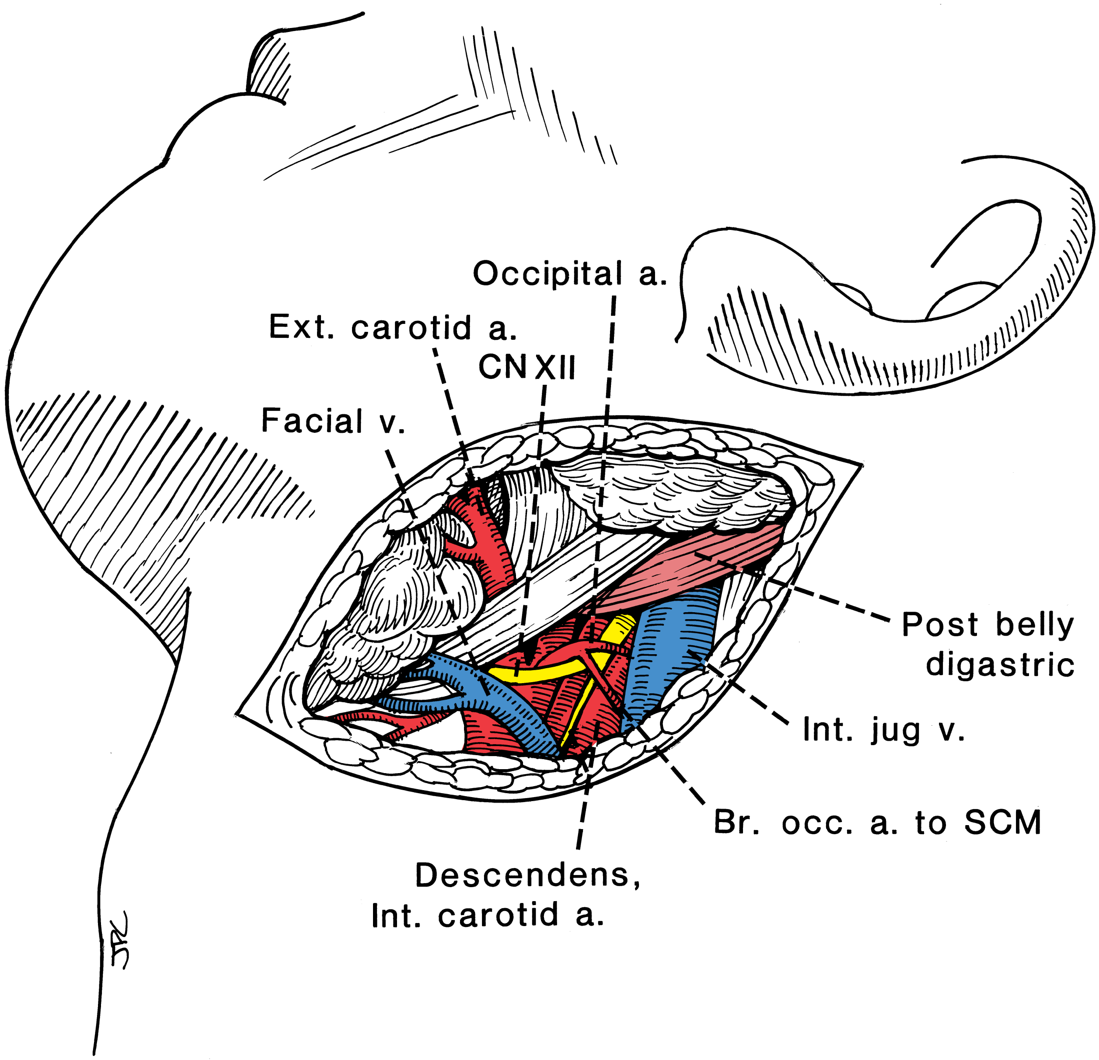
in its vertical segment. The twelfth cranial nerve then travels deep to the posterior belly of the digastric muscle and over the internal carotid artery (Fig. 3–4B).

The horizontal segment of the hypoglossal nerve begins where it is crossed by the occipital artery or where the nerve is crossed by the sternocleidomastoid artery, which branches from the occipital artery.[19–21] The horizontal segment ends as the nerve passes anteriorly to the deep tendon of the posterior belly of the digastric muscle. Although the course of the first and second segments of the hypoglossal nerve present with a variety of anatomical variations,[21] the anatomy of the ascending portion of the nerve is relatively constant. Traveling anteriorly, the nerve forms the superior leg of Lesser's triangle.[19] The remaining limbs of the triangle are the angle of the union of the anterior and posterior bellies of the digastric muscle. The lingual artery courses in this triangle, deep to the hypoglossal nerve, and travels medial to the hypoglossal muscle to enter the muscular substance of the tongue. The lingual vein continues to course with the hypoglossal nerve over the lateral surface of the hyoglossal muscle.

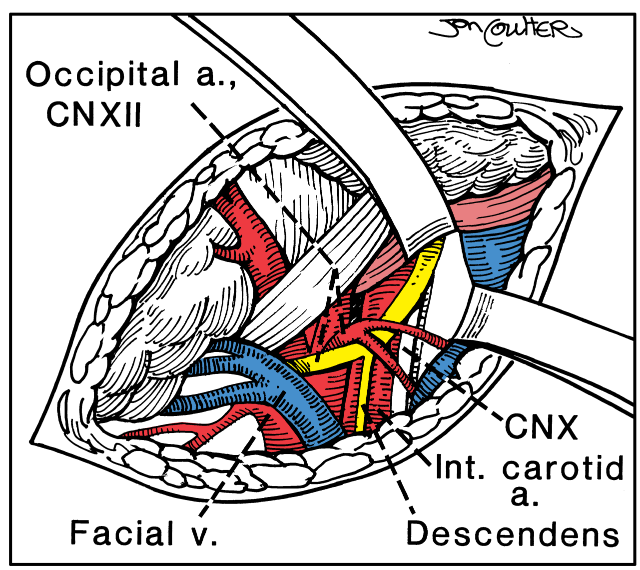
At times the vertical segment of the hypoglossal nerve may be obscured by posterior displacement behind the internal jugular vein or adhesions to the nodose ganglion of the tenth cranial nerve. Reflecting the posterior belly of the digastric forward, identifying the jugular vein and reflecting it posteriorly, identifying the occipital artery or the sternocleidomastoid branch hooking the hypoglossal nerve and finally the identification of the descendus hypoglossus are all key anatomical landmarks in dissecting and isolating the hypoglossal nerve.[22] Confirmation is made by electrical stimulation and observing contraction of the tongue muscles.

Surgical Technique

Figure 3–4 demonstrates the anatomical considerations to find the twelfth cranial nerve. Details of the procedure are illustrated in Figure 3–5. The surgical exposure of the hypoglossal and facial nerves are similar to the XII-VII jump graft technique noted in Figure 3–6. Instrumentation used for this procedure is listed in Table 3–2.

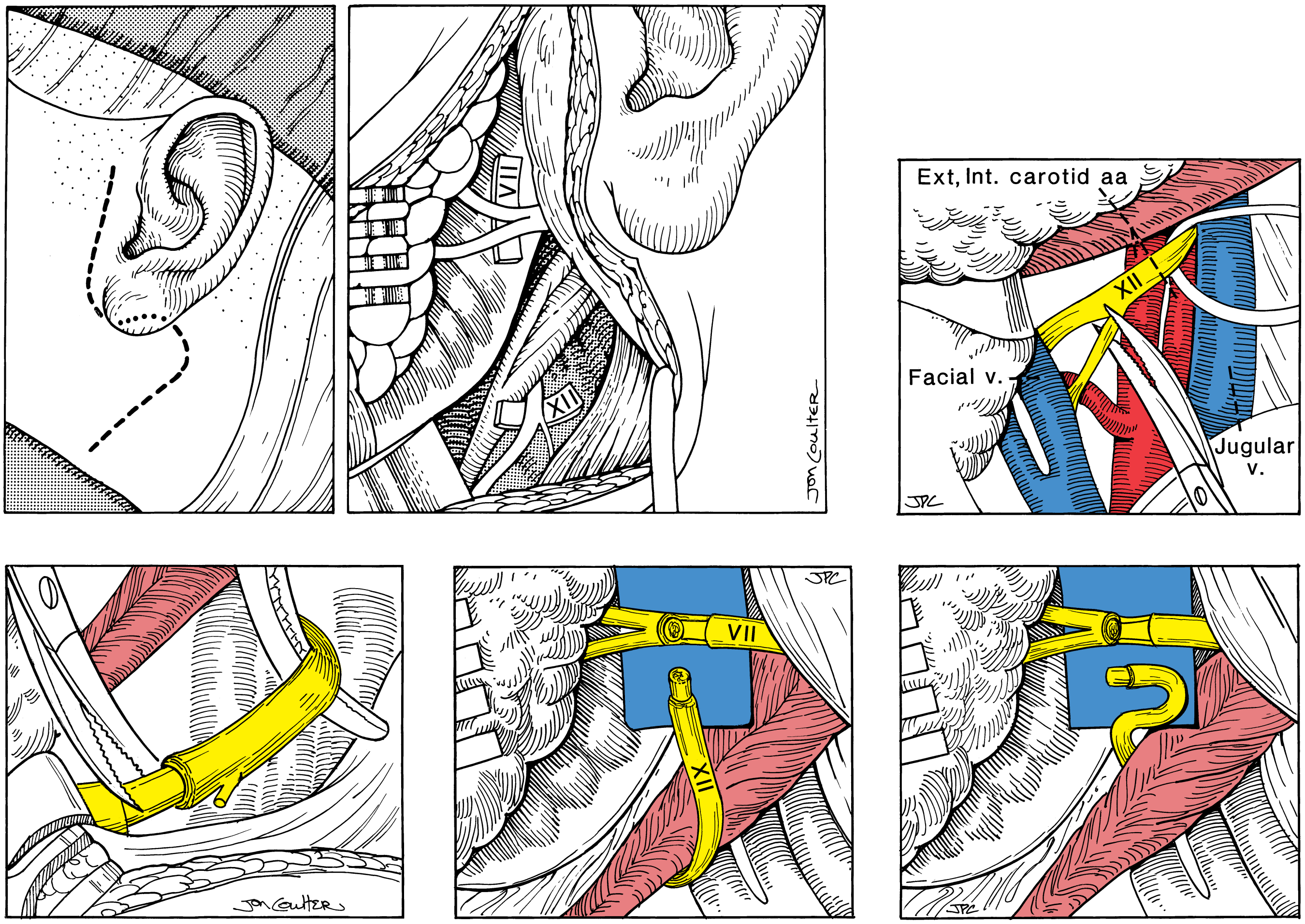


A



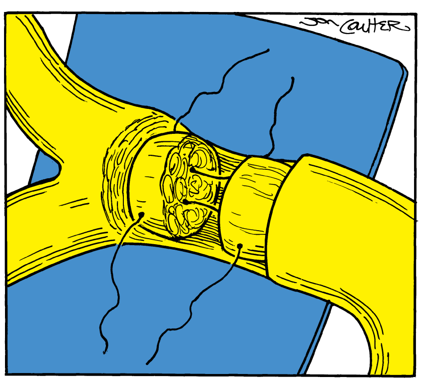
B

Figure 3–4. **A**, The surgical anatomy of the hypoglossal nerve. The twelfth nerve is usually found along the medial surface of the jugular vein and hooked by the occipital artery and a branch to the sternocleidomastoid muscle. **B**, The key landmarks in identifying and isolating the horizontal section of the twelfth nerve just distal to the descendens hypoglossi requires retracting the posterior belly of the digastric muscle superiorly and reflecting the jugular vein posteriorly. The twelfth nerve can be positively identified by noting the takeoff of the descendens hypoglossi and by direct electrical stimulation, noting the brisk contraction of the tongue muscles.



A, B C

D–F



G

Figure 3–5. Hypoglossal-facial nerve crossover technique. **A**, An incision similar to that for a parotidectomy is made. **B**, The parotid is dissected away from the facial nerve trunk as it exits the stylomastoid foramen. The facial nerve is followed to just past the pes anserinus. A parotidectomy is not necessary. The hypoglossal nerve is isolated as it courses between the jugular vein and carotid vessels just on the undersurface of the digastric muscle (see Fig. 3–4). **C**, The descendens hypoglossi is divided with a scissors with serrated blades. The serrations discourage the nerve from slipping as the blades are closed and crushing is less likely. **D**, After the epineurium is trimmed proximally and distally, exposing the perineurium containing endoneurial material, the scissors is now used to divide the hypoglossal nerve in this zone distal to the descendens hypoglossi takeoff (see Fig. 2–21). **E**, The twelfth cranial nerve is shown coming inferior and lateral to the digastric muscle. The epineurium of the hypoglossal nerve has been trimmed back exposing perineurium. The epineurium has been trimmed back proximally and distally over the facial nerve. The perineurial endoneurial content is exposed. The deep surface of the epineurium is not divided, thus holding the facial nerve in position. If the epineurium is completely divided, the proximal and distal ends of the facial nerve will retract making it more difficult for nerve repair. The facial nerve trunk is placed over a sheet of blue background paper. This serves as a work platform. **F**, The hypoglossal nerve is brought medial to the digastric muscle and significant additional length is achieved with this maneuver. Now the twelfth cranial nerve can be sutured to the distal facial nerve without tension. **G**, Usually two 8-0 monofilament sutures placed through perineurium out endoneurium through endoneurium and out perineurium of the donor and recipient nerves provide adequate approximation. Steps **D**, **E**, **F**, and **G** are accomplished with the aid of a binocular operating microscope.

Combining Reanimation Techniques

While hypoglossal-facial anastomosis is certainly a valuable facial reanimation technique, it does not satisfy all of the criteria of an ideal reanimation procedure. In particular, while the midface and mouth area are usually reanimated to achieve patient satisfaction, eye reanimation is often insufficient. In Pensak's et al. study,[15] 75% of patients reported incomplete eye closure, and 21% made mention of ophthalmologic problems following isolated XII-VII anastomosis. This is similar to our own experience. As such, we have found that it is necessary to combine various eye reanimation procedures, most often gold weight or eye spring implantation, in patients undergoing hypoglossal-facial anastomosis (see Chapter 6). This not only serves to provide immediate improvement in eye closure, but significantly enhances the final result.

Hypoglossal-Facial Nerve Jump Graft

The hemitongue paralysis that occurs as a result of a classic hypoglossal-facial nerve crossover procedure can result in profound functional deficits in speech, mastication, and swallowing. Further, these difficulties can be incapacitating in patients who have, or have the potential for, bilateral and/or other cranial nerve deficits, particularly those who have experienced injury to the tenth cranial nerve, who have an existing twelfth cranial nerve loss, or who have neurofibromatosis Type II. Naturally, hypoglossal-facial nerve anastomosis is not appropriate for reanimating both sides of the face in patients with bilateral facial paralysis. In addition, some patients refuse to accept the sequelae of unilateral twelfth cranial nerve dysfunction.

Other methods of facial reanimation that are appropriate for these patients include VII-VII cross-face graft,[23–26] spinal accessory-facial nerve crossover,[27] and/or temporalis muscle transposition,[28,29] or free muscle neurovascular anastomosis[17,20–34] combined with various eyelid-reanimating procedures.[35,36] The other nerve substitution techniques will be discussed subsequently in this chapter, while the other approaches will be covered in Chapters 4 through 9.

A search for an alternative method of using the hypoglossal nerve as the power source without creating a deficit in the tongue was prompted by the number of problems that were observed with the standard XII-VII procedure. As already mentioned, the high incidence of tongue deficit with its associated problems has been well recognized. In addition, there were two other problems that were peculiar to sacrificing the entire twelfth cranial nerve to reanimate the face. One involved too much recovery in which the patient had uncontrollable mass movement that presented as grimacing, and often was painful. This problem can be managed to some extent with Botox injection or selective myectomy. The other problem was far more serious and was the major motivation to attempt to reanimate the face using the jump graft approach. The concept of borrowing from "Peter to pay Paul" does not really apply to the formal XII-VII anastomosis because both "Peter and Paul" are the same. Imagine a patient 2 years after a XII-VII crossover with a severe tongue deficit and no improvement in facial function. This scenario occurs in 10% of patients who have undergone the classic hypoglossal-facial nerve anastomosis.

Axons in the hypoglossal nerve and all other peripheral nerves thread their way through neural tubules and at random in an interweaving fashion, so that splitting the nerve invariably results in transection of axons at multiple points along the course (Fig. 3–3). This leads to degeneration, not only of the segment split for anastomosis to another nerve, but also in the main trunk of the nerve. These facts probably explain Conley's poor results using split-nerve grafts. Failure of the descendens hypoglossi to reinnervate the paralyzed face was probably the result of an inadequate number of axons (Fig. 3–2).

The XII-VII jump graft procedure avoids causing tongue paralysis and its sequelae by partially incising rather than transecting the twelfth cranial nerve. This leaves enough viable normal uncut ends of hypoglossal nerve axons in healthy condition to spare tongue function while sufficient numbers of axons are rerouted to regenerate across the interposition graft to reinnervate the paralyzed face. The three patients operated on early in the study had tongue deficits because the incision into the hypoglossal nerve was greater than intended. The contribution of the descendens hypoglossi to the diameter of the hypoglossal nerve was not appreciated. This complication was avoided in later cases by separating the descendens hypoglossi from the hypoglossal nerve for transection.

The hypoglossal-facial interposition jump graft was developed as a result of a personal communication between the author and Julia Terzis, M.D., who uses a similar procedure to keep the distal facial nerve axons viable in patients for whom a staged seven-seven crossover or free muscle transfer is planned.[37]

Indications

The indications for placing a XII-VII jump graft are similar to those for classic hypoglossal-facial nerve anastomosis and include complete interruption of the facial nerve, with lack of availability of the central stump for repair, intact extracranial facial nerve and mimetic muscles, and repair possible within 30 days of injury and not more than 1 year after injury. In addition, the XII-VII jump graft may be placed when the classic XII-VII procedure is contraindicated when the hypoglossal nerve is intact on only one side, when the possibility of a tongue deficit must be avoided, when a deficit of the tenth cranial nerve is present (combining a twelfth cranial nerve with a tenth cranial nerve deficit runs the risk of incapacitating the patient's ability to swallow without aspirating), in patients with neurofibromatosis Type II or adenoid cystic carcinoma, and in patients who have undergone skull base surgery with involvement of multiple cranial nerves.

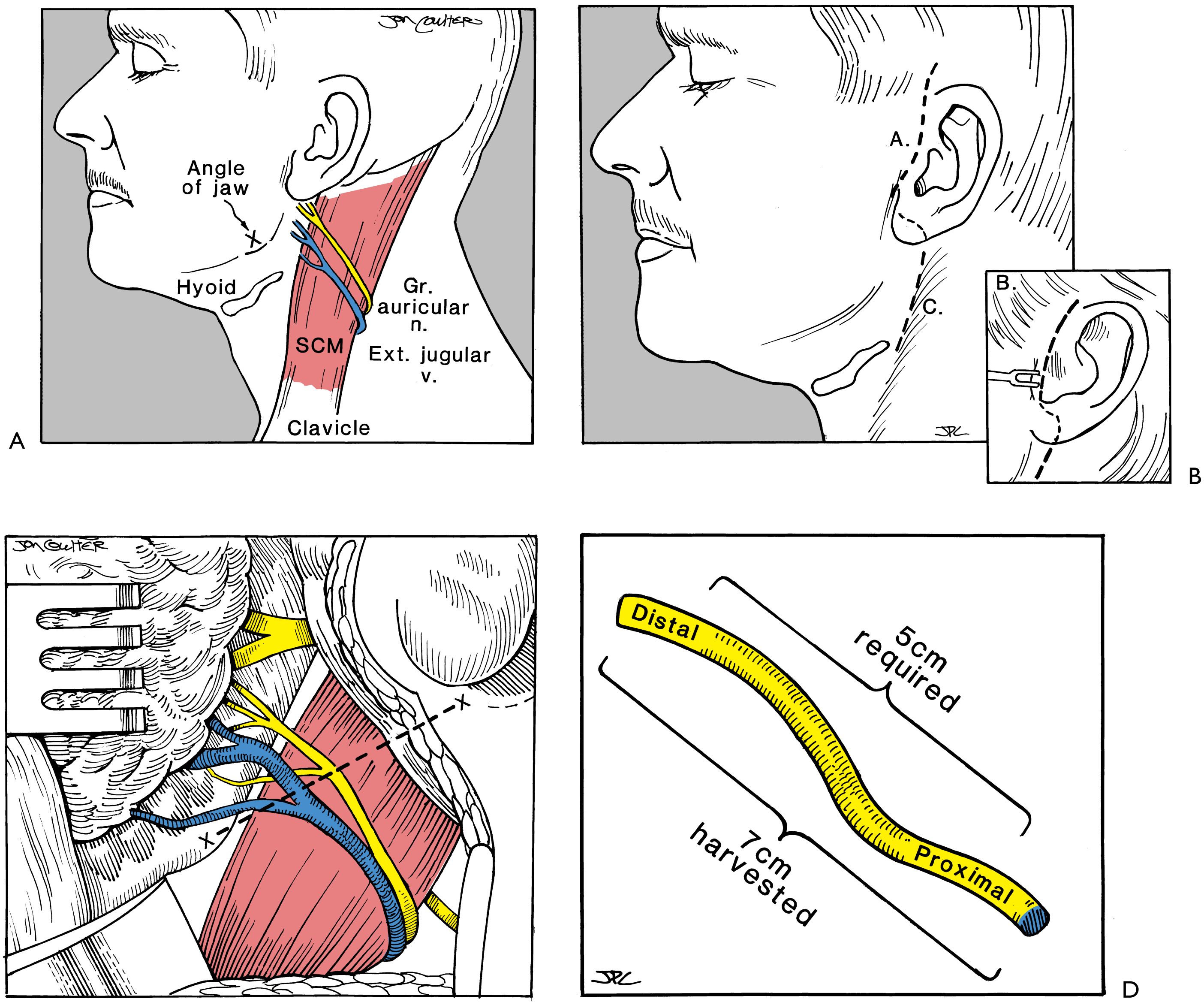


Figure 3–6. Hypoglossal-facial nerve jump graft technique. **A**, Topographical landmarks for this procedure are noted. **B**, For cosmetic considerations, the incision is made in the preauricular crease if it is present (A). If it is not, the surgeon has the option to make the incision in the tragal-helicine fissure extending the incision behind the tragus and then through the tragal lobular fissure behind the lobule (B). The incision is continued down into the neck along a natural skin crease to the level of the greater cornu of the hyoid (C). Care must be taken to preserve the greater auricular nerve which is used as a graft bridge between the facial and hypoglossal nerves. The greater auricular nerve runs just beneath the subcutaneous tissue and may be severed if the initial skin incision is too deep. **C**, The facial nerve is exposed after the parotid has been mobilized. The facial nerve is followed distally passed the pes anserinus. The great auricular nerve is found just deep to the subcutaneous tissue in a line that bisects the posterior border the sternocleidomastoid muscle and the line between the mastoid tip and the angle of the jaw (XX). The nerve courses parallel and just behind the external jugular vein. Note the relationship of the great auricular nerve to the eleventh nerve. Care must be taken not to injure the eleventh nerve in following the most proximal end of the great auricular nerve behind the posterior border of the sternocleidomastoid muscle. **D**, The greater auricular nerve is dissected and removed. This nerve graft is placed on a saline soaked 4×4 for later use. Seven centimeters of nerve is obtained even though only 5 cm are required for this procedure. The additional length allows for trimming.

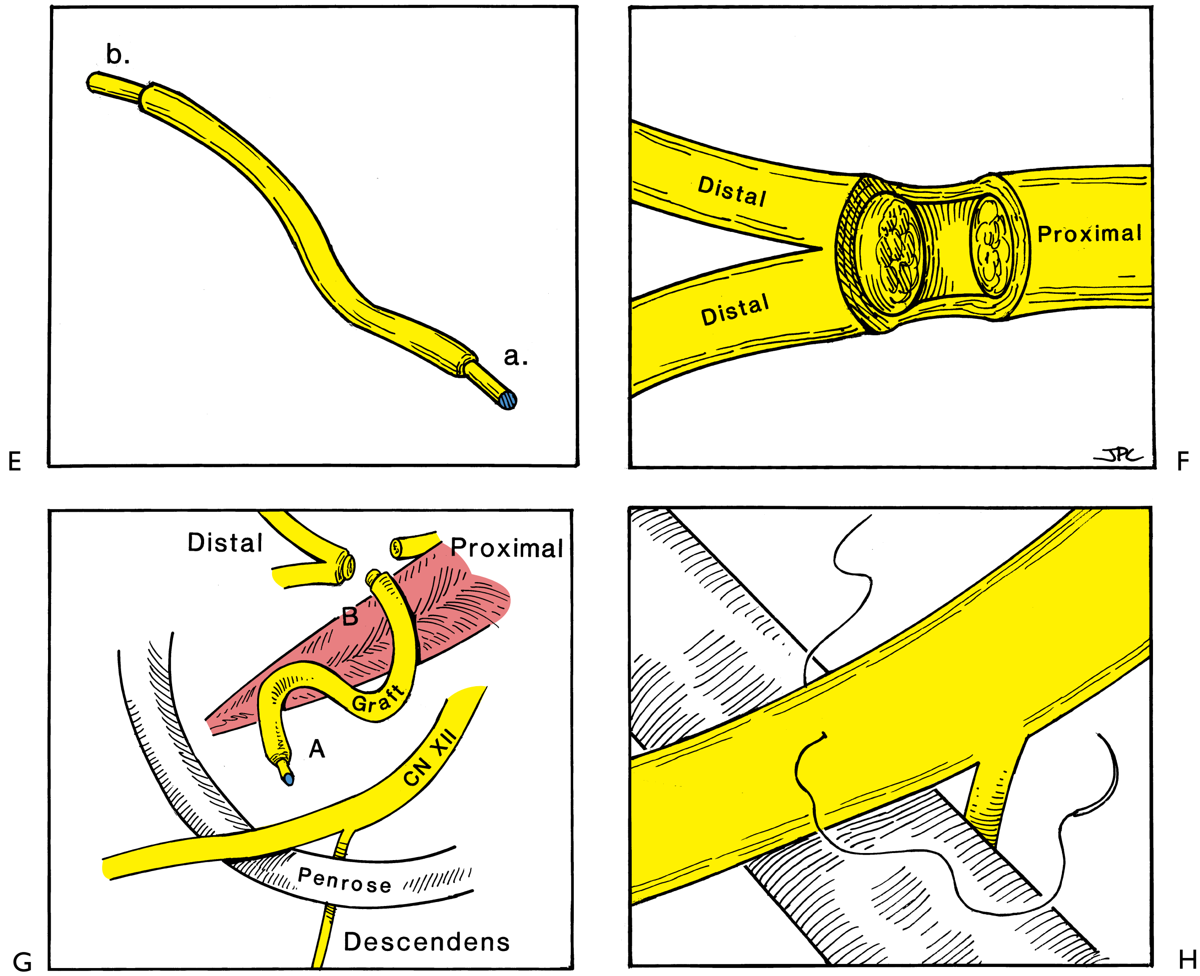


Figure 3–6. *(continued)* **E**, The proximal end of the great auricular nerve (a) should be marked with methylene blue and the epineurium stripped back exposing the endoneurial surface both on the proximal (a) and distal ends (b). **F**, The facial nerve is prepared for anastomosis by stripping back the epineurium along the main trunk and the nerve divided preserving the deep surface of the epineurium. This step prevents the ends of the facial nerve from retracting and stabilizes the nerve for suturing. **G**, This is a schematic of the surgical field. The greater auricular graft is placed aside and the twelfth cranial nerve is uncovered. The hypoglossal nerve is isolated as it courses between the internal jugular vein and the internal and external carotid artery, just beneath muscle (see Fig. 3–4). The descendens hypoglossi is identified, and a $\frac{1}{4}$-in Penrose drain is placed under the hypoglossal nerve and over the descendens hypoglossi. This step separates the twelfth cranial nerve from the descendens. Now one can determine more accurately the actual diameter on the hypoglossal nerve without the contribution of the descendens. This will allow for a more accurate determination when the intent is to incise only one-third of the diameter of the hypoglossal nerve. The distal end of the great auricular nerve (B) is placed against the distal end of the facial nerve, matching endoneurial surface to endoneurial surface. Usually the distal end of the great auricular nerve will match perfectly with the distal end of the facial nerve in cases where the repair is done within 30 days following injury. In situations where the nerve is repaired a year or more after injury, the endoneurial surface provided by the facial nerve may be significantly smaller than the great auricular nerve. In such cases, the distal end of the facial nerve is cut on a bias and even may be bivalved in order to increase the endoneurial surface to accommodate the nerve graft. In patients where the nerve repair is performed a year or more after injury, the increase in the connective tissue component of the cross-section of the facial nerve becomes apparent and trimming that back to expose the working end of the nerve (the endoneurial surface) becomes more critical in ensuring an appropriate match between recipient and donor nerves. The distal end of the graft and distal end of the facial nerve are then sutured passing an 8-0 monofilament suture from perineurium through endoneurium of the distal end of the facial nerve through endoneurium and perineurium of the graft, and then placing three throws, producing a square knot to prevent the suture from unraveling. An additional suture is placed in order to ensure accurate coaptation between the ends and to prevent not only separation but rotation. It should be noted that the distal end of the graft is attached to the distal end of the facial, and the proximal end of the graft is attached to the twelfth cranial nerve. **H**, An 8-0 monofilament suture is placed through the twelfth cranial nerve marking a point that is approximately one-third of the diameter of the nerve. This was suggested by Dr. Jack Kartush (Michigan Ear Institute, Farmington Hills, Michigan) to ensure that when one makes a divet in the nerve that no more than one-third of the nerve is divided ensuring preservation of tongue function. The Penrose drain is stretched with a self-retaining retractor to isolate and pull the hypoglossal nerve toward the surgeon. This important maneuver helps the surgeon when incising the hypoglossal nerve to be sure that the descendens hypoglossi is not confused as contributing to the diameter of the twelfth cranial nerve. *(Figure continued next page.)*

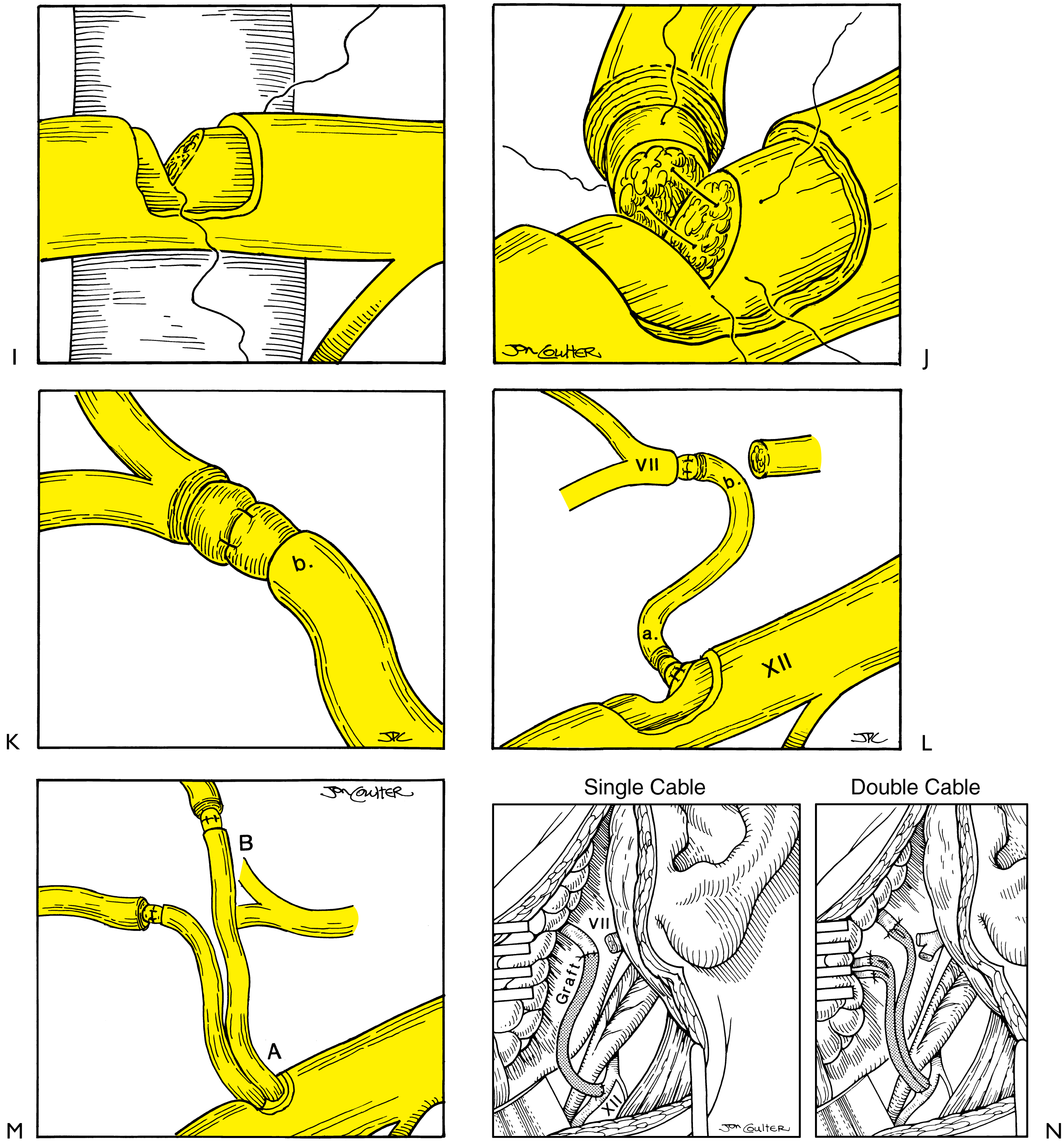


Figure 3–6. *(continued)* **I**, A beveled incision is made not more than one-third through the hypoglossal nerve, partially transecting the nerve and exposing a portion of the proximal endoneurial surface. The hypoglossal nerve is then stimulated electrically proximal to the partial transection to check for functional integrity of the nerve; brisk contraction of the tongue muscles indicates that a significant portion of hypoglossal nerve function has been preserved and correlates well with sparing of tongue function postoperatively. However, we have observed instances where there was a temporary postoperative tongue paresis even though the tongue muscles did contract in response to stimulating the proximal end of the twelfth cranial nerve. This was in spite of only sectioning one third of the diameter of the twelfth nerve. This could be due to a temporary conduction block across the site of section or be related to the amount of tension or the duration that tension was exerted by the application of the Penrose drain. A permanent tongue deficit can be created by dividing the twelfth cranial nerve beyond the recommended one third or if the amount and the time of tension created by the Penrose drain is not minimized. Keeping these details in mind, next the epineurium is trimmed along the lateral surface of the twelfth cranial nerve with a double action scissors (Fig. 2–21). Scissors with serrated edges work more effectively with nerve tissue cutting sharply with minimum tearing and crushing effect. **J**, Usually the proximal end of the great auricular nerve will match the endoneurial surface created in the twelfth cranial nerve. The proximal end of the graft is sutured to the proximal end of the defect created in the twelfth cranial nerve. **K**, The distal end of the graft is secured to the distal facial nerve with two or more sutures as neccessary. **L**, Jump graft completed. **M**, In some situations, to provide maximal innervation and appropriate matching between the facial nerve and hypoglossal nerve, a double cable graft may be placed between the two cranial nerves. **N**, Single and double cable 12-7 jump graft procedures.

Table 3–2 Instrumentation for Cranial Nerve Substitution

SPECIAL EQUIPMENT
Operating microscope with 250 mm lens
Bipolar Bovie console

SPECIAL INSTRUMENTATION
Jewelers bipolar tip
Microinstrument set

SPECIAL SUPPLIES
Weck-cel spears 00-8680
Background paper
Zomed Vari-Stim nerve locator 85-62010
Methylene blue 1% amp

SUTURE
8-0 Ethilon #2822G for nerve graft

DRESSING AND DRAIN
7 mm Blake drain
Steri strips
Kerlix super sponges
3″ Kling

ANTIBIOTICS
Clindamycin (Cleocin) 600 mg + NSS SNS 30 cc to irrigate wound

Surgical Technique

Figure 3–4 demonstrates the anatomical considerations to find the twelfth cranial nerve. Details of the XII-VII jump graft procedure is illustrated in Figure 3–6. The instrumentation used for this procedure is listed in Table 3–2.

At the suggestion of Dr. Fred Shaia (neuro-otologic surgeon, Richmond, Virginia), an effort was made to avoid an interposition graft by connecting the distal facial nerve directly to the partially incised hypoglossal nerve. This was attempted on three occasions between 1989 and 1991. The facial nerve in each of these cases was injured during acoustic tumor surgery. The facial nerve was mobilized in the temporal bone, sectioned at the second genu, and transposed from the mastoid segment in an effort to reach the hypoglossal nerve. In each of these cases, there was insufficient length of facial nerve to reach the incised segment of the hypoglossal nerve just distal to descending hypoglossi take off. Rather than risk tension at the suture site, the greater auricular nerve was used to bridge the gap allowing a tension-free anastomosis. Recently, Atlas and Lowinger[38] successfully used this technique suggested by Shaia in three patients and achieved highly satisfactory cosmetic and functional results without compromising hypoglossal function. This technique of a single anastomosis is a significant contribution. Atlas and Lowinger were able to mobilize adequate facial nerve length (where we failed) by removing the mastoid tip, dissecting the facial nerve from the parotid substance past the pes ansarinus, and dividing the facial nerve in the fallopian canal at the second genu.

Results

Between April 1986 and June 1996, we placed a total of 69 grafts in 66 patients (bilateral XII-VII jump grafts placed in three patients). A nerve graft was obtained from the great auricular nerve in 65 instances and the sural nerve in 4. The graft was placed between the partially divided twelfth cranial nerve and connected to the facial nerve at its main trunk in the majority of cases, just beyond the pes anserinus in 10 cases, or two or more of the peripheral branches of the facial nerve arising beyond the parotid in 5 cases.

The XII-VII jump graft procedure was combined with facial-facial crossface grafting in three patients, with regional reanimation techniques such as implantation of eyelid weights, springs, or cartilages and with temporalis muscle transposition in the majority of patients.

Hypoglossal nerve deficits occurred in 9 of 66 (14%) patients. In four patients, the deficits were temporary and recovered, while in five (8%) the deficits were permanent (Table 3–3). Two of the five patients had tongue atrophy. Both had difficulty swallowing and eating, while one had difficulty with speech. One of these patients with tongue atrophy had some difficulty with swallowing, mastication, and speech before the XII-VII procedure because of involvement of multiple cranial nerves III through VII, IX, and X deficits as a result of surgery to repair a brainstem arteriovenous malformation. By adhering to the principles in the surgical technique description, preservation of tongue function is ensured.

Recovery of facial function was noted as early as 3 months and as late as 24 months after XII-VII jump graft placement. Because in some cases the results of surgery were not evident until 2 years after the procedure, results achieved with nerve repair techniques require a minimum follow-up of 2 years.

Facial tone and symmetry were achieved in every patient, as noted with the standard XII-VII procedure. None of our patients experienced mass movement—a problem with the patients who underwent the classic XII-VII procedure—and our patients were less likely to have problems

Table 3–3 Incidence of Permanent Tongue Deficit

	12-7 11 Patients	12-7 Jump 69 Patients
Tongue paresis	–	3 (4%)
Tongue deviation	3 (27%)	
Tongue atrophy	3 (27%)	2 (3%)
Difficulty swallowing or eating	5 (45%)	2 (3%)
Impaired speech	3 (27%)	1 (1%)

Standard 12-7 patients - Eleven of 11 (100%) patients had permanent tongue deficit.

12-7 jump graft - Five of 66 (8%) patients had permanent tongue deficit.

with swallowing, mastication, and speech than those who underwent the classic procedure. Eye reanimation procedures greatly enhanced our patients' ability to separate the eye movement from mouth movement. Restoration of facial movement was excellent in 20 patients (2 of whom were treated for bilateral facial paralysis) (Fig. 3–7) and superb in 6 patients (Fig. 3–8; see Table 3–1).

Conclusion

Our procedure, the XII-VII jump graft, is not uniformly better than the classic XII-VII procedure; however, while the XII-VII jump graft procedure preserves tongue function, the return of facial motor function is not as strong and recovery takes longer compared with the classic procedure (Fig. 3–9). The fact that the recovery is not as strong as a formal XII-VII procedure explains why synkinesis is uncommon with a XII-VII jump graft. Synkinesis is directly related to how much recovery occurs; the more recovery, the more likely the synkinesis will be prominent. Further, the best results are obtained with our procedure when it is performed within 3 months of facial nerve injury, whereas comparable results can be obtained with the classic procedure when repair is performed a year after injury. Perhaps using the technique introduced by Atlas and Lowinger[38] will improve the XII-VII jump graft results and make it even more competitive with the classic XII-VII anastomosis.

We did have excellent results of XII-VII jump graft placement in three of eight patients in our series operated on between 13 and 48 months after facial nerve injury. We believe that in one of these patients, operated on 20 months after facial nerve injury, the excellent results were due more to ancillary reanimation procedures than to the effects of the interposition graft alone. In a second patient, the continuity of the facial nerve had been preserved, although the nerve was injured during surgery to remove an acoustic nerve tumor. The results of nerve grafting in this case were excellent, probably because of the presence of intact axons and lack of complete collagenization of neural tubules. In the third case, reanimation surgery was performed 15 months after facial nerve injury, and although results are usually best when surgery is performed within 3 months of injury, this recommended time window is not absolute.

Finally, for patients with facial paralysis who cannot tolerate compromise in tongue function, placement of a hypoglossal-facial nerve jump graft may provide signifi-

A, B

Figure 3–7. An 8-year-old girl with bilateral facial paralysis 5 months after surgery for astrocytoma involving the brainstem. **A**, Patient looking to the right indicating a right sixth cranial nerve palsy and **(B)** an effort to close the eyes and grimace. There is absolutely no facial movement. **C**, Two years following the XII-VII jump graft and a bilateral gold weight implant. Repose. **D**, Smiling. It should be noted that eye muscle surgery was done to help correct the effect of the sixth cranial nerve palsy. **E**, Closing the eyes.

C–E

F

G

H

Figure 3–7. *(continued)* **F**, Tongue to the left. **G**, Tongue straight ahead and **(H)** to the right indicating no evidence of any motor deficit from the bilateral XII-VII jump graft. (From May M et al.[40] With permission.)

cant improvement in facial function when combined with other facial reanimation techniques without the sacrifice of tongue function that usually accompanies the performance of a classic hypoglossal-facial nerve anastomosis procedure.

Facial Nerve Cross-Face Anastomosis

Since its original description by Scaramella,[23] the cross-face nerve graft technique has been modified by several surgeons including Smith,[24] Anderl,[25] Fisch,[12] and Conley (Fig. 3–10). The major areas of modification relate to the type of surgical exposure for the normal and abnormal sides, the length and timing of the graft hook-up to the paralyzed side and which branches on the normal side are used. Considerable controversy exists as to the value of the cross-face nerve graft. From our experience with over 31 cases, it appears that cross-face nerve grafting should not be employed as the primary procedure, but rather might be of value as an adjunct to other procedures that are performed to restore facial function (Fig. 3–11). The obvious disadvantage of the procedure is that it sacrifices normal facial function for the potential benefit to the paralyzed side. The more distal the branches used on the normal side, the less “fire power” provided; the more proximal, the greater the donor deficit. The length of the nerve grafts requires more time for nerve regeneration, and thus suggests that the procedure must be carried out relatively soon following injury before distal neurofibrosis prevents successful reneurotization.

Our Experience

The facial nerve cross-face anastomosis technique suggested by Fisch[12] was used to treat 19 patients (see Fig. 3–10B), while 12 were treated as suggested by Smith[24] (Fig. 3–12). The results of each technique were comparable. In spite of this, the technique illustrated in Figure 3–12 was preferred for the following reasons: (1) a shorter donor graft could be used, (2) the graft could be taken from the great auricular nerve found within the operative field instead of the longer sural nerve from the leg, (3) the exposure could be done through incisions placed in normal crease lines between the lip and cheek, and (4) very little undermining or dissection was necessary to find the plexus of nerves on the involved and normal sides.

Results

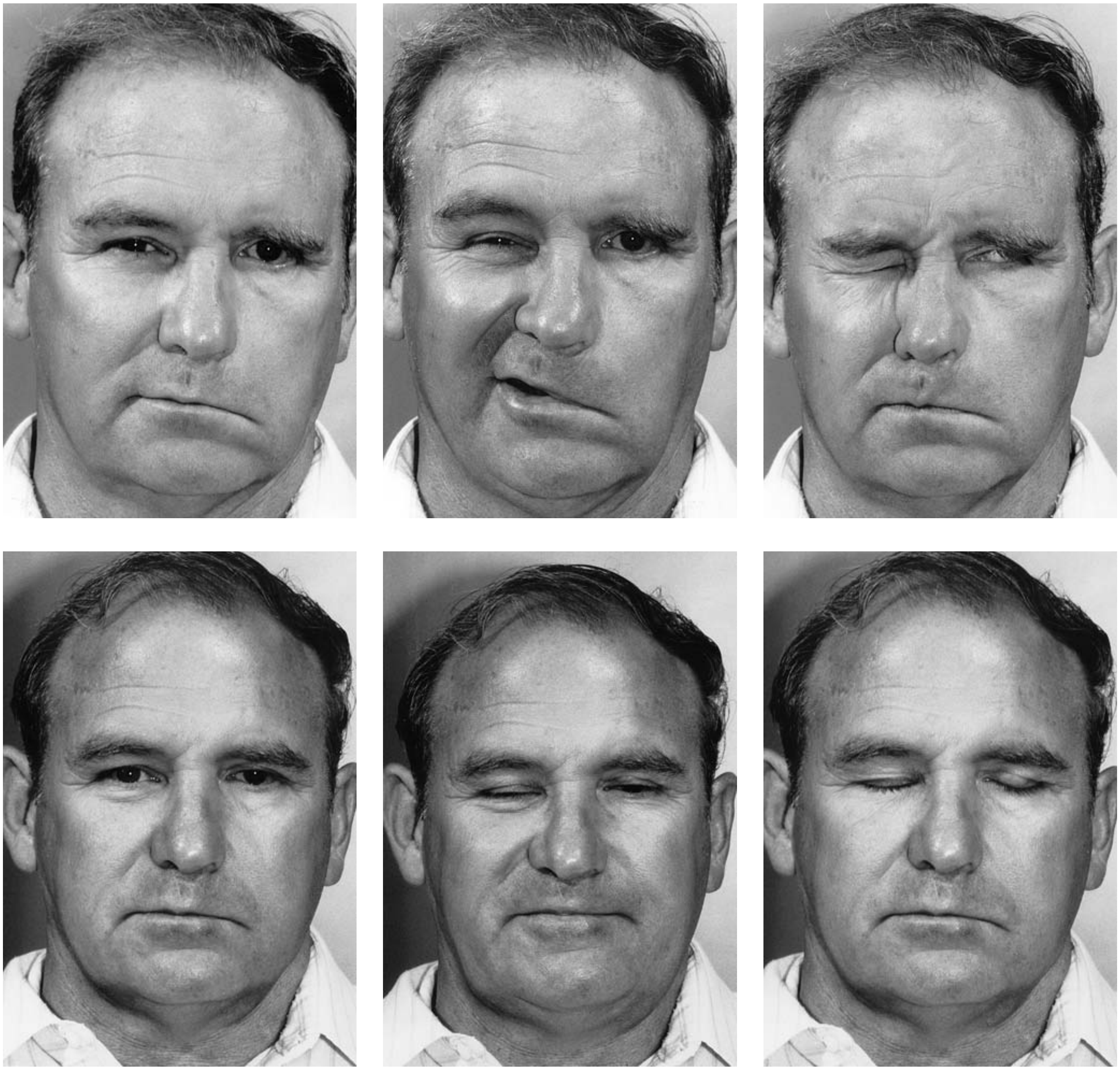
Results could be determined in 15 patients who were available for follow-up. Good results were achieved in seven patients, fair in three, and poor in five. However, these good results may be misleading, because five of the seven patients with good results had incomplete paralysis or had

A–C

D–F

G–I

Figure 3–8. Superb results of XII-VII jump graft performed 3 months after right acoustic tumor surgery. Patient with complete right facial paralysis prior to XII-VII jump graft. **A**, In repose. **B**, Smiling. **C**, Closing eyes. 2 years post-jump graft. **D**, In repose. **E**, Smiling. **F**, Grimacing. There is no tongue deficit. **G**, Tongue to right. **H**, Tongue straight ahead. **I**, Tongue to the left. (From May M et al.[40] With permission.)



A–C

D–F

Figure 3–9. Good result of XII-VII jump graft performed 15 months post-acoustic surgery. Patient with a total facial paralysis prior to XII-VII and gold weight implant procedures. **A**, In repose. **B**, Smiling. **C**, Closing eyes. Fifteen months later. **D**, Facial symmetry and tone. **E**, Lip-cheek crease forming with some lateral movement and elevation of the corner of the mouth, upper lip, and cheek. Return of tone and strength around the eye demonstrated as he pushes his tongue against his front teeth. **F**, Eye closure. Ten days post XII-VII jump graft. *(Figure continued next page.)*

partially recovered function at the time of the procedure and the faciofacial anastomosis was done to further improve the function. Further, two of these five patients were treated by a combination of procedures. Nevertheless, the results were good in two patients who were treated primarily by facial-facial nerve cross-face anastomosis (Fig. 3–11; see Table 3–1).

The disappointing results of the facial nerve cross-face anastomosis procedure noted in five patients were due to sloughing of the graft in one as a result of infection; in another patient, a congenital facial nerve deficit was present, and it is possible that there was not an adequate peripheral neural system or muscles available for reinnervation. The procedure was performed $1\frac{1}{2}$ years after nerve injury in one patient and 2 years or more after the onset of the paralysis in two other patients.

Conclusions

From our experience, it appears that the facial nerve cross-face anastomosis should not be employed as a primary procedure, but rather should be used to power a free muscle graft or to augment other procedures that are performed to restore facial nerve function. The procedure should be performed no later than 6 months after injury, when the central stump is not available, and when the peripheral

Figure 3–9. *(continued)* **G**, Tongue to the right. **H**, Tongue straight ahead. **I**, Tongue to the left. There is no clinical evidence of a motor deficit involving the tongue. Recovery began at 10 months and is slowly improving. It is anticipated that he will continue to improve over a period of 2 to 5 years. The 12-7 jump graft was performed outside the ideal time window and yet useful recovery was achieved. He may benefit from fine-tuning surgery but nothing should be done for at least three years to see the full affect of the initial procedure. Ultimately he may be a candidate for a temporalis muscle transposition to improve lateral mouth function. The advantage of the XII-VII jump graft is mainly tongue-sparing, but it does not give as strong a response as a formal 12-7 crossover.

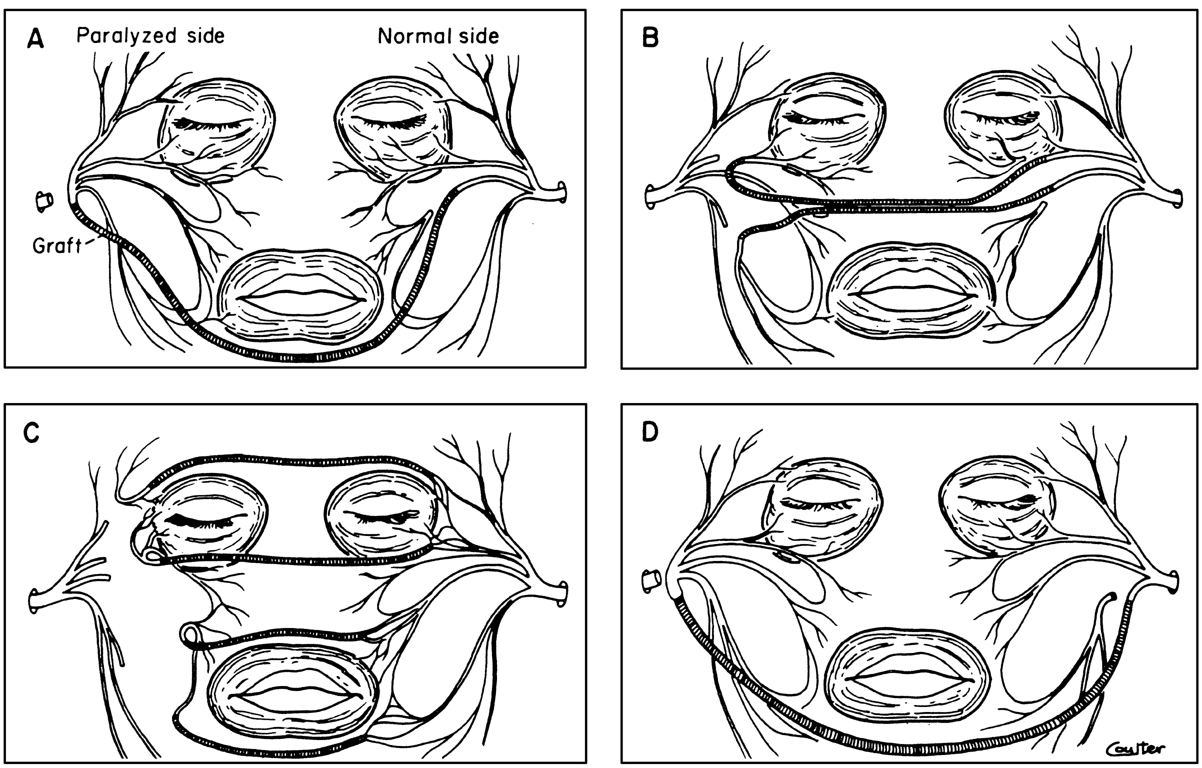


Figure 3–10. Facial cross-face graft technique. Variety of techniques for facial cross-face graft. **A**, Scaramella's cross-face graft. The graft may also be passed over the upper lip. **B**, Fisch's technique. **C**, Anderl's modifications. In Conley's experience, the frontal and marginal mandibular functions returned in only 15% of patients, even with primary nerve grafting. **D**, Conley's preferred technique is to anastomose the entire lower division of the normal side with the main trunk of the paralyzed side. Exposure is easily obtained with standard parotid incisions. The graft may be passed over the upper lip.

system, including neural tubes and muscles, are intact. The same conclusion was reached by Samii,[26] who reported on his experiences managing 22 patients.

Some final words of caution regarding use of the cross-face graft. One must have reasonable expectations from a procedure that by its nature can provide a limited of number of axons and never be able to match the endoneurial surface of the recipient facial nerve. The length of the gap between the donor and recipient can be as long as 24 cm for the formal facial cross-face graft and as short as 7 cm with a mini cross-face graft. There is an advantage to using a shorter graft but the disadvantage is fewer axons to share. On the other hand, the match between the donor and the recipient with a mini face graft is a good one. Perhaps this is the reason that expec-

Figure 3–11. Results of facial cross-face graft. **A**, Three months after resection of an acoustic schwannoma. Note tarsorrhaphy on paralyzed side and sagging face. Facial cross-face nerve anastomosis was performed. **B**, Spontaneous smile 1 year after facial nerve surgery. This is an example of the best results the author has achieved with the technique described in Figure 3–12. (From May M.[41] With permission). A, B

tations for the mini cross-face procedure is more realistic, creating symmetry around the mouth and no more. It is tempting to maximize the number of axons borrowed from the normal donor side but the danger is the potential for creating a deficit on the normal side. A patient was referred following a cross-face graft where the normal eyelid closure became impaired and required restorative procedures. In addition, we have observed synkinesis and weakness on the normal donor side following a cross-face graft.

The facial cross-face anastomosis is a major procedure for the limited expected results. Consider the amount of recovery achieved after taking a double sural graft requiring long vertical incisions in both legs: unsightly scars in the legs as well as required incisions made in the face, the need for two procedures (one to take the graft and one to place it), and the time involved (the procedure to hook the graft up to the recipient site is performed a year after the first). I refer to this procedure as a "long run for a short slide." This procedure should never be performed in a patient who is a potential candidate for another procedure that has a much more reliable and predictable outcome such as the direct nerve repair, the XII-VII cross-over, or the XII-VII jump graft. If the cross-face graft is chosen I suggest that the cross graft be brought under the chin as depicted in Scaramella and Conley's technique (Fig. 3–10). By placing the graft under the chin, it will not interfere with simultaneous or subsequent reanimation procedures such as the temporalis muscle, free muscle, or static procedures that require working in the midface territory.

XI-VII Anastomosis

Anastomosing the spinal accessory nerve to the facial nerve was first reported by Drobnick[1] in 1879. The procedure never gained great popularity because of the shoulder deformity as well as the unnatural result it produced as far as the face was concerned. Patients had a shoulder droop with pain and frequently poor facial tone except when making an effort to move the shoulder. Three patients who were referred had this procedure performed and in each instance, the patient had a sagging face at rest but strong mass movement with an effort to move the shoulder, even though there obviously was no shoulder movement noted (Fig. 3–14). The XI-VII anastomosis does maintain the integrity of the facial peripheral nerve and muscles. Therefore, improvement in facial function is theoretically possible in patients after a successful XI-VII procedure with a XII-VII jump graft. Three patients evaluated following an XI-VII anastomosis turned down the suggestion to possibly improve their situation with further surgery.

There has been a resurgence of interest with this operation based on the possibility of using a branch of the spinal accessory, therefore not incurring a shoulder deformity and yet still achieving facial rehabilitation.[21] The authors overcame shoulder drop by suggesting the use of the sternocleidomastoid branch of the spinal accessory to hook up to the facial nerve. This was quite feasible based on cadaver dissections and histologic cross sectional studies showing that the length of the donor nerve was ample to reach the facial nerve and axon counts from the end of the sternocleidomastoid branch represented 17 to 42% of the cross sectional axon population of the seventh cranial nerve. Clearly, the XI-VII procedure is not competitive with the other techniques that have been described and should be considered only when there are no other options.

Summary

The XII-VII crossover procedure is the gold standard for reanimating a patient when the proximal end of the facial nerve is not available and the peripheral system is viable. The problem with tongue morbidity can be overcome with a XII-VII jump graft although the strength of reanimation is not as strong and it takes longer for recovery. The XII-VII

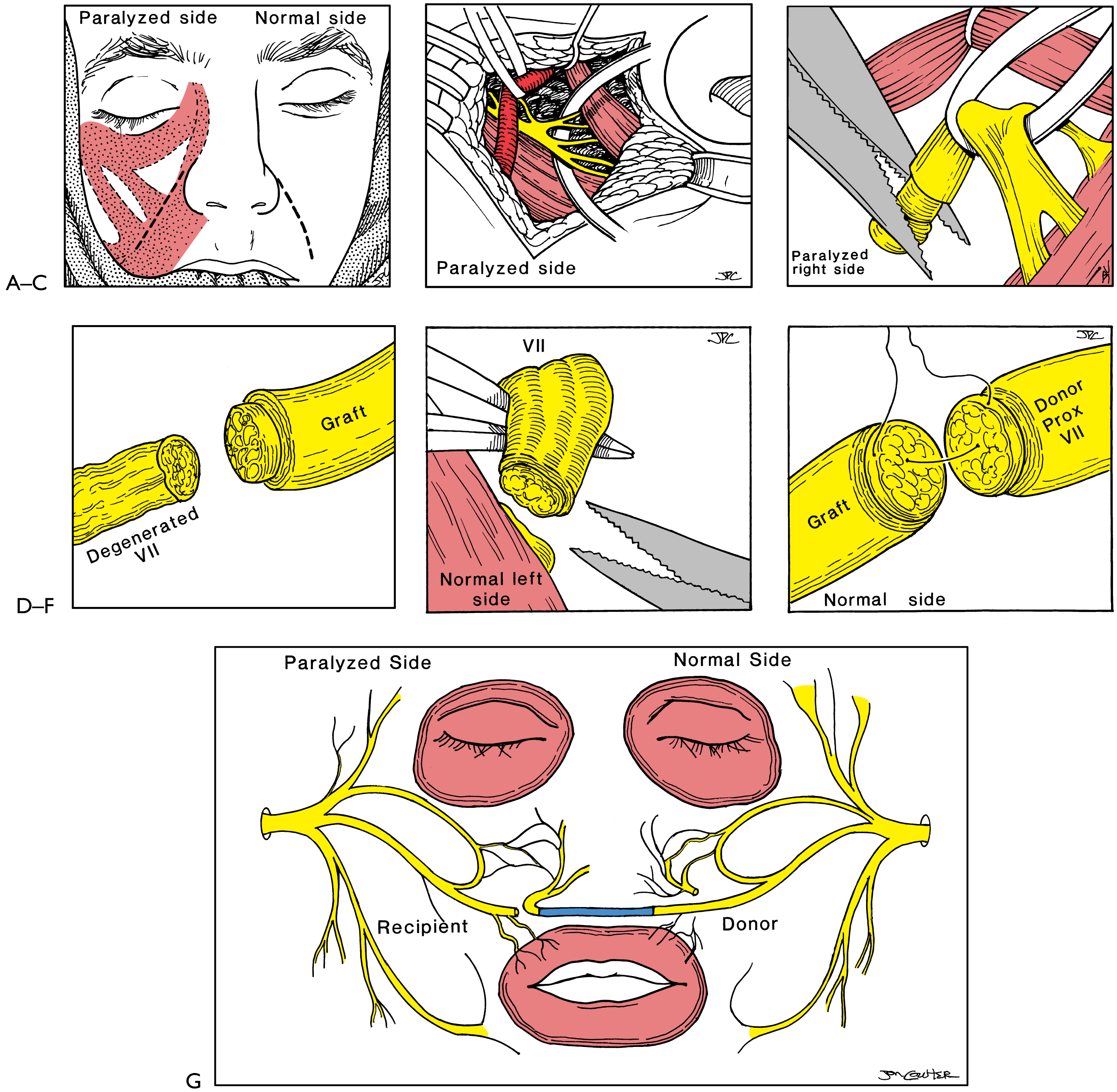
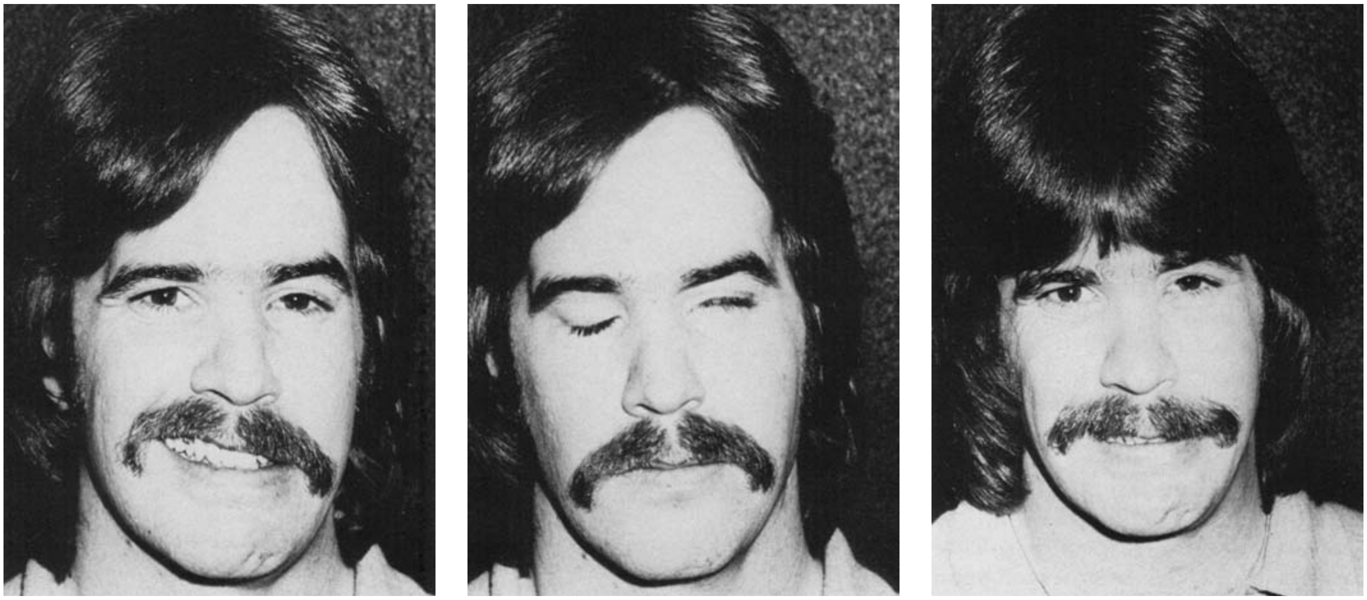


Figure 3–12. Mini-facial nerve cross-face graft technique. **A**, Incisions are made in the lip-cheek crease on each side. **B**, A plexus of facial nerve branches innervating the midface is found just deep to the facial muscles. A plastic marker is looped around these terminal branches as another loop is used to pull the facial artery laterally as it courses over these nerve twigs. **C**, Slight tension is placed on the twigs on the paralyzed side and the proximal portion of the nerve trunk is transected at a point away from their insertions into the undersurface of the facial muscles. A scissors with serrated blades are used. The epineurium is stripped back as described previously. **D**, View through the binocular microscope of the degenerated facial nerve branch on the right paralyzed side. The graft is sutured to the end of the facial nerve branch that will innervate the facial muscles. Note that the number of axons available on the paralyzed side and the fibrous tissue; axon ratio will vary depending upon the time postinjury. The ideal time to perform this procedure is within 30 days of the injury since beyond that time progressive neural tube collapse with collagenization and fibrosis progresses rapidly so that the peripheral system becomes less receptive to reneurotization. **E**, The midface facial nerve plexus on the normal left side is found and sectioned in a similar fashion as was done on the right side, except the facial nerve branch is divided as distally as possible to achieve maximum length for grafting. **F**, Note that there is usually a good axon surface match on the normal side as opposed to the right side where the nerve is undergoing degeneration. The endoneurial surface provided by the graft is usually larger than the distal end of the seventh (the recipient). **G**, This procedure as indicated by its title is a mini procedure directed to reinnervate the oral sphincter region only. Tone, symmetry, and the re-establishment of a lip-cheek crease is useful providing it is part of a comprehensive rehabilitation program and thus should be combined with other reanimation procedures. To be effective, this procedure should be performed within 30 days of injury and not later than 6 months postinjury.

A–C



D

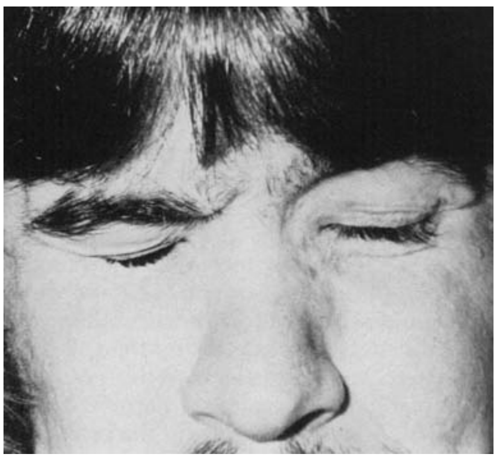


Figure 3–13. Results of facial nerve cross-face graft and temporalis muscle transposition. **A**, Two years following transmastoid interposition graft for an iatrogenic facial nerve injury which occurred during transmastoid surgery. Smile asymmetrical. **B**, Incomplete eye closure. One year following temporalis muscle transposition for eye reanimation and facial nerve cross-face graft surgery; **C**, Smile symmetrical. **D**, Eye closure complete.

A–C

Figure 3–14. Patient 18 years post XI-VII crossover following an acoustic tumor surgery. **A**, Note extreme shoulder droop, the effect of loss of the trapezius muscle. With shoulder relaxed, the left side of the face droops. There is no tone. **B**, Note facial asymmetry is more marked with a spontaneous smile. **C**, Pleasing voluntary facial expression with activation of the eleventh nerve by her voluntary attempt to lift the shoulder. Note contraction of the sternocleidomastoid muscle and lower trapezius as she uses the eleventh nerve to power the facial area. Based upon my observation evaluating five patients rehabilitated with an XI-VII crossover, this is typical of the best results achieved. Also note left cornea is opacified from exposure keratitis. Usually this can be prevented by early aggressive therapy (see Chapter 6).

jump graft option is competitive with the standard XII-VII procedure provided it is performed within 30 days following nerve injury and not later than 1 year. The facial-facial cross-face graft gained great popularity in the 1980s, but most surgeons have been disillusioned with its results and the procedure is now relegated as a procedure for powering a free muscle, or is combined with other techniques. The amount of reanimation achieved with a cross-face graft cannot stand alone and should be part of a system of procedures to offer a patient the greatest potential for symmetry and maximum voluntary movement with protection of the eye and oral competence. The XI-VII procedure has no place at all in the list of options for facial reanimation except when there is no other option.

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4

Muscle Transposition Techniques: Temporalis, Masseter, and Digastric

Mark May, M.D.

Regional muscle transposition is a proven effective means to reanimate the mouth in patients with long-standing facial paralysis and in selected patients undergoing facial nerve grafting or hypoglossal-facial nerve anastomosis. There are **three regional muscles** available for reanimation. The *temporalis muscle* is the most popular because of its location, length, contractility, and vector of pull to restore the position of the corner of the mouth to create a lateral smile (Fig. 4–1). The *masseter muscle* is the second choice in the event that the temporalis muscle is not available or under certain circumstances to augment the effect of the temporalis muscle or following radical parotid surgery. The *digastric muscle* is also available for transposition to partially restore the loss of the depressor effect on the paralyzed lower lip.

The reanimation surgeon must keep in mind that regional muscle transposition techniques are one component in a comprehensive program to improve facial function. This program includes one or more of the following: (1) facial nerve grafting (see Chapter 2), (2) hypoglossal-facial anastomosis (see Chapter 3), (3) eye reanimation procedures (see Chapter 6), (4) static-suspension techniques to "fine-tune" the results achieved with the procedures mentioned (see Chapter 7), (5) combination procedures (see Chapter 8), (6) cosmetic camouflage (see Chapter 9), and (7) patient education to achieve maximal control of voluntary muscle activity.

Because the historical review of regional muscle transposition for facial reanimation (Fig. 1–1) as well as general perspectives and guiding principles have been covered in great detail in Chapter 1, they will not be repeated here. Rather, the material in this chapter will stress those aspects of regional muscle transposition that are of greatest interest to the reanimation surgeon.

Temporalis Muscle Transposition

The temporalis is the most useful regional muscle available for transposition to improve the position of the corner of the mouth and restore a voluntary lateral smile in a patient with long-standing facial paralysis (Fig. 4–2).

The vector of the temporalis muscle is best suited to help restore a *lateral smile, the most common type of human smile* (Fig. 4–1). Restoring a *canine smile* is more difficult, and a "*full-denture*" smile is not recommended for reasons that will be mentioned later. However, the voluntary balanced lateral smile may be achieved provided the patient is motivated and willing to work with a well-trained therapist. Although results are dependent on surgical technique, one cannot expect successful results in a patient who is not interested or capable of learning how to use the new system and more importantly in a patient where the muscle itself is compromised (Fig. 4–3).

The strength of the temporalis muscle is weak in the edentulous patient. Further, patients who have loss of posterior teeth and who occlude on their incisors also fit into this category. These patients are not ideal candidates for the temporalis muscle procedure. On occasion, patients with a developmental facial paralysis may also have involvement of other cranial nerves. In such cases, it is important to evaluate the integrity of the temporalis muscle. Finally, in patients who have had skull base or middle cranial fossa surgery, the temporalis muscle may be partially or completely denervated, injured, or removed as part of the surgical procedure.

Save the Temporalis Muscle

The temporalis muscle may be damaged by the surgeon performing middle fossa or skull base surgery. Every effort must be made to preserve the temporalis muscle, considering it is essential for facial reanimation in patients who are not candidates for nerve grafting or cranial nerve substitution.

The usual approach described for middle cranial fossa surgery involves making a cruciate incision in the temporalis muscle or a hockey-stick incision across its base, thus significantly compromising the muscle for any future use in the event that facial reanimation is required. May et al.[1] stressed preserving the temporalis muscle and recommended that it be preserved in middle fossa surgery. The muscle is elevated in an inverted U-shaped fashion from the temporal squama subperiostially without compromising the surgical approach to the middle cranial fossa (Fig. 4–4).

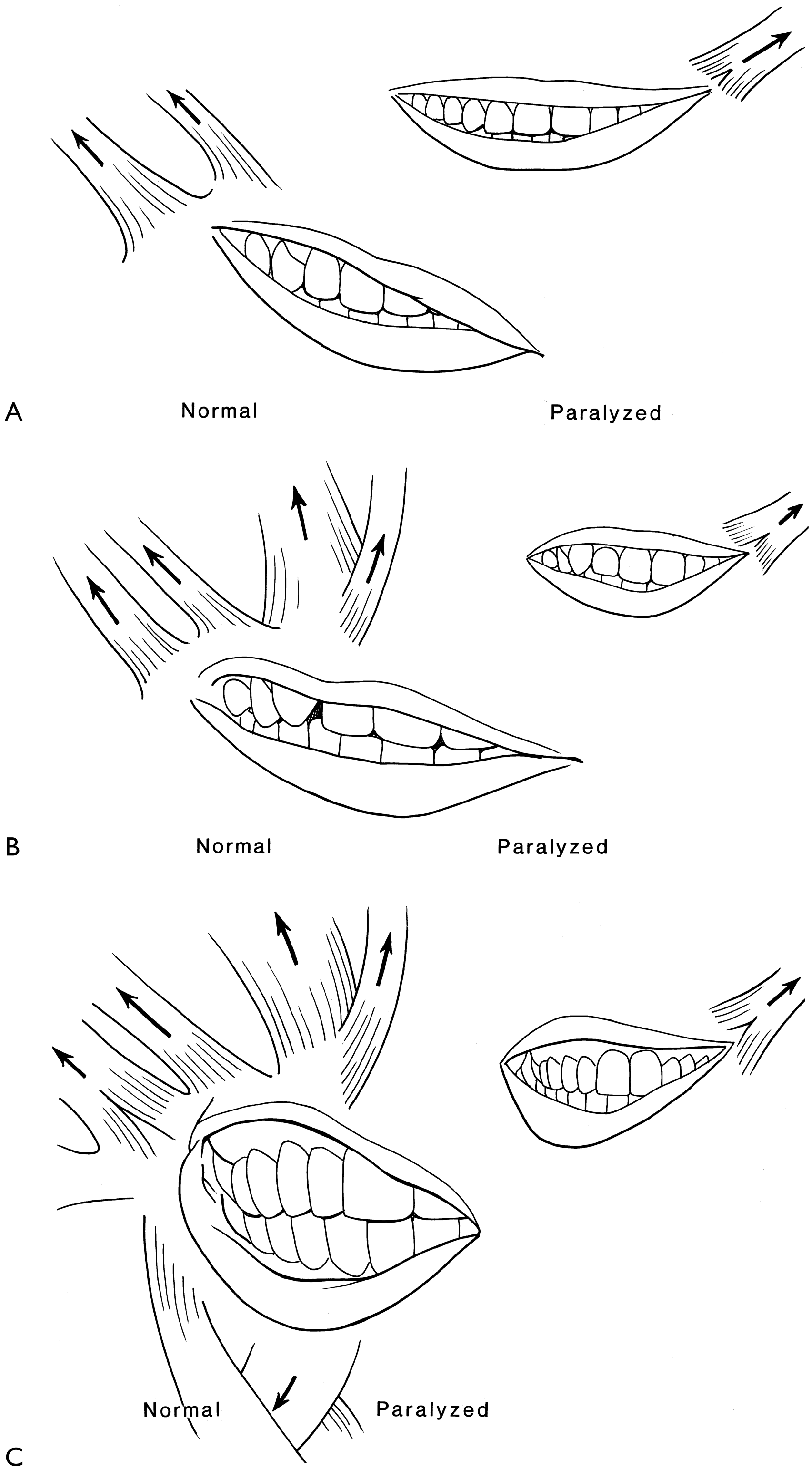
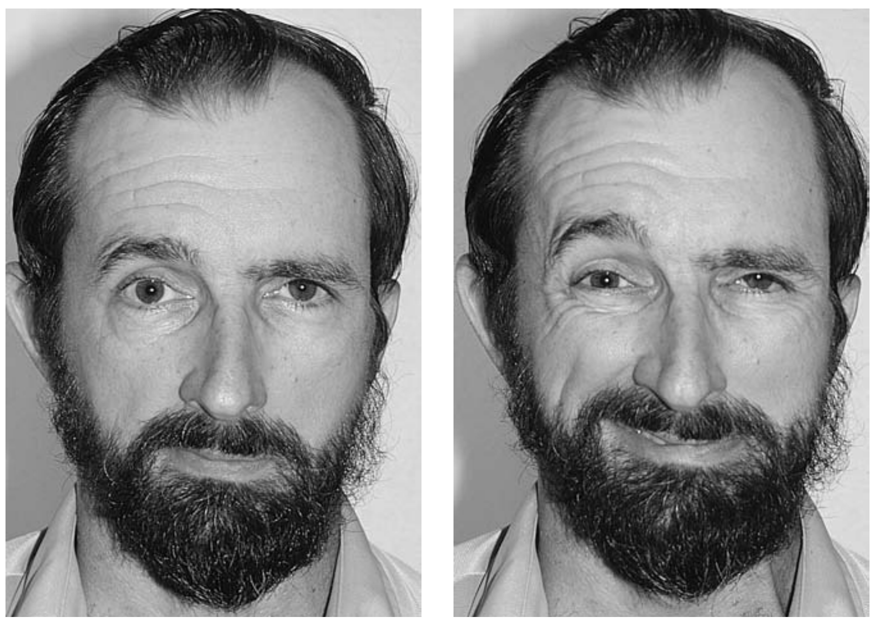


Figure 4–1. There are three types of smile: lateral, canine and full. **A**, The lateral smile is the most common type and is produced by the lateralizing muscles of the mouth (see Chapter 6). The temporalis muscle transposition procedure is ideal to reconstruct the lateral smile in a patient with facial paralysis because the transposed temporalis muscle's vector of pull is in the upward and lateral direction (see Fig. 4–12). The canine **(B)** and full smile **(C)** are more difficult to reproduce. Actually, there is a risk of producing oral incompetence by adding an upward lift to the upper lip in an effort to recreate a canine smile and oral incompetence is a certain outcome when a full smile is produced (see Figs. 4–8 and 4–9). Therefore, reconstruction of the lateral smile should be the reanimation surgeon's goal. Patients with the less common types of smile (canine and full) can learn to modify their normal side to imitate the reconstructed paralyzed side .

A–C

Figure 4–2. Ideal candidate for temporalis muscle transposition. Immediate reanimation and possibility to augment results of nerve graft. Patient presented with slowly progressive right-sided facial paresis over a period of $2\frac{1}{2}$ years. **A**, Note widened interpalpebral fissure, drooping lower eyelid, loss of facial creases, and inability to smile on the paralyzed right side. **B**, Eight weeks following resection of vertical-horizontal segment of facial nerve enveloped by an arteriovenous malformation. Note the pleasing voluntary smile achieved with temporalis muscle transposition procedure performed at time of tumor resection. A gold weight inserted into right upper eyelid causes a slight drooping but improved corneal protection. A nerve graft was performed as well, but 8 weeks is too short a period for any useful return of function. **C**, Two years following nerve graft, a spontaneous smile is noted. Compare **B** to **C**: **B**, There is a controlled voluntary symmetrical smile but no facial creases. **C**, A spontaneous smile with return of facial creases indicates significant facial nerve regeneration. The results of the nerve graft are augmented by the temporalis muscle transposition procedure. The temporalis transposition does not disrupt or interfere with the facial nerve branches (see Fig. 4–7). (From May M et al.[6] With permission.)

Figure 4–3. Poor candidate for temporalis muscle transposition. Temporalis muscle was used to fill in skull base defect. **A**, **B**, One year postresection of jugular foramen schwannoma. The facial nerve was divided and repaired with an interposition graft. Note facial tone has returned. There is slight movement of the corner of the mouth on the involved left side. Improvement in facial function as a result of the nerve graft will continue. **C**, **D**, A depression was noted in front of the ear and above the zygomatic arch. There was no temporalis muscle palpated when the patient was asked to clench his teeth. A review of the operative note explained the absence of the temporalis muscle.



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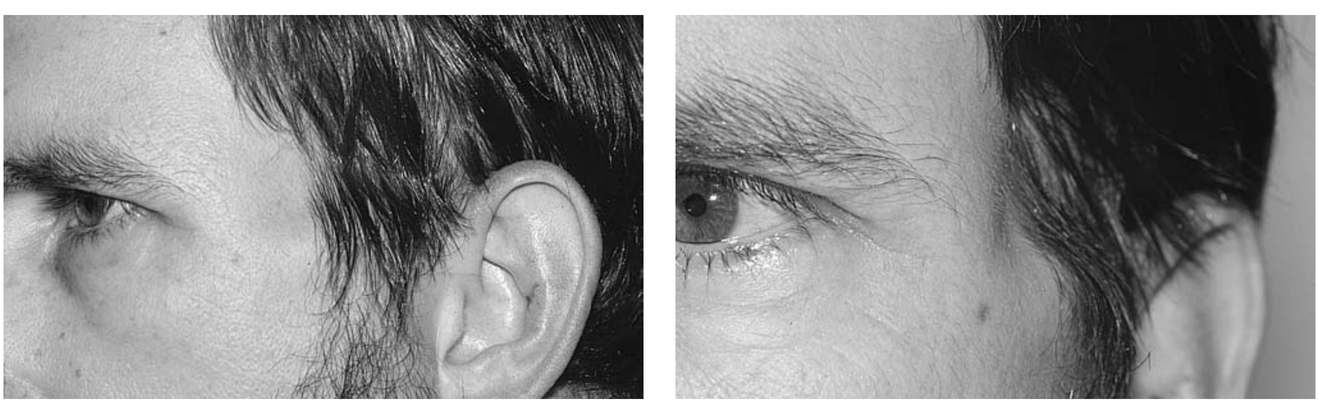
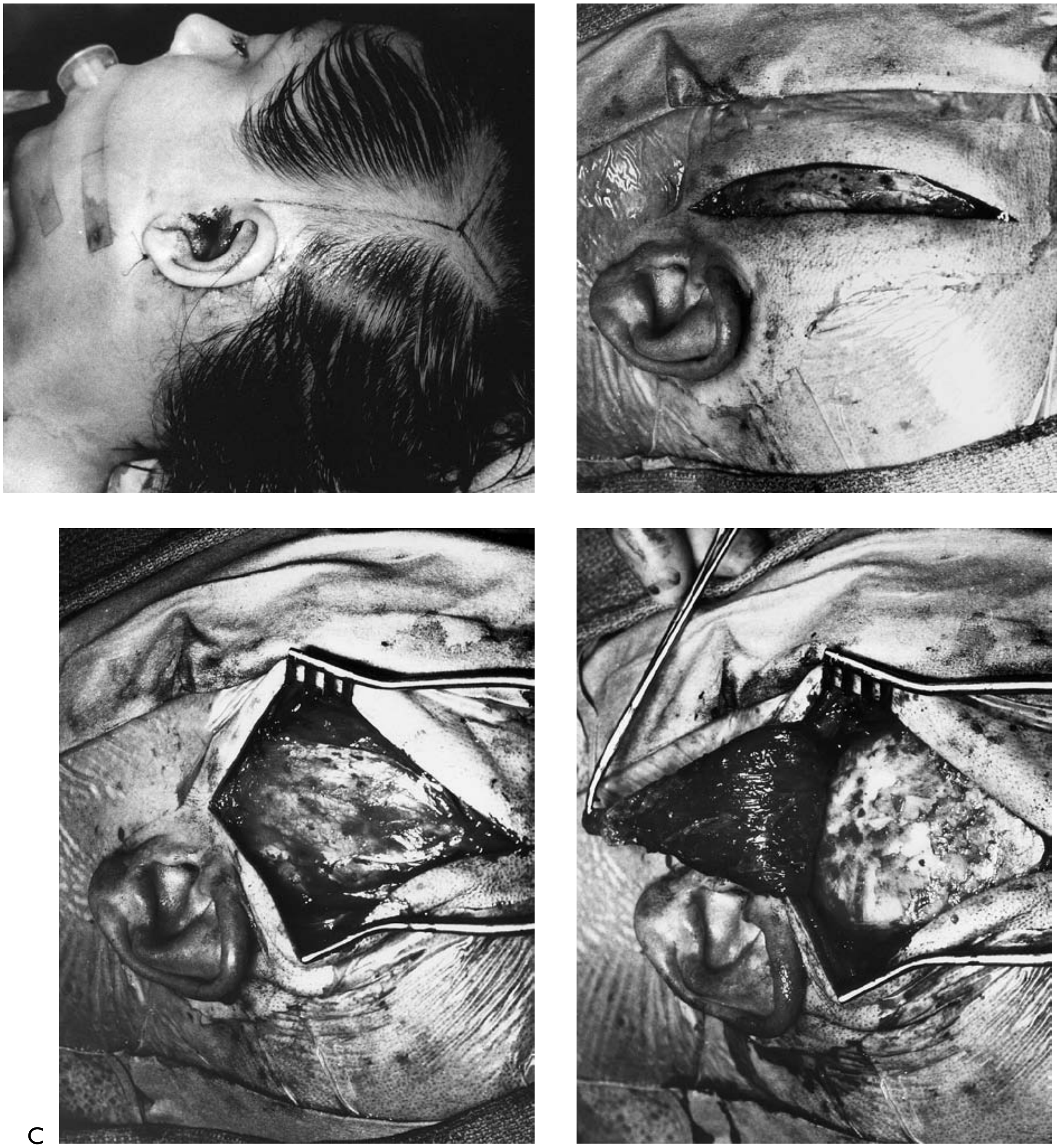
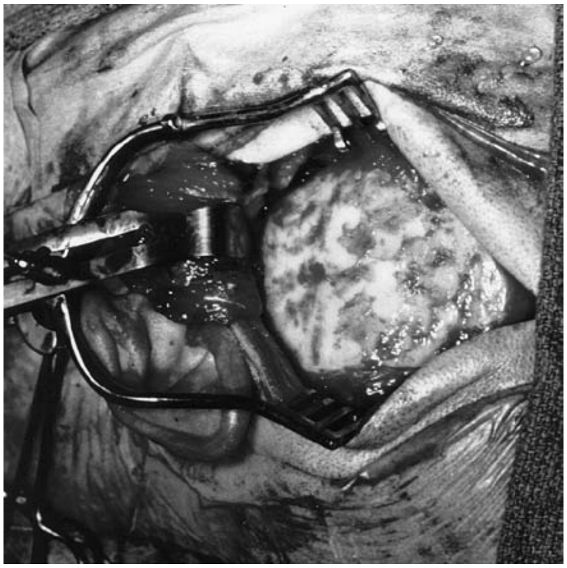


C D



A B C D

Figure 4–4. The temporalis muscle can be preserved without compromising exposure for middle fossa surgery. **A**, Scalp incision outlined. **B**, Vertical incision down to temporalis fascia. **C**, Large self-retaining retractor in place. **D**, A 4-cm-wide inferiorly based U-shaped flap is incised over the middle of the temporalis muscle following the longitudinal course of its fibers. This fascia-muscle-pericranial flap is developed by subperiosteally dissecting the temporalis muscle away from the cranium. The flap is rotated inferiorly to the level of the zygomatic arch.


E


F


G


H


I

Figure 4–4. *(continued)* **E**, The flap is held in place with a self-retaining retractor. **F**, Following the middle fossa procedure, the bone flap that was removed is replaced. **G**, The temporalis muscle is sutured back in place. **H**, Post-middle fossa procedure to resect facial nerve schwannoma. Eye reanimation has been performed with eyelid spring, lower lid tightening, and cartilage implant (see Chapter 6). **I**, Two months following middle fossa procedure, the temporalis muscle was used to reanimate the mouth. A voluntary smile is produced 6 weeks post-temporalis muscle transposition.

Author's Experience

Muscle transposition comprised approximately 10% of the 3068 reanimation procedures performed (Table 1–4). Two hundred eighty-six temporalis transposition procedures were performed on 267 patients between January 1977 and June 1996 (Table 4–1). It is important to note that the temporalis muscle was used to reanimate the eye during the early experience (Fig. 4–5). However, using the temporalis muscle to reanimate the eye and mouth created less than ideal results: (1) the eye and mouth moved as a unit, (2) the lower lid frequently became ectropic, and (3) a large bulge formed over the check, and a deep depression was noted in the temple area. In addition, using the temporalis muscle for the eye was effective for closing the eye during the day hours, but during sleep when the temporalis muscle was relaxed, the involved eye usually stayed open. Based on these observations, the temporalis muscle is no longer used for eye reanimation. The preferred approach is to reanimate the eye separately from the mouth (see Chapter 6). In this way, patients can control the voluntary movements of the eye region independently from the lower face with a more natural result.

A major advantage of temporalis muscle transposition is the possibility to reanimate or augment patients with partial facial function or patients likely to have some recovery (Figs. 4–2 and 4–6). More than one third of the patients treated with the temporalis muscle transposition had incomplete facial palsy (Table 4–1).

Because the facial nerve lies deep to the superficial musculoaponeurotic system (SMAS), the temporalis muscle can be transposed through a tunnel over the superficial SMAS and beneath the subcutaneous tissues of the face without disturbing the facial nerve fibers (Fig. 4–7). Based on this fact, the temporal muscle procedure can be performed at the same time as a nerve repair or XII-VII crossover. This gives the patient an immediate improvement and in no way interferes with the ultimate outcome of the nerve repair technique (Fig. 4–2). Further, the results of a nerve repair or a XII-VII crossover are enhanced by the temporalis muscle transposition procedure.

Table 4–1 Temporalis Muscle Transposition in 267 Patients January 1977 To June 1996

Female:Male		3:2
Age (years)		2.5–83
Procedures		286
Mouth	255	
Eye	18	
Eye and mouth	13	
Bilateral		6
Mouth	5	
Eye and mouth	1	
Palsy		
Complete		177
Incomplete		90

How the Operative Technique Evolved

Rubin[2] and Baker and Conley[3] popularized the technique of temporalis muscle transposition and frequently combined it with the masseter muscle for facial reanimation. As a student of Rubin and Conley, I am most appreciative of their guidance in the application of this technique for the benefit of my patients.

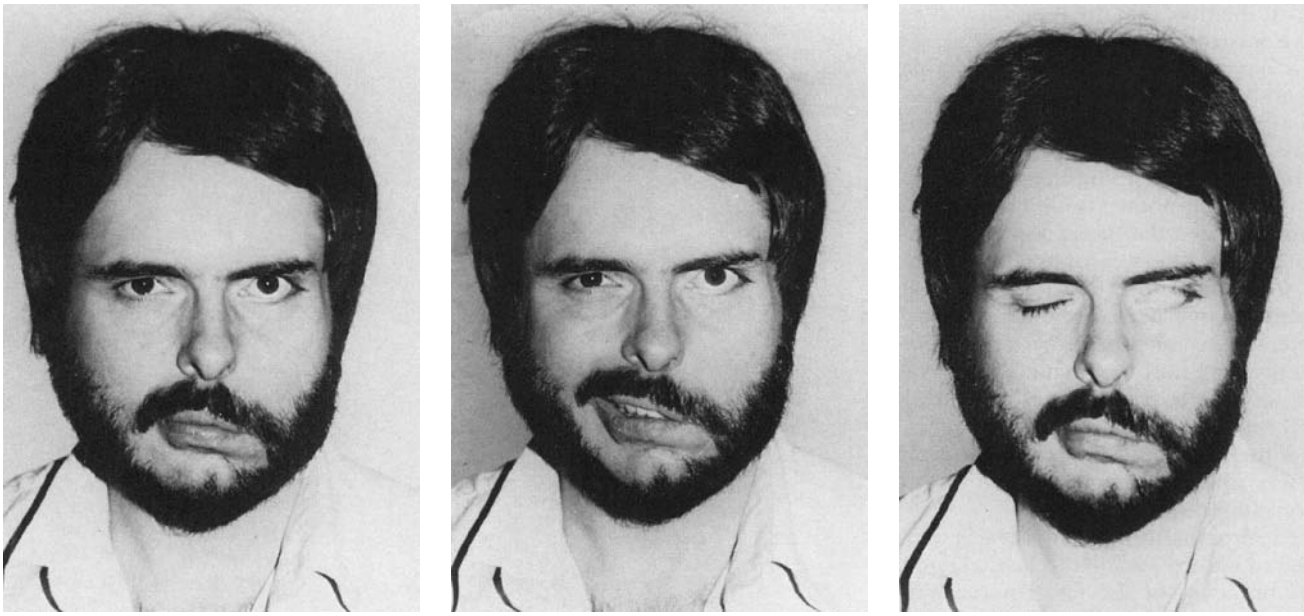
My initial experience with the temporalis muscle was disappointing until I visited Dr. Leonard Rubin and observed the master at work. He shared with me all of the fine points that he learned over the years while developing a procedure that was reliable and producible. Rubin's philosophy and details of his technique are described and illustrated in the previous edition and in his own textbook published in 1977.[4]

The surgical technique that will be described evolved over a period of 20 years and is based on what I learned from my teachers and patients, and by trial and error. The patient's preoperative and postoperative photographs and videotapes as well as the details of the surgical procedure performed, were critically reviewed, and the progress made in the postoperative period was carefully evaluated.

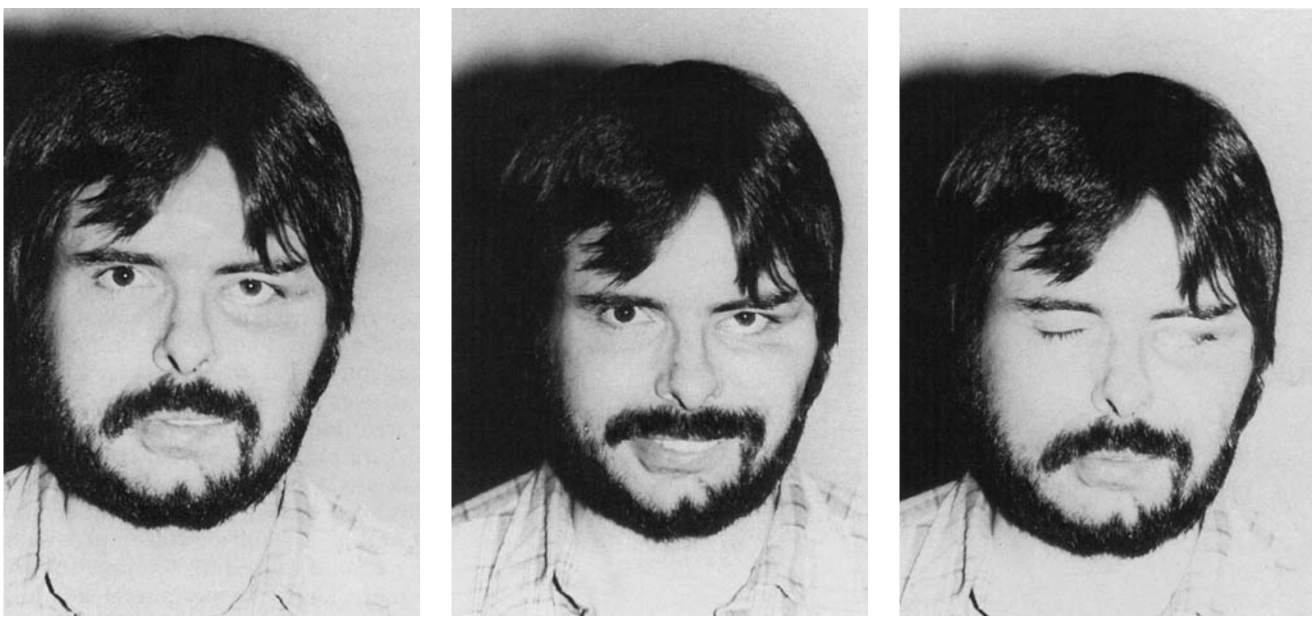
In our first review in 1984,[5] we reported that the temporalis muscle was best used to reanimate only the mouth and that other techniques should be used for the eye region. The muscle lengthening approach suggested by Rubin[4] was modified by Conley.[3] Rather than removing the facia over the temporalis muscle and then reattaching it as suggested by Rubin, Conley incorporated periosteum attached to the skull as the preferred tissue to lengthen the muscle. Another modification of the Rubin technique was to use the middle portion of the temporalis muscle and attach it to only the corner of the mouth, rather than using the entire muscle and attempting to reconstruct the mirror image of the smile on the normal side.

I found that I could not reproduce the goals set by Rubin to create the exact smile of the normal side on the paralyzed side (Fig. 4–1). When I tried to create a canine or full smile, oral incompetence or gaposis was caused (Figs. 4–8 and 4–9). Although both Rubin and Conley frequently used the masseter muscle in conjunction with the temporalis, I found that excellent results were achieved with temporalis muscle alone. The masseter muscle added bulk; and therefore, its use was limited to situations where additional bulk was advantageous. Further details regarding the masseter transposition techniques will be discussed subsequently.

The bulkiness over the zygomatic arch created by the temporalis muscle transposition was overcome to some extent by making a wide tunnel from the root of the zygoma just in front of the tragus to the lateral orbital rim. If two fingers could be comfortably placed in the tunnel over the zygomatic arch at the base of the incision used to obtain the temporalis muscle, the muscle would lie in a flattened state rather than being bunched up as it would be in a narrow tunnel. In addition, in cases with total paralysis



A–C



D–F

Figure 4–5. Results of temporalis muscle transposition to reanimate eye and mouth. **A**, Thirty years after a sudden complete left facial paralysis thought to be due to an ear infection at age 3. Face in repose shows loss of tone, widening of the interpalpebral fissure, collapse of the lateral nasal ala, and sagging of the corner of the mouth. **B**, Voluntary smile. **C**, Voluntary eye closure. **D**, Two months following temporalis muscle transposition to reanimate the eye and mouth. Note symmetry of face, especially interpalpebral fissures. The lateral nasal ala is in its normal lateral position, and the bulge over the cheek created by the transposed muscle is minimal. **E**, A voluntary smile is created by clenching the teeth. Note the corner of the mouth is pulled laterally to show the upper teeth in a natural way. In spite of the fact that the patient is clenching his teeth to smile, the eye is not closing, showing that individual movements can be developed by highly motivated patients. **F**, Attempt at eye closure without the mouth moving by clenching the jaw. Compare the amount of eye closure achieved in the postoperative period with that seen preoperatively.

and where nerve regeneration was not anticipated, the fat pad above the zygomatic arch was resected. Facial nerve fibers destined for the eye and midface region pass through the suprazygomatic arch fat pad, so this fat pad should not be disturbed except in the condition mentioned. Placing the temporalis muscle under great tension by stretching it to its limits prior to fixing it to the corner of the mouth greatly diminishes the temporalis bulge in the cheek region. When a bulge formed in the postoperative period, it was usually due to the temporalis muscle separating from the attachment to the corner of the mouth. Reattaching the temporalis muscle to the corner of the mouth can correct this problem.

The defect left by the muscle in the temporal fossa was initially corrected by a Silastic block. This carved block was uncomfortable for the patient because it was too firm and

A, B

Figure 4–6. Temporalis muscle transposition to improve impaired facial function following Bell's palsy. Patient presents with hypo- and hyperkinesia due to faulty regeneration following Bell's palsy on the left side. **A**, Note with effort to smile, the left eyebrow elevates, the left eye is wider, the nose is pulled to right, the upper lip droops, and the chin dimples. **B**, Result achieved with temporalis muscle transposition. (From May M et al.[17] With permission.)

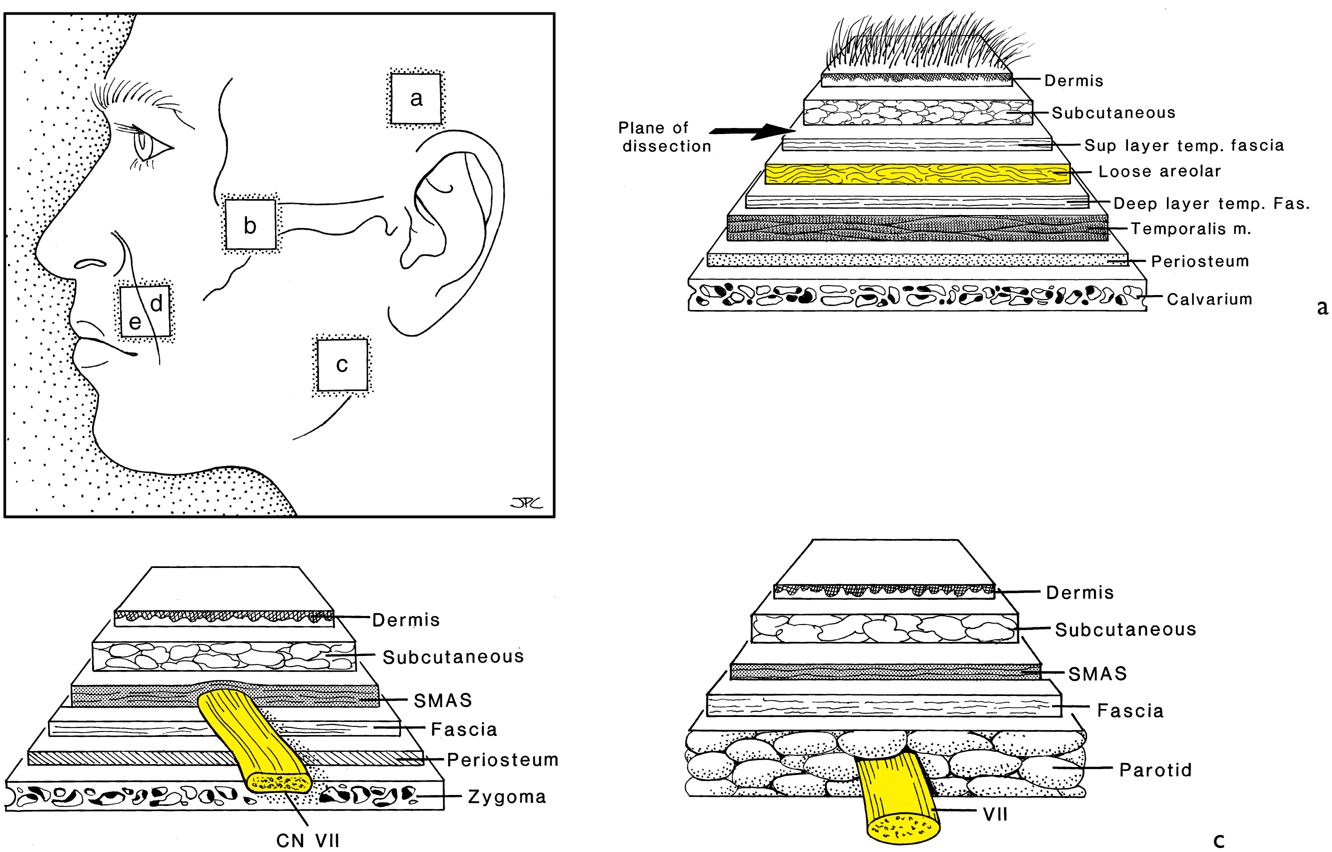
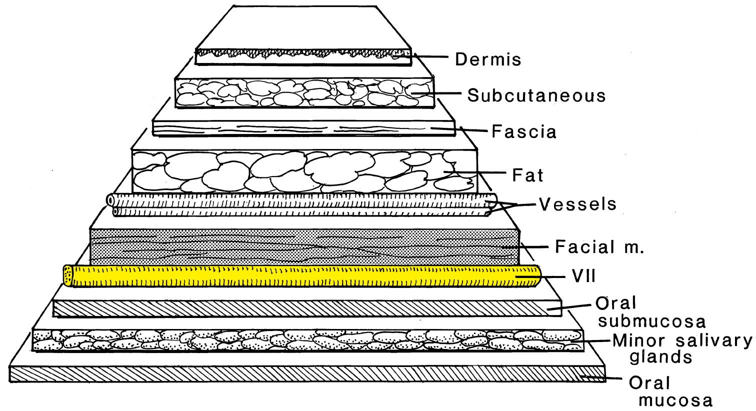
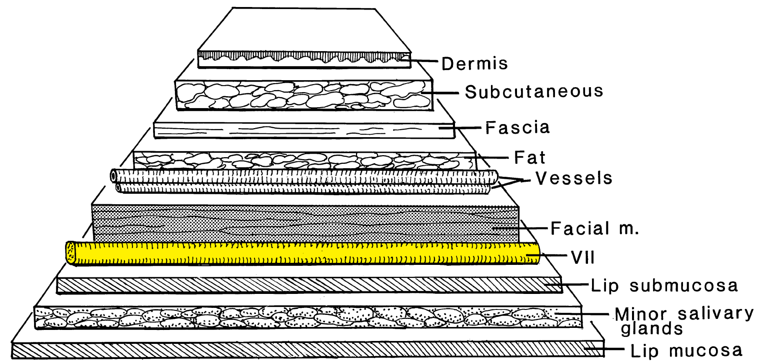


Figure 4–7. Anatomical basis for location of tunnel to pass the temporalis muscle without injuring the facial nerve. Cross-section in various areas of the facial soft tissues showing relationship of the facial nerve to the SMAS. **A**, The map indicating sites sampled. **a**, Sampled from scalp region (area a on map). The plane of dissection is where tunnel begins in the temporal area and extends to soft tissues covering the the zygomatic arch. The temporalis muscle will be rotated downward and passed through this tunnel to reach the mouth area. Facial nerve fibers of the upper division pass through the loose areolar tissue between the superficial and deep layers of the temporalis fascia. **b**, Sampled from area over zygomatic arch (area b on map). The facial nerve branches lie deep to SMAS from here to the lip-cheek crease where the nerve fibers run deep to the facial muscles. The tunnel for the temporalis muscle is developed by blunt dissection between the subcutaneous tissue and SMAS. **c**, Sampled from parotid region (area c on map). The facial nerve is enveloped and protected by the parotid gland.

Figure 4–7. *(continued)* **d**, Sampled from the cheek region above the lip-cheek crease (area d on map). The facial nerve is deep to the facial muscles. The tunnel for the temporalis muscle ends in this area and is fixed to the oral lip submucosa (see F). **e**, Sampled from the cheek region just below the lip-cheek crease (area e on map). The facial nerve is deep to the facial muscles. The tunnel for the temporalis muscle ends here and is fixed to the lip submucosa. The suture must not penetrate the mucosa and communicate with the oral cavity. For more anatomical details and discussion, see Chapters 2 and 6. (Modified from Liebman EP et al.,[18] Pensler JM et al.,[19] and Mitz V, Peyronie M.[20])



d



e

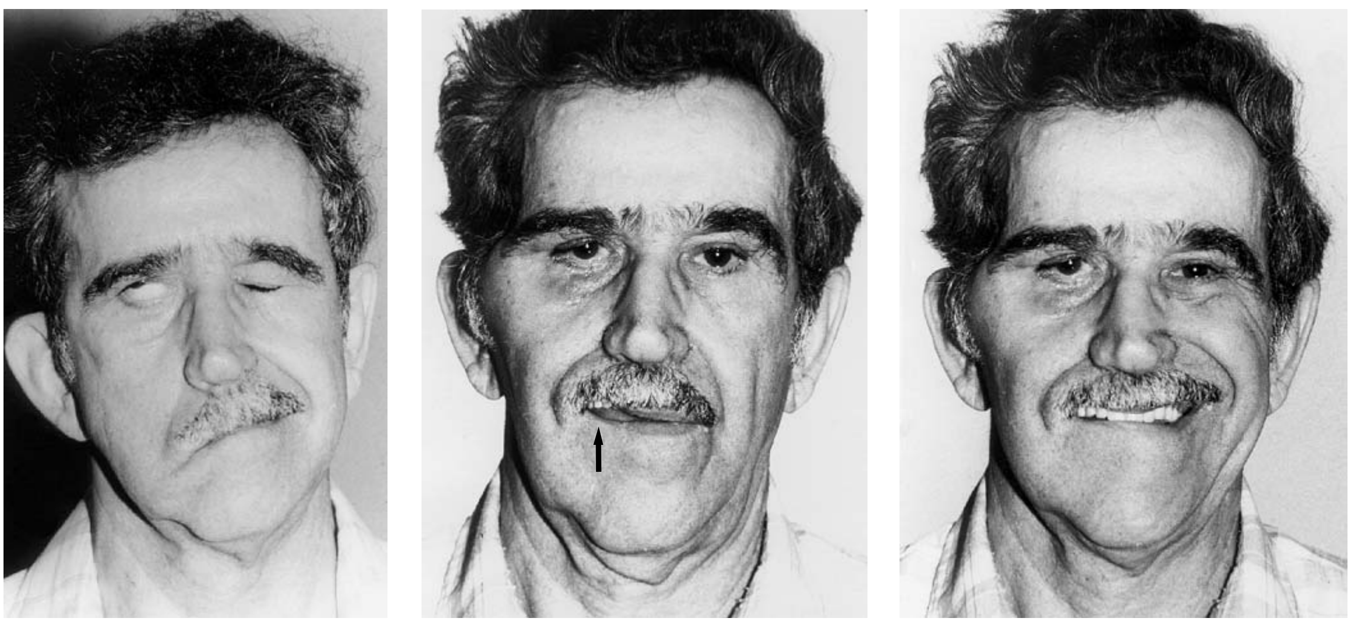
A, B

C, D

Figure 4–8. Example of oral incompetence "gaposis" due to temporalis muscle transposition over correction. **A**, Patient 2 years post-acoustic surgery. Temporalis muscle transposition is performed. **B**, Dissection in lip-cheek crease. **C**, The submucosa is identified. The gloved finger is used to prevent the fixation suture between the temporalis muscle and submucosa from entering the oral cavity (see Figs. 4–7d and e). **D**, Note the overcorrection which is desirable. *(Figure continued next page.)*

E–G

Figure 4–8. *(continued)* **E**, Face-lift is combined with the temporalis muscle transposition. **F**, **G**, One year following reanimation surgery. At rest and producing a voluntary smile. The result is excellent (see Fig. 4–14 for classification system). Note the "gaposis" (arrow) in the lateral commissure in **F**, and mucosal bubblelike fullness (arrow) in the lateral commissure area in **G**. This required lateral commissureplasty (see Chapter 7 for technique). (From May M.[5] With permission.)



A–C

Figure 4–9. Example of oral incompetence "gaposis" due to creating canine smile with temporalis muscle transposition. **A**, The patient presented with progressive facial weakness over a period of 2 years. The involvement is total with a flaccid paralysis. An osseous hemangioma was removed from the parageniculate ganglion area, and the mouth was reanimated with a temporalis muscle transposition and eyelid with a spring implant. **B**, Note the "gaposis"-oral incompetence due to an effort to create a canine smile (arrow). **C**, The result, except for oral incompetence, was considered excellent. The patient was so delighted with the cosmetic result that he was not interested in revision surgery.

created a foreign-body sensation. In addition, there were two cases where the block actually extruded.

The temporalis muscle for facial reanimation was used in 224 procedures over a 13-year period.[6] As noted in this report,[6] the Silastic implant was no longer available commercially because the manufacturer withdrew all Silastic implant products as the result of litigation involving breast implants. Because of this, the defect created in the temple area was filled in with a pericranial flap consisting of the superficial temporal fascia vascularized by the temporal artery and vein as suggested by Dr. Mack Cheney at the Ohio State Head and Neck Reconstruction Symposium in June 1992. Cheney et al.[7] reported their experience with 30 patients using the temporoparietal fascial flap to obliterate the temporalis muscle donor site. In our experience, this flap did not provide enough tissue to fill most defects and tended

A B

Figure 4–10. Alopecia as a consequence of raising a temporoparietal fascial flap to fill in temporal depression created by the temporalis muscle transposition procedure. **A**, Loss of hair anterior and posterior to vertical incision used to expose the temporalis muscle. The loss of hair is due to injury to hair follicles where the temporoparietal fascia is separated from the overlying subcutaneous tissue layer. **B**, The hairstyle in women usually allows adequate coverage, but this may not be true in men.

to become depressed over time. On occasion, alopecia was noted in the area where the temporoparietal fap was dissected from the subcutaneous layer along the incision site (Fig. 4–10). A trial with Gore-Tex to fill in the defect was associated with a high infection and extrusion rate. Presently, our preferred technique involves rotating the residual temporalis muscle into the defect (see Surgical Technique).

In the 1993 temporalis muscle update report,[6] we noted that polytef (Gore-Tex) used as a muscle extender was associated with a delayed 30% extrusion rate. As a result of this observation, we began using autologous tissue such as fascia lata in preference to Gore-Tex.

Surgical Indications

The most common indication for temporalis muscle transposition is for patients following acoustic tumor surgery (Table 4–2). The following are specific indications for muscle transposition surgery to reanimate the face: (1) developmental facial paralysis in a patient of consenting age, defined as one who understands the risks, potential complications, and benefits, (2) long-standing facial paralysis, defined as no improvement in facial function for a period of time sufficient to be certain that spontaneous regeneration is unlikely—usually 2 years or longer, (3) following cerebellopontine angle surgery when the proximal stump of the facial nerve is unidentifiable or is unsuitable for facial nerve grafting and when the patient refuses to have the hypoglossal nerve sacrificed, (4) massive soft tissue loss as a result of a shotgun wound to the face, (5) poor prognosis for long-term survival following total resection of the parotid, or

Table 4–2 Temporalis Muscle Transposition in 267 Patients (January 1977 to June 1996)

Causes of Paralysis		
Trauma		156
Iatrogenic*	142	
Accidental	14	
Tumor		62
Benign	33	
Malignant	29	
Birth		27
Bell's palsy		5
Atypical Bell's		5
Infection		5
Herpes Zoster		4
Central		1
Other		2

*Most commonly following acoustic tumor surgery.

partial or total temporal bone resection for cancer, (6) the presence of a tenth cranial nerve deficit where it is not advisable to consider a hypoglossal-facial anastomosis for fear of crippling the swallowing mechanism, (7) cases of von Recklinghausen's disease when a likelihood of other cranial nerves being involved exists, (8) rare situations in which the cause of the facial paralysis is not found and spontaneous recovery is still a possibility, and (9) to augment the results following a nerve graft or hypoglossal facial nerve anastomosis in selected cases (Fig. 4–2).

Preoperative Care

Operative consent is obtained from all patients prior to scheduling. The informed consent consists of reviewing anticipated results, common potential complications, and the anticipated postoperative course with the patient. In addition, the patient is informed that other procedures or adjustments such as tightening, which we refer to as "fine-tuning" (see Chapter 7), may be needed in the future. Patients are given the option to review photographs and videotapes, and to consult with patients who have had similar procedures.

Surgical Anatomy of the Temporalis Muscle

The temporalis muscle is uniquely suited to reanimate the paralyzed corner of the mouth (Figs. 4–11 and 4–12). This fan-shaped muscle arises from the temporal fossa, except for a small part on the deep surface of the zygomatic arch. Its fibers converge and descend into a tendon that passes through the gap between the zygomatic arch and the side of the skull to attach to the coronoid process. For purposes of reanimation, the temporalis muscle is elevated off of the temporal fossa and rotated laterally over the zygomatic arch, which serves as a fulcrum. The nerve and blood supply are on the deep side and conveniently enter the muscle well out of the surgical site, making it unlikely that the surgical procedure will compromise the nerve or blood supply. The muscle is covered by a thick fascia that serves to strengthen the muscle and allows the anchoring of sutures from the muscle to the corner of the mouth. On occasion, the fascia may be used to extend the length of the muscle in the rare event that the muscle does not reach the corner of the mouth. Only the midportion of the muscle is utilized because the thickness, length, and contractility of this segment lends itself quite well to transposition. It also is a vector to re-establish the corner of the mouth in terms of its position at rest and lateral superior excursion to simulate a smile. The length of the muscle can be increased by extending the vertical incisions anterior and posterior along the edges of the elevated midmuscle strip down to the level of the zygomatic arch. Injury to the facial nerve is avoided by not elevating the muscle beyond the level of the zygomatic arch.

Surgical Technique

(Figure 4–13.) The surgical technique is illustrated in a step-by-step fashion highlighting in great detail the technique as it is presently performed. The instrumentation for the

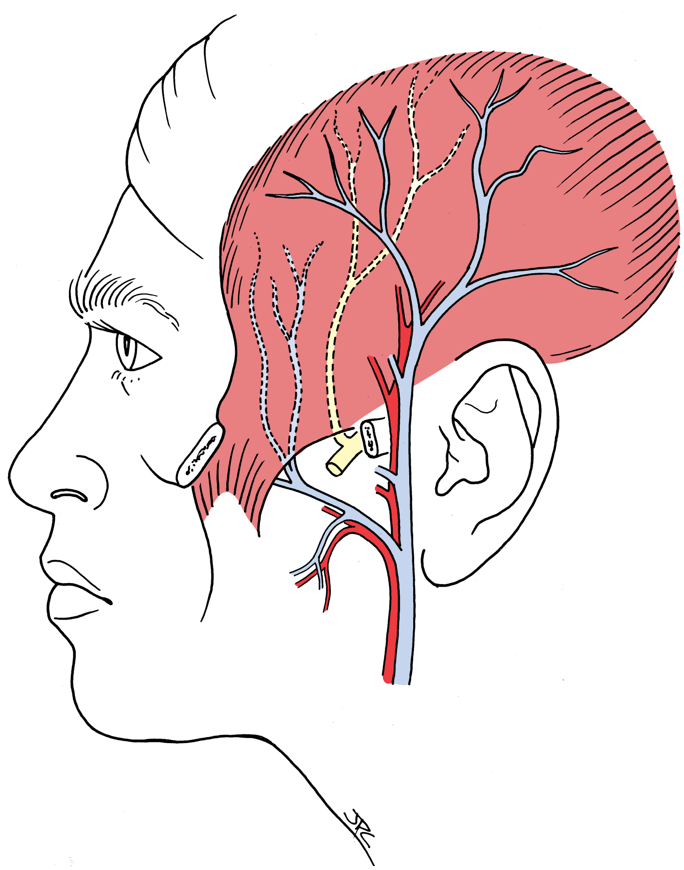


Figure 4–11. Surgical anatomy of temporalis muscle.

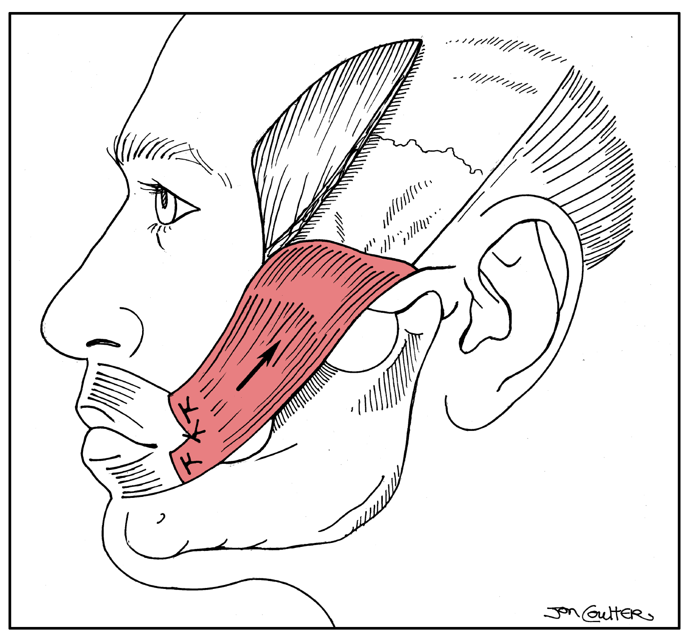


Figure 4–12. The vector of the temporalis muscle's contraction is favorable to create a lateral smile in a patient with facial paralysis.

Figure 4–13. Temporalis muscle transposition technique (see Tables 4–3 and 4–4 for instrumentation). **A**, The dotted lines indicate the sites for incisions. The lip-cheek incision (C-D) line is marked prior to administering anesthesia. The patient is asked to create a smile on the normal side so that the incision line on the paralyzed side can be made to correspond to the mirror image of the normal side. The incision in the lip-cheek crease should be made just below the line made with the marking pencil. This will place the incision line in the smile crease created by the muscle transposition technique. The incision in the scalp (A-B) is made just in front of the helix and extended superiorly and slightly posteriorly to reach the parietal region of the skull. The hair is not shaved, but is parted. A narrow pathway in the area of the incision is cleared of hair using a scissors. To keep the hair from falling into the surgical site, surgical towels are clipped with skin clips along either side of the intended incision line. (The surgical towels that are clipped to either side of the scalp incision area are not shown.) The incisions along the vermillion in the lateral-one third of the upper and lower lip (E-F) do not communicate at the lateral commissure. These incisions are used to fix the temporalis to the lip-cheek crease and the corner of mouth in children or patients who do not have a natural lip-cheek crease present. **B**, The location of the lip-cheek crease or fixation point can be determined by placing a finger into the corner of mouth on the paralyzed side and pushing upward and laterally. A crease will form, and this should be marked. **C**, After the face, neck, and scalp have been prepared with Betadine solution, the exposed facial and cervical skin is blotted with a sterile surgical towel. Following this, a transparent plastic sticky drape (Steri-drape) is placed over the scalp and face. The drape envelops the endotracheal tube and prevents dislodging it during surgery. While the Steri-drape is placed over the tube, the anesthesiologist holds the tube up and away from the mouth and chin. The Steri-drape is trimmed to expose the operative site in such a way that the endotracheal tube can be moved to allow free access to the mouth. Lidocaine 1% with 1:100,000 epinephrine is infiltrated into the incision sites. The injection takes affect within 5 minutes and minimizes cutaneous oozing of blood. **D**, **E**, The surgeon's view looking from the top of head toward the patient's feet. **D**, The initial incision is made in the skin of the scalp with a scalpel blade and continued through the subcutaneous tissue to the loose aponeurotic tissue with a cutting needle-tip cautery for purposes of hemostasis. *(Figure continued next page.)*

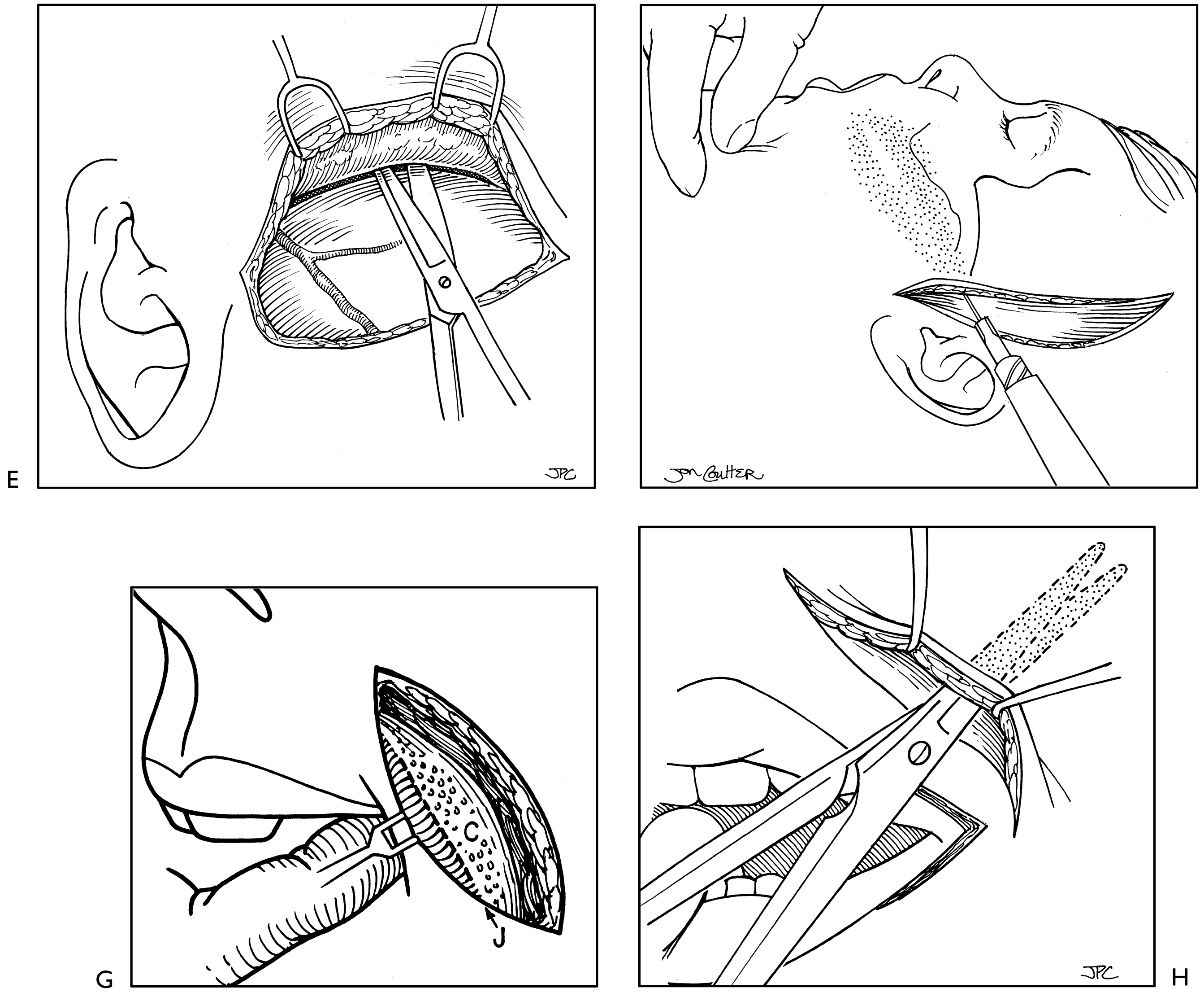


Figure 4–13. *(continued)* **E**, After the superficial layer of the temporalis fascia has been identified, a tunnel is dissected between this layer and the subcutaneous tissue. (See Fig. 4–7 to visualize the tissue planes.) **F**, Hydrodissection. The tunnel is extended from the scalp incision, superficial to the SMAS, in the direction of the corner of the mouth. Injecting normal saline into the subcutaneous layer helps hydrodissect and preserve the underlying SMAS layer. This protects the underlying facial nerve branches. This is particularly important in patients who have some intact facial function, or who have a chance of spontaneous recovery, or when a reinnervation procedure is planned. **G**, The lip-cheek crease is undermined toward the lip. With a finger inside the mouth, the submucosa of the lip is pushed into the wound (J). The surgeon looks for oral submucosa (C) at the level of the lip-cheek crease. **H**, A tunnel through this exposure is made by blunt dissection between the subcutaneous tissue and SMAS.

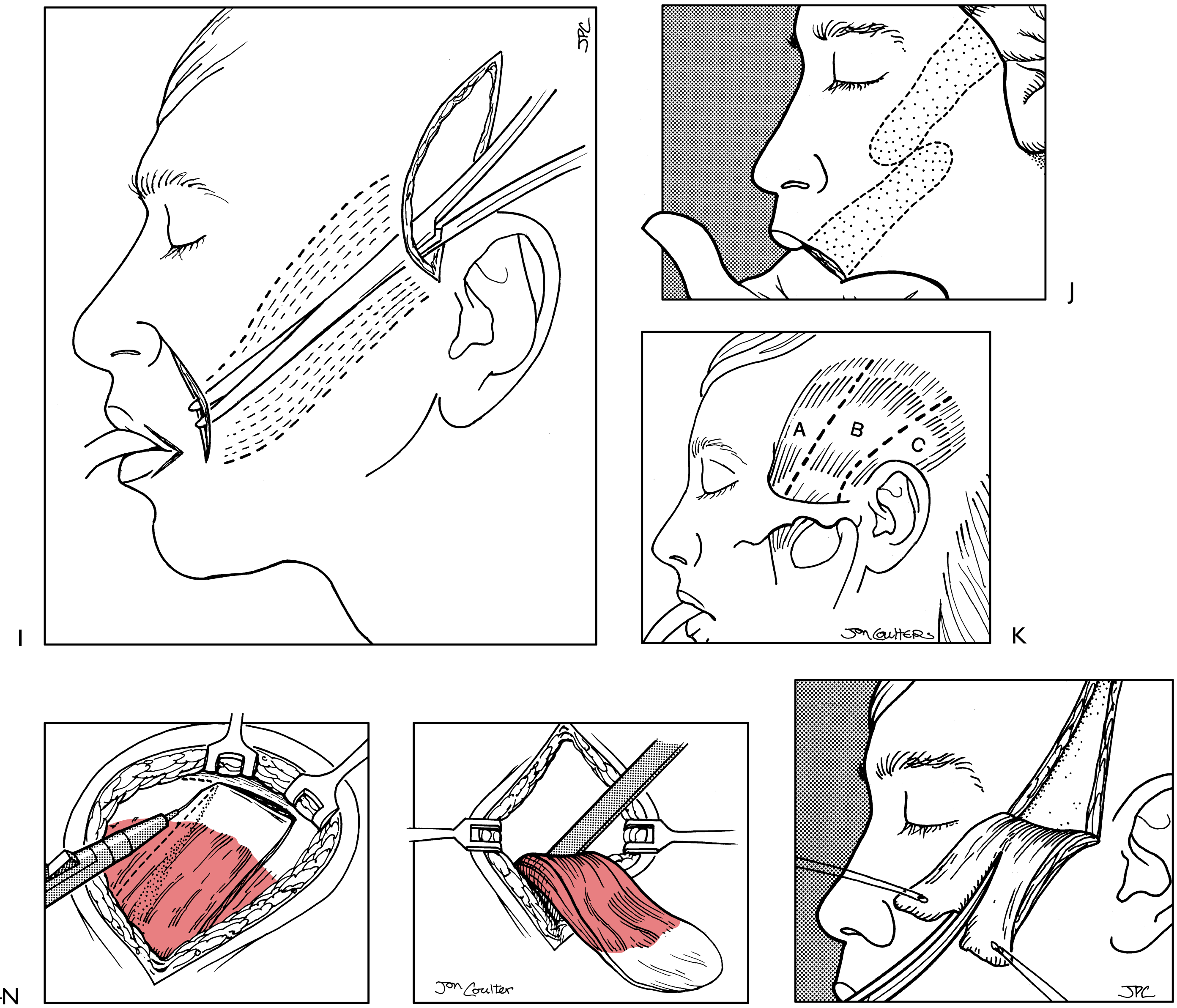


Figure 4–13. *(continued)* **I**, The tunnel is completed from above. A tunnel is savaged with a scissors to the lip-cheek crease. This will allow the temporalis muscle to be folded flat over the zygomatic arch and helps reduce the bulge created by the muscle in this region. **J**, The tunnel in the zygomatic region extends from the zygomatic process of the temporal bone to the lateral orbital rim. The tunnel is enclosed by blunt dissection placing one finger through the lip-cheek crease incision and another through the upper incision. **K**, Only the midportion of the temporalis muscle is utilized (B). The anterior portion of the muscle (A) is long and thin, and has limited contractile strength. The posterior portion (C) is too short to reach the mouth. The midportion (B) measures 4 cm, the width of two fingers. The advantages of using just the midportion (B) are less bulk and prominence over the zygomatic arch when the muscle is rotated toward the mouth and the ability to extend the anterior and posterior incisions to the level of the zygomatic arch to achieve maximum length and still maintain a viable neurovascularized pedicled muscle flap. **L**, The temporalis muscle with the deep temporalis fascia is exposed. The midportion of the muscle-fascia-periosteum is marked with a marking pencil. In order to have tissue attached to the muscle to pull it through the tunnel from the scalp to the lip-cheek incision, the periosteum is left attached to the temporalis muscle. The periosteum is separated from the parietal region with a cutting cautery. **M**, The periosteum attached to the muscle-fascia block is elevated from the lateral skull with a heavy blunt elevator to the level of the zygomatic arch. Care must be taken to preserve its neurovascular supply as the deep aspect of the muscle is elevated inferiorly. **N**, The temporalis muscle flap is bisected longitudinally, creating two 2-cm-wide pedicles. A 2-0 Prolene suture in a figure 8 is placed through each pedicle, and the needle is left on the suture. *(Figure continued next page.)*

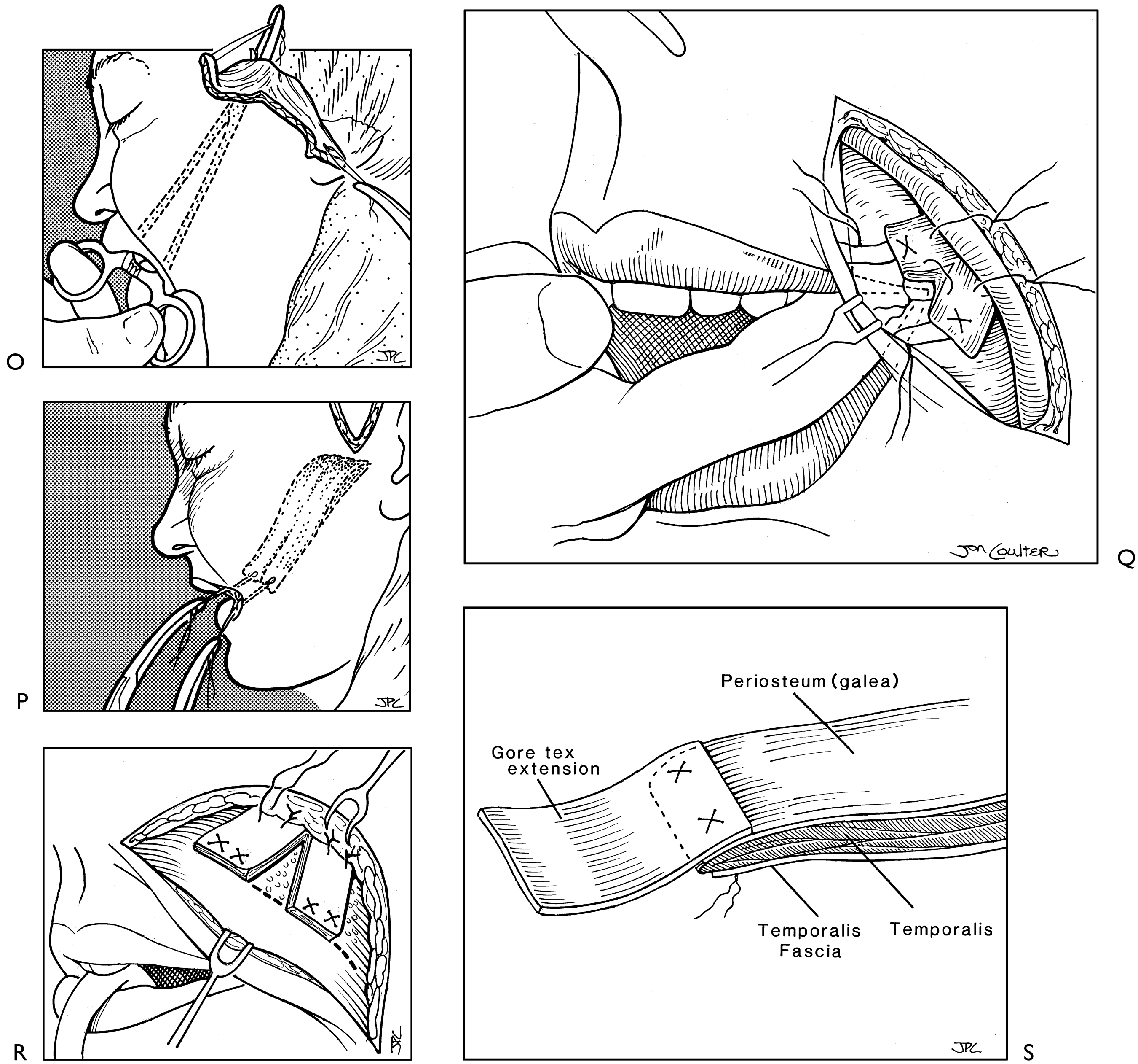


Figure 4–13. *(continued)* **O**, **P**, Large clamps are used to pull the needles with sutures and attached muscle pedicles through the subcutaneous tunnel. **P**, The temporalis muscle slips are pulled through the tunnel, putting traction on the periosteum until the muscle can be stretched beyond the lip-cheek crease line (see Fig. 4–13G). **Q**, The pedicles of the temporalis muscle are sutured to facial muscle if present or submucosal layers such that one slip is above and one slip is below the oral commissure. The sutures are placed with the assistant pushing the cutaneous-mucocutaneous line up toward the muscle and retracting the upper portion of the lip-cheek wound superiorly with a blunt rake. Additional sutures are used to secure the muscle in such a way that the corner of the mouth is pulled toward the angle between the two pedicles to create a lateral smile that is overcorrected to show the first upper molar. The lip-cheek crease can be accentuated by suturing the lateral aspect of the transposed temporalis muscle to the subdermal layer of the upper border of the lip-cheek incision. Fixing the muscle slips to the subcutaneous margin of the upper aspect of the lip-cheek crease wound provides a second fixation point that will draw the skin just above the lip-cheek crease incision along with the lip. **R**, In cases where the muscle pedicle is not long enough to accomplish what is described in **Q**, then suturing the muscle to the lip-cheek crease line can still produce a pleasing lateral smile. In the event that the muscle pedicle is still too short, adding an extender is required. Initially we used Gore-Tex, but because of a high incidence of late granuloma formation and extrusions, fascia lata is preferred (see Complications).

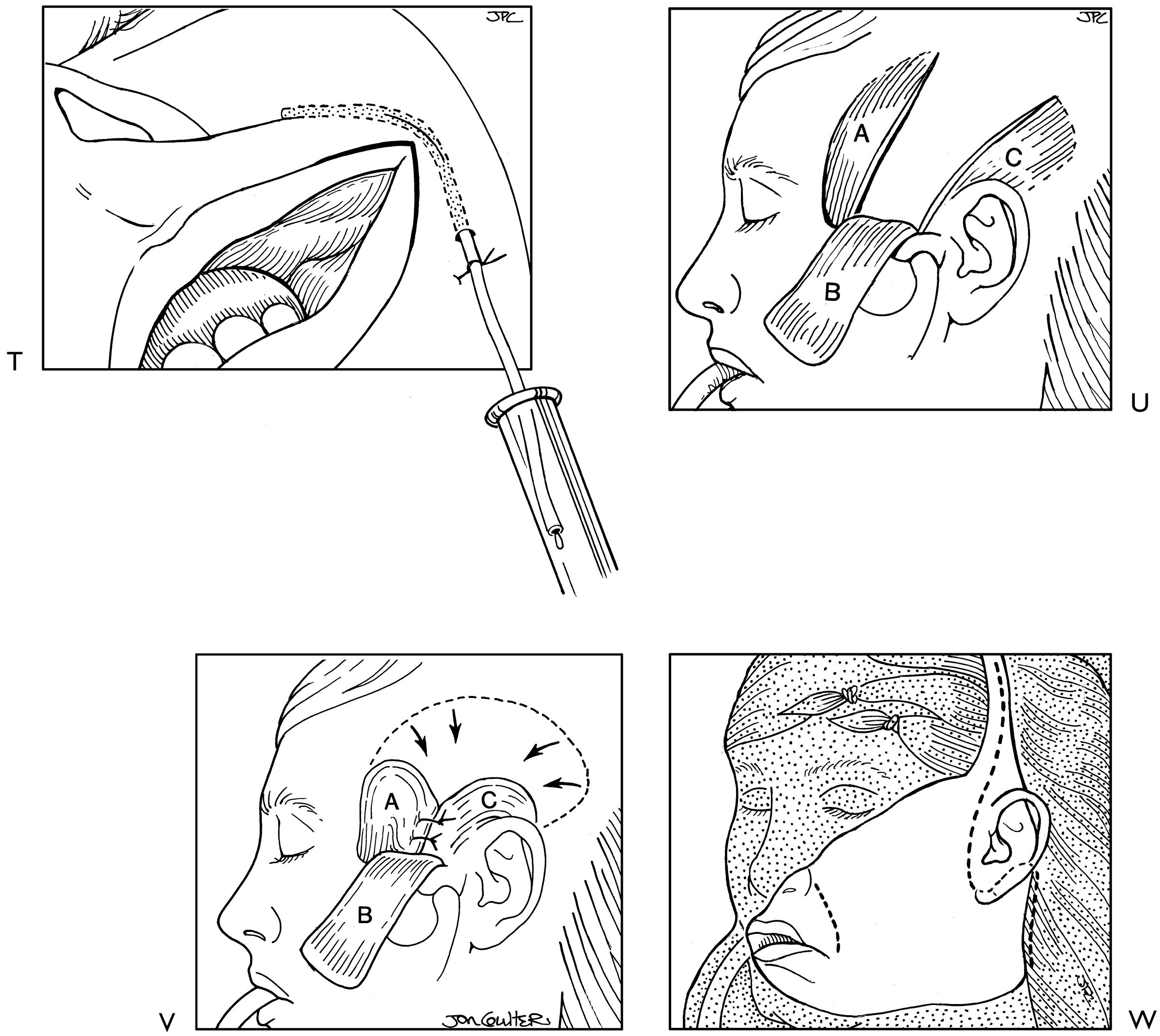
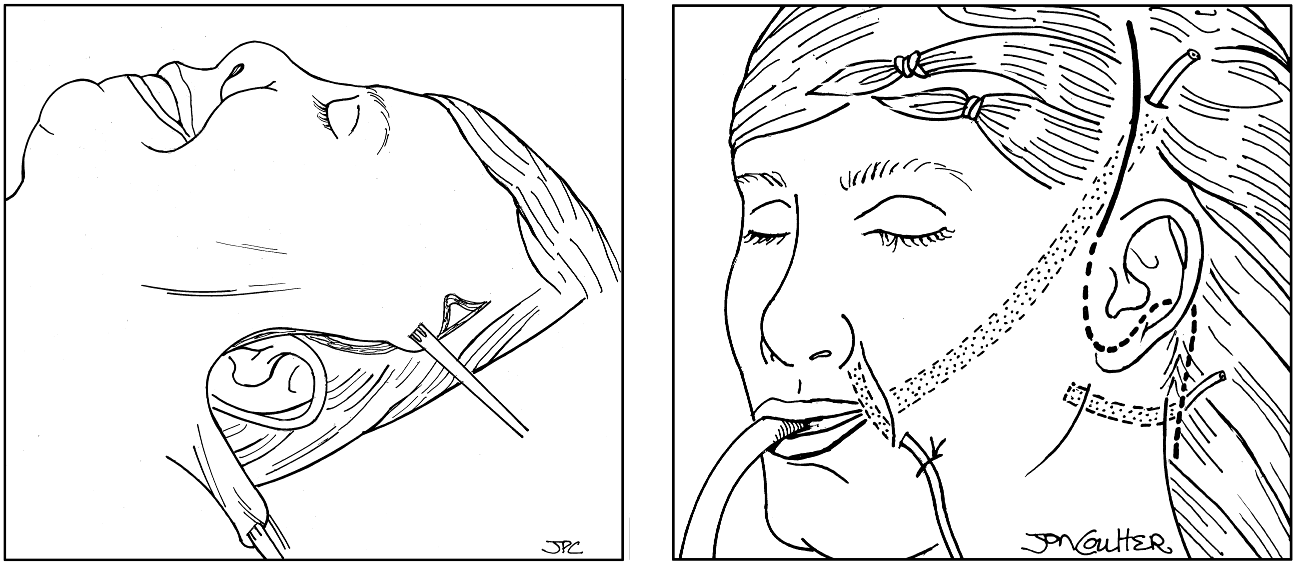


Figure 4–13. *(continued)* **T**, At the completion of the procedure, a test tube drain is placed at the corner of the mouth. The incision is closed with 5-0 Prolene in a subcuticular fashion and the skin edges further approximated with 6-0 mild chromic. The wound is dressed with Steri-strips. Ideally, at the completion of the procedure, the buccal mucosa is exposed with the upper anterior and lateral teeth. If the mouth is not in this position at the completion of the procedure, the final results will be unsatisfactory. This overcorrection will slowly decrease over a period of 3 to 6 weeks to create a lasting, subtle smile. **U**, A significant depression in the temporal area is created by the temporalis muscle transposition. **V**, By using vascularized temporalis muscle, the depression is filled, and the problems associated with the other techniques are avoided. Alloplasts such as Gore-Tex, a free homograft such as dermal fat, and fascia lata are rarely used because of problems with early and late infection as well as extrusion. These problems occurred in spite of perioperative antibiotics, soaking the implants in an antibiotic solution, irrigating the wound with an antibiotic solution, and using suction drainage. Rotating the temporoparietal fascial flap as suggested by Cheney et al.[7] was useful in some patients where the fascia was abundant and the depression was minimal. Otherwise, it failed to correct the cosmetic defect, and postoperative alopecia has been noted (Fig. 4–10). **W**, The results of the temporalis muscle transposition can be augmented by liposuction and face-lift. Temporal incision is extended down a preauricular crease and behind the ear in a standard fashion for a face-lift.
(Figure continued next page.)



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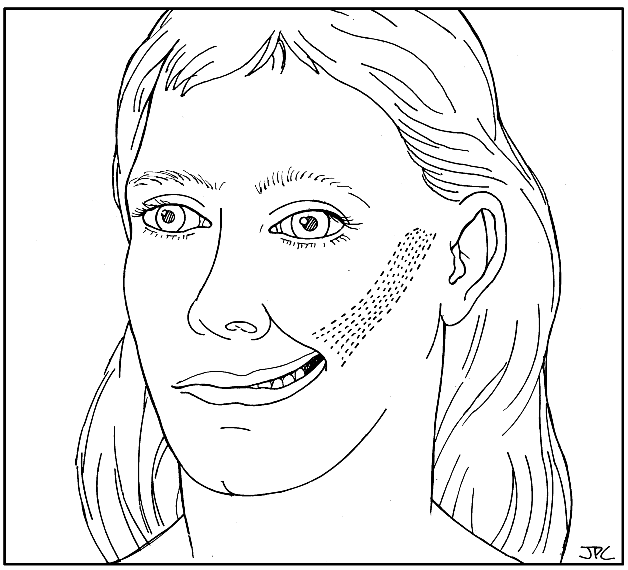


Z

Figure 4–13. *(continued)* **X**, The redundant facial skin is resected after the temporalis muscle is fixed in place, and the lip-cheek incision is closed. **Y**, Closure of the scalp wound follows. Prior to closing the scalp incision, a Jackson-Pratt drain is inserted and brought out through a separate stab incision just above the wound. All drains are attached to continuous suction. The scalp incision is closed with 2-0 chromic suture and skin staples. Upon completion of the procedure and prior to extubation, the hair is washed and combed with a mixture of saline and peroxide in a 1:1 ratio. Antibiotic ointment is applied to the incisions, and each is covered with a Telfa pad. Abdominal dressing pads and fluffs are used to stabilize the lateral face area. These are held in place with roller gauze, and the entire dressing is covered with a stockinette with an opening for the eyes, nose, and mouth. Periobital and facial edema is most pronounced between the third and the fifth day, and slowly subsides over a period of 10 days to 3 weeks. The patient may not be able to open the eyelids for 3 to 5 days. An antibiotic eye drop is used 4 times a day, and crusts are removed from the eyelashes several times daily until the eye begins to open. The dressing and drains are left in place for 48 hours and then removed. The subcuticular suture in the lip-cheek crease incision is removed on the fifth postoperative day, and the patient is discharged. **Z**, The patient returns 3 weeks after surgery so that the skin clips in the scalp incision can be removed. Jaw clenching exercises are begun 6 weeks after surgery. In most cases, results achieved at 6 weeks have been lasting, and patients have continued to improve for the next year.

temporalis transposition and use of Gore-Tex is listed in Tables 4–3 and 4–4.

Postoperative Care

Care in the immediate postoperative period includes elevating the head to 30 degrees, sustained continuous suction to the drains in the scalp and mouth area, intravenous clindamycin 600 mg every 8 hours, pain medication as needed, and a soft mechanical diet. Each of these measures are maintained for 48 hours. A soft diet should be continued for a minimum of 3 weeks.

Following the procedure, there may be a considerable amount of swelling and ecchymosis, particularly around the eye region. This usually persists for 3 to 5 days, but substantially resolves by the third week. After 3 weeks, the results of the procedure can be appreciated. The mouth position should be overcorrected at the time of surgery. Ideally, the overcorrection that results in upward and lateral displacement of the lateral oral commissure decreases over the next 3 weeks. At that time, the patient begins to show dramatic improvement in movement of the corner of the mouth. The patient with the ideal result can produce a broad smile by tensing the temporalis muscle (Fig. 4–8). Six weeks after the surgery, the patient is referred for consultation with a specially trained physical therapist.

Table 4–3 Equipment for T-Muscle Transposition

Special equipment
Bipolar Bovie console

Special instrumentation
Small Deavor retractors (to lift cheek incision)
Jewelers bipolar and bayonet forceps
Tonsil clamps (2) (shod with vessel paws–to pull muscle through cheek tunnel)
Reese scissors P6574 (Padgett KC MO) to make subcutaneous tunnel for temporalis muscle
Eyelid tray
Army-Navy retractors (to expose temporalis muscle)

Special supplies
Marking pen
Vessel paws #4101 Sil-Med Corp
20 cc syringe with 19-gauge spinal needle (fill with injectable NSS to infiltrate suhcutaneous layer)
Contact lenses
Clindamycin 600 mg in 30 cc normal saline (to irrigate wound or soak alloplast implant–Gore-Tex or Silastic)

Suture
4-0 Ethibond X557 (to suture muscle to mouth)

Dressing and drains
Universal facial band #210 (My True Image Mfg. Co.)
7-mm Blake drain
TLS closed suction drain #6640 Porex Surgical Inc. (kit containing one 7 French silicone drain tube with trochare, two sterile 15 cc evacuation tubes and connection hub)
Kerlix super sponges

Table 4–4 Equipment for Gore-Tex Graft

Special instrumentation
Reese scissors P6574 (Padgett KC MO)
Eyelid set
Bipolar Bovie console

Special supplies
Gore-Tex graft 1 mm (15293-10)
Marking pen
Clindamycin 600 mg dissolved in 30 cc normal saline to irrigate wound and/or soak Gore-Tex

Suture
3-0 Ethibond X762 (to attach Gore-Tex to temporalis fascia muscle)
4-0 Ethibond X557 (to attach Gore-Tex to corner of mouth)

Dressing and drains
TLS closed suction drain #6640 (Porex Surgical Inc.)

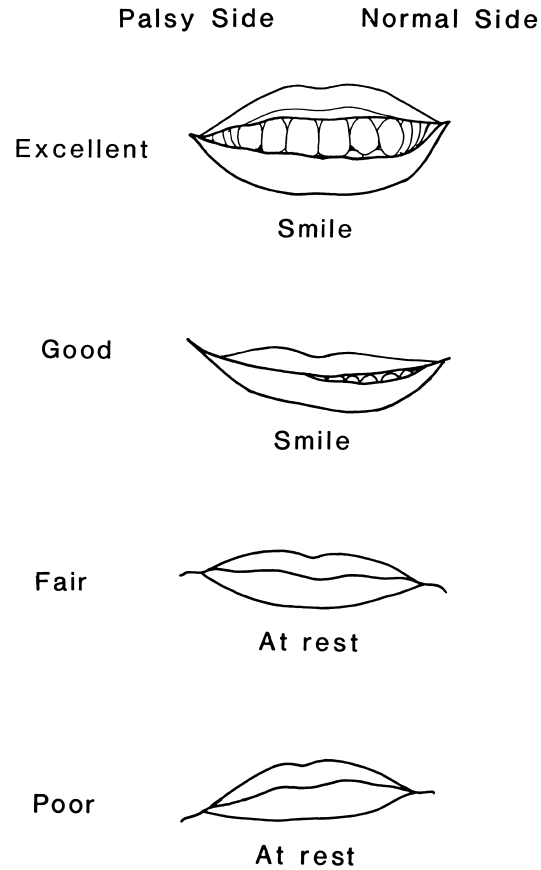


Figure 4–14. Classification system to report results of muscle transposition for reanimation of the mouth.

Results

The results of using the temporalis muscle to reanimate the mouth are recorded as "excellent," "good," "fair," or "poor," as depicted in Figure 4–14. The results listed are based on this system (Table 4–5). Over 90% of the patients are improved, and close to 80% are classified as good to excellent.

At the outset, it is conceded that there will always be a deficit in spontaneous response that cannot be compensated for by any rehabilitative procedure or any amount of practice or training. A patient who learns movement by intention and concentration, on the other hand, can manifest remarkable recovery and even imitate emotional response when so directed by conscious effort.[8]

Difficulties Determining Results

The results listed in Table 4–5 are based on postoperative telephone interviews, and review of preoperative and postoperative photographs and videotapes. Evaluation at the time of the patient's last visit was most valuable. Unfortunately, long-term (2 years or longer) follow-up was available in less than 60% of the patients. Because the majority of patients travel long distances, it is difficult for them to return for follow-up and they often depend on the referring doctor for this purpose. Therefore, attempting to report

Table 4–5 Results of Temporalis Transposition in 236 Procedures

	No. of patients	%	
Excellent	87	37%	95% Improved
Good	98	41%	
Fair	40	17%	
Poor/failed	11	5%	

results in a meaningful way is limited by the factors mentioned. In addition, over 50% of the patients were reanimated to improve an incomplete palsy, and the majority of the patients had multiple procedures, making it even more difficult to accurately determine how much of the recovery was due to the temporalis muscle transposition procedure. One last consideration was the need for revision surgery ("fine-tuning") to accomplish the final result. Results with the temporalis muscle that were rewarding in properly selected cases are shown in Figures 4–2, 4–4, 4–8, 4–9, 4–15, and 4–16.

Complications

Records were reviewed of 267 consecutive patients reanimated for facial paralysis using the temporalis muscle transposition over a 20-year span between January 1977 and June 1996 (Table 4–6). Complications occurred in 48 patients (18%). Of the 48 patients with complications, alloplastic implants were involved in 14 (30%) patients. Infection was the most common complication occurring in 35 of the 48 patients (73%). An alloplastic implant was involved in 9 of these 35 (39%) patients. Clearly the use of alloplastic implants played an important role in the numbers of patients who had problems related to the surgery. The use of alloplastic materials included implanting Silastic to fill the depression in the temple region (11 patients) and attaching Gore-Tex strips to lengthen the temporalis muscle (3 patients). There were 10 patients with a hematoma or seroma. In 2 of the 10 patients, the seroma or hematoma was associated with the use of a Silastic implant. There were

Figure 4–15. Patient with developmental left facial paresis. **A**, In repose. Left eye wider and drooping of upper lip. **B**, Lack of animation on involved left side. **C**, **D**, Mouth at rest and smiling. There is a full smile with show of upper and lower teeth on normal right side. Lower lip function intact. Left upper lip and corner of mouth deficit most marked.

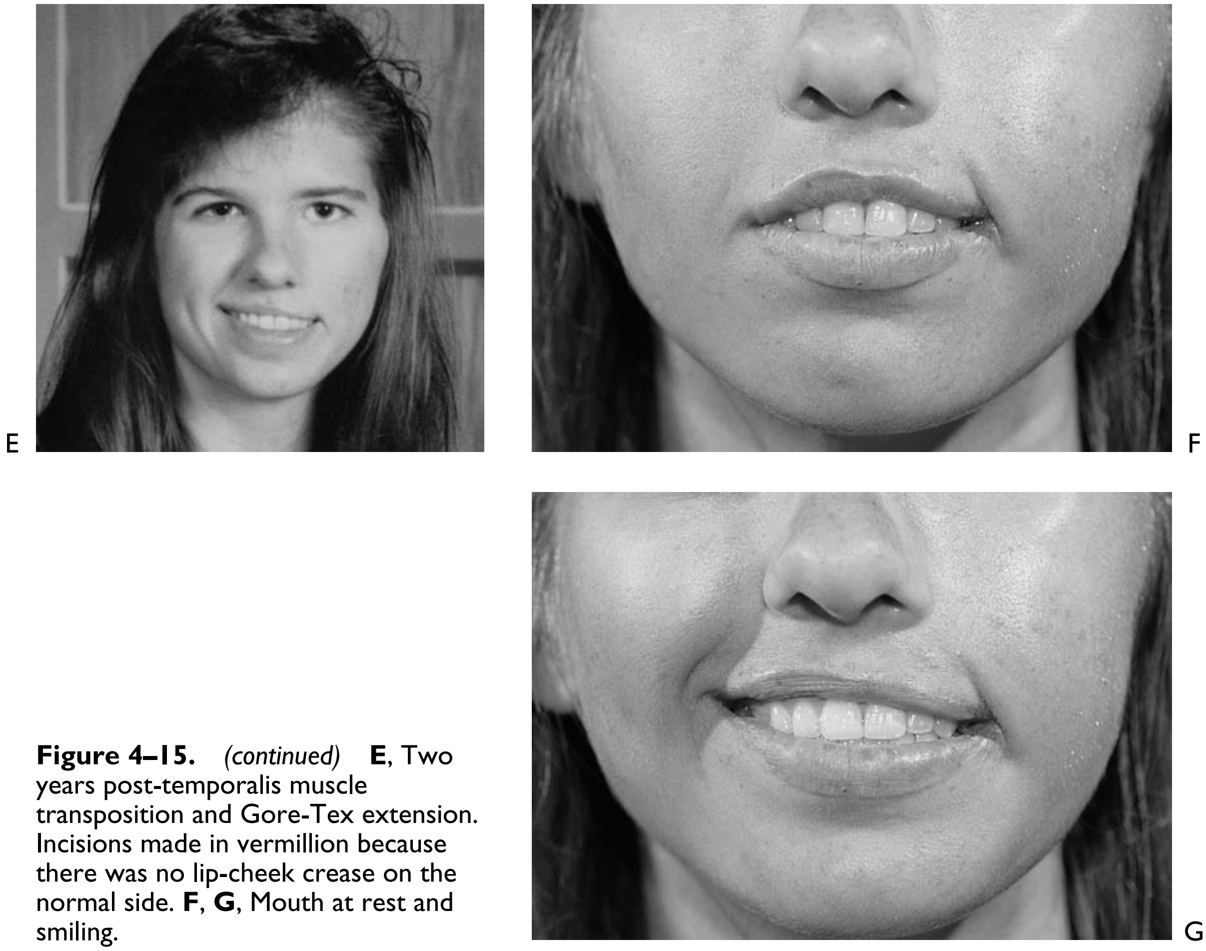


Figure 4–15. *(continued)* **E**, Two years post-temporalis muscle transposition and Gore-Tex extension. Incisions made in vermillion because there was no lip-cheek crease on the normal side. **F**, **G**, Mouth at rest and smiling.

three patients whose implants extruded 6 to 48 months following surgery. One patient was diabetic, another had skin over the temple that was very thin and atrophic following a previous middle fossa procedure, and the third extruded several weeks after blunt trauma over the site of the implant.

Excluding the patients with infection associated with an alloplastic implant, the majority of complications occurred early in our experience and prior to adopting the following routine: (1) using perioperative intravenous antibiotics, (2) making an active effort to separate saliva from the wound by placing Betadine (povidone-iodine) saturated surgical sponges in the mouth prior to making incisions around the mouth, (3) irrigating the wound with an antibiotic solution, (4) soaking the alloplast in an antibiotic solution prior to placing it in the wound, and (5) using suction drainage maintained for 48 hours postoperatively. The alloplastic implant seemed to be the common denominator in the majority of patients who developed a postoperative infection. This was in spite of the preventive measures mentioned.

As a result of this experience, we reviewed our total experience with alloplasts. We placed 105 Silastic implants in 102 patients (3 were bilateral) between January 1977 and June 1991. The implant was used to fill the defect in the temple area above the zygomatic arch and in front of the ear. Of the 105 Silastic implants, 13 (12%) required postoperative treatment. Eight implants became infected, and four were removed. Two implants were associated with a hematoma, and in both cases, the implant was removed. In three cases, the implant extruded.

Gore-Tex was used to reinforce or extend the temporalis muscle in 20 procedures. Three out of 20 became infected and required removal, 2 of the 20 formed a granuloma and a draining fistula 3 and 4 years, respectively, after surgery. Both were treated by incision and drainage, and trimming a portion of the Gore-Tex that involved in the reactive process at the suture site in the lip-cheek area (Fig. 4–17).[9]

Considering there were problems associated with 13 Silastic and 5 Gore-Tex implants or 18 of 48 (38%) patients with complications, we strongly discourage the use of alloplasts. Our preferred method of filling the temple defect is rotating the remnant of the temporalis muscle and suturing it in place above the zygomatic arch (Fig. 4–13).

The small number of cases that formed a hematoma or a seroma invariably could be related to either failure to place a suction drain or failure to maintain the continuous suction.

Close adherence to the above-mentioned recommendations will lower the number of complications to a tolerable level. Recognition and early intervention by appropriate incision and drainage, re-establishing suction drainage, and evacuation of hematoma or seroma formation will prevent any significant problems and ensure a higher success rate.

Figure 4–16. Bilateral temporalis muscle transposition. Fifteen-year-old boy with developmental bilateral paresis of bilateral VI, VII, IX, and XII cranial nerves. **A**, Maximum effort to smile. Slight movement noted corner of mouth and lower lip, more on right than left. **B**, Incomplete eyelid closure with effort. **C**, Five weeks post-bilateral temporalis muscle transposition. Voluntary smile created by clenching teeth. **D**, Eyelids approximate with effort to close eyes. Gold weight implants successful.

Table 4–6 Complications with Temporalis Muscle Transposition in 267 Patients (January 1977 to June 1996)

Complication	No. of Patients	*Alloplastic Implant Involved
Infection	35 (73%)	9 (39%)
Hematoma/seroma	10 (21%)	2
Implant extrusion	3 (6%)	3
Totals	**48 (18%)**	**14 (30%)**

* Alloplastic implants [Silastic (11), Gore-Tex (3)] involved in 14 (30%) of 48 patients with complications.

Revision Surgery

Revision "fine-tuning" surgery (see Chapter 7) was performed in 66 patients following temporalis muscle transposition (Table 4–7). The major reason for revision was failure to improve the position of the corner of the mouth compared to the preoperative state. The most common cause was that the muscle attachment pulled away from the corner of the mouth (Fig. 4–18). Usually when this happened, the muscle was either too short, too thin, or weak, as in the case of a patient with dentures or poor occlusion of the posterior teeth. Revision involved reattaching the muscle with or without lengthening. If lengthening was required, we recommend that fascia lata or palmaris longus tendon be used instead of an alloplast (see Chapter 7). Cor-

Figure 4–17. **A**, Problems with Gore-Tex. A chronic granuloma and draining fistula formed 9 months following temporalis muscle transposition with Gore-Tex extension. **B**, The chronic foreign body reaction resolved after resection of the involved segment of Gore-Tex.

Table 4–7 Revision Surgery ("Fine-Tuning") Performed in 66 Patients Following Temporalis Muscle Transposition

Indication	Cause	Correction
Corner mouth unchanged from preoperative state, sags or droops	Temporalis muscle pulled away from corner of mouth	Reattach temporalis muscle
Oral incompetence	Overcorrection of canine smile causing "gaposis" in area of lateral commissure	Release and lateral commissure repair (see Chapter 7)

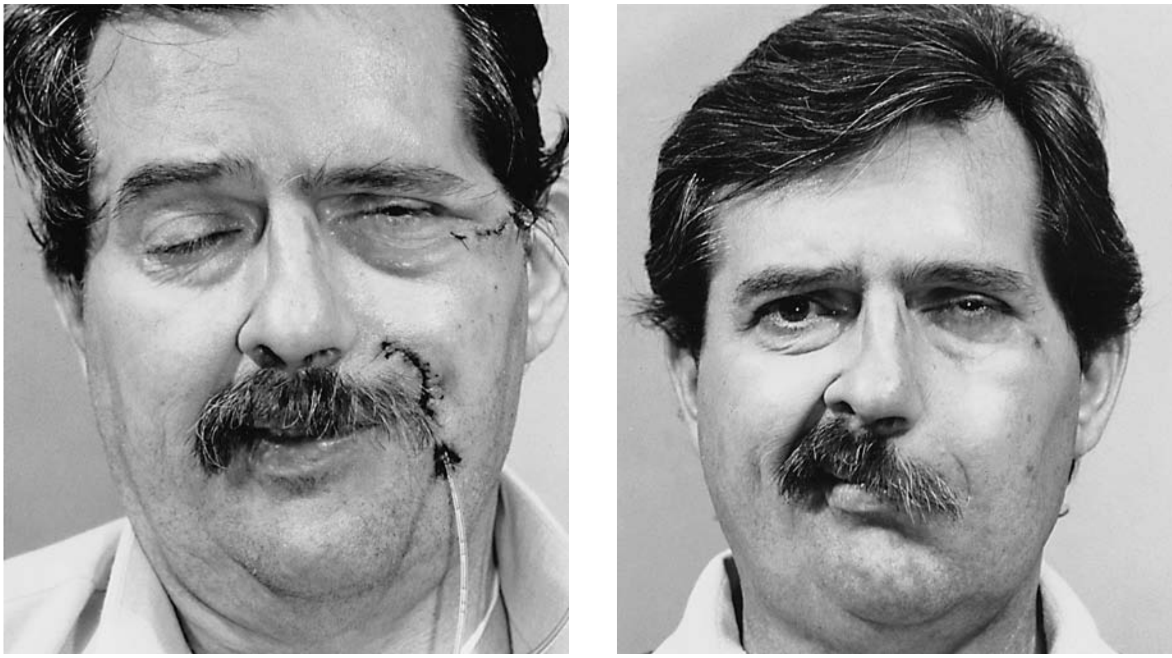
recting the pulled-away muscle requires freeing up the muscle from the tunnel that was previously created to get maximum length in order to restretch the muscle for a maximum effect. If the muscle is allowed to remain in its retracted position, not only will it be less effective, but a prominent cheek bulge remains.

A useful remedy to this common problem was suggested by Buchholtz et al.[10] who suggested taking a free temporalis fascia graft harvested from the contralateral scalp and placing it around the oral commissure of the paralyzed side of the face through an incision in the nasolabial crease. Several weeks later, the temporalis muscle transposition on the paralyzed side is attached to the previously placed fascia graft. This two-stage procedure provides for a secure anchoring point for the temporalis flap and may decrease the incidence of the temporalis muscle pulling away from the corner of the mouth. This technique has been particularly useful in children where the anchoring point between the temporalis muscle and angle of the mouth became disrupted or separated. In patients where the fascia was placed several weeks before the temporalis transposition, the fixation point held and the results were lasting.

Another reason for failure to improve the paralyzed position of the corner of the mouth occurred in patients who had a denervated muscle either unrecognized preoperatively or created by the temporalis muscle transposition procedure itself. In cases where the vertical incision is extended below the level of the zygomatic arch and particularly with a cutting cautery, it is possible to injure the motor nerve supply to the temporalis muscle. Great caution must be taken to avoid this problem by limiting the inferior extent of the vertical incision to the level of the zygomatic arch and not below this line. Further, use of the electric cutting cautery as the surgeon approaches the zygomatic arch is potentially dangerous and places the nerve supply to the temporalis muscle at risk.

In three patients, it was known before surgery that the temporalis muscle was damaged; one patient had previous skull base surgery and the other two had middle fossa procedures. In each of these patients, some residual temporalis muscle could be used for static suspension. In situations where the muscle is either denervated or damaged, the muscle can still be used to some advantage because of its vector and capability of supporting fascia, palmaris muscle tendon, or an alloplast like Gore-Tex to bridge the compromised muscle with the corner of the mouth.

Lateral oral commissure incompetence or "gaposis" (Figs. 4–8 and 4–9) is a problem that occurred in six patients. It occurred when the upper lip and corner of the mouth are overcorrected. Correction of this defect requires



A B

Figure 4–18. Problems with Gore-Tex. Gore-Tex used for static suspension (see Chapter 7 for technique). **A**, Two days after surgery. Test tube drains in place. **B**, Six months later. The Gore-Tex failed to accomplish permanent fixation to soft tissues around lip-cheek crease.

releasing the upper lip and tightening the lateral commissure (see Chapter 7).

Masseter Muscle Transposition

The use of the masseter muscle for regional facial reanimation, either alone or in combination with the temporalis muscle, was described by both Rubin[4] and Conley.[3] In my experience, it is usually not necessary to transpose masseter muscle, because excellent results have been achieved with the temporalis muscle alone. The major disadvantage of using the masseter muscle is the introduction of additional bulk that creates a bulge in the corner of the mouth and leaves a depression along the mandible at the site of its original position. Removal of buccal fat at the time of masseter rotation is designed to alleviate some of the distortion caused by rotating the muscle into the perioral region.[11] However, there are situations in which these disadvantages are acceptable. For example, the masseter can be rotated into the mouth region following radical cancer surgery of the parotid where nerve grafting is not possible. Transposing the masseter with interdigitation into the freshly denervated mimetic muscles provides for maximum myoneurotization to all of the muscles in the middle third of the face.[12]

The entire masseter muscle is used for this purpose. The periosteal attachment of the masseter muscle is elevated from the mandible and attached to the mouth in a similar manner to that used to attach the temporalis muscle. This provides length and adds strength to the masseter mouth fixation point.

Another application of the masseter muscle transposition is to combine the masseter muscle transfer to the lower region of the face and place a cable graft to the upper facial nerve division. This creates a simultaneous dual system to rehabilitate the paralyzed face using two independent reanimation techniques in an effort to optimize facial movement.[13] The concept of combining procedures is an attempt to increase the chances that the patient will have useful function in the event that one system fails.[14] Another potential benefit of combining rehabilitative systems involves regionality of motion (see Chapter 8). The concept is to reduce the potential for mass movement created by one system to rehabilitate the entire face. The physiologic basis for dual system reanimation comes from the work of Miehlke and Stennert.[15]

Surgical Anatomy

Effective use of the masseter muscle requires a thorough understanding of its anatomy (Fig. 4–19). As with the temporalis muscle, the course, direction, and location of the neurovascular supply is critical to the effective use of this muscle for reanimating the corner of the mouth. Note innervation to the masseter muscle arises deep to the zygomatic arch and on the deep side of the masseter muscle coursing from posterior superior to anterior inferior in a diagonal direction. Incisions to mobilize the muscle must not violate that nerve. As noted in Figure 1–1A, which illustrates Lexer's original technique, the vector for the masseter muscle is similar to that provided by the temporalis muscle except the masseter muscle is shorter and thicker, and its contraction excursion is shorter. For these reasons, it is not competitive with the temporalis muscle except in the special situations already noted. The surgical technique is similar to the temporalis muscle in that sutures cannot be relied on

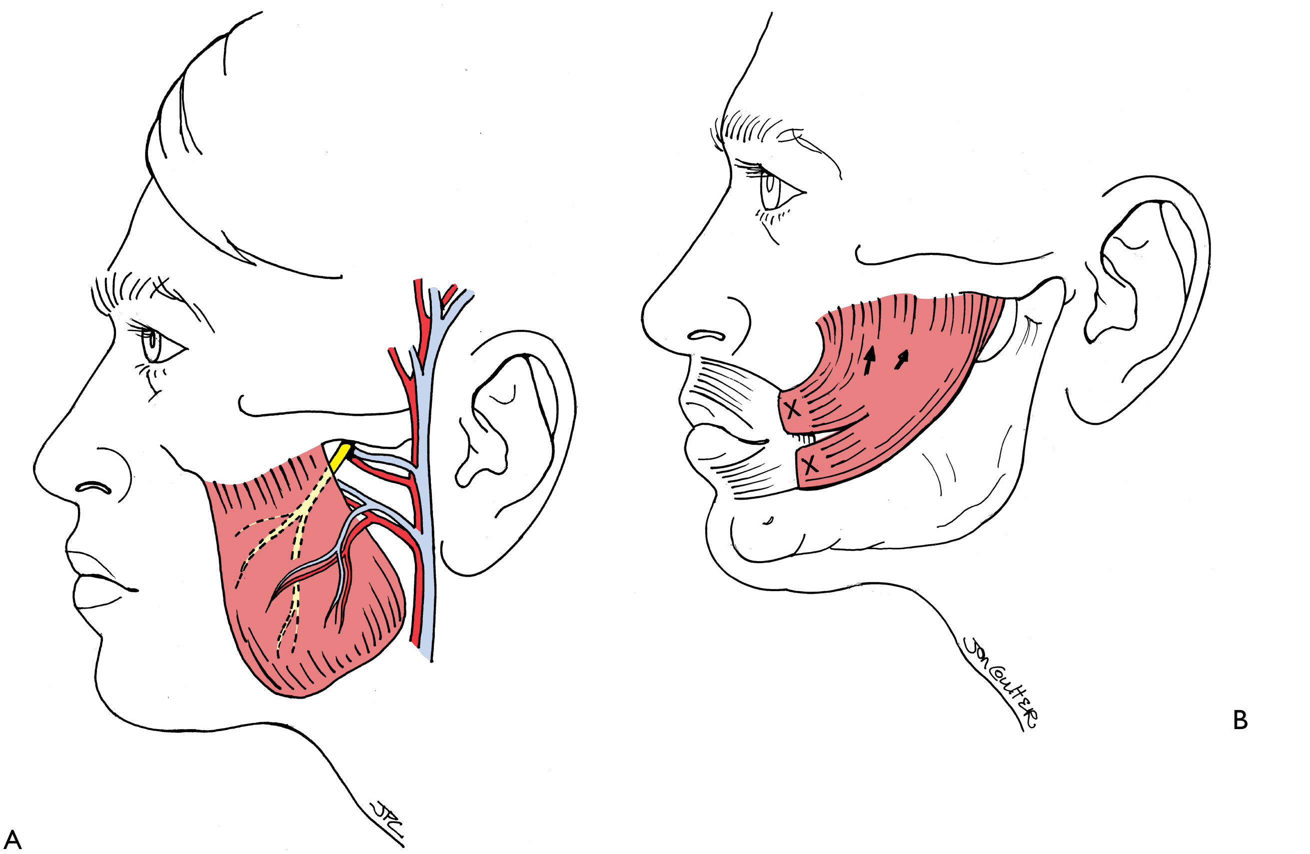


Figure 4–19. **A**, Surgical anatomy of masseter muscle. **B**, The masseter muscle is not as suitable as the temporalis muscle to reconstruct a smile. The vectors of pull exerted by the transposed masseter muscle not as favorable as the temporalis muscle. The masseter muscle is shorter, and the contractile excursion is less than the temporalis muscle's.

to hold if passed through muscle alone without the attached periosteum. Therefore, just as with the temporalis muscle where galea or periosteum attaches the temporalis muscle to the temporal fossa, the masseter muscle must be elevated from the mandible with its deep periosteal attachment.

Surgical Technique

The details of surgical technique are demonstrated in Figure 4–20.

Experience with Masseter Muscle for Reanimating the Mouth Area

The masseter muscle was used to reanimate 10 patients and was combined with the temporalis muscle in every case but 2. In these patients, the temporalis muscle was not available. The masseter muscle was used for the mouth, and the temporalis muscle for the eye.

The most common cause of the paralysis in this group of patients occurred in the course of acoustic tumor surgery.

Results and Complications

In 8 of 10 patients available for follow-up, every patient improved with good to excellent results in over one-half of the patients (Fig. 4–21). There was only one minor complication, an infection that resolved promptly following a limited incision and drainage.

Digastric Muscle Transposition

Developmental absence or injury to the mandibular branch of the facial nerve creates an obvious distortion of the lower lip on the involved side. The deficit creates a deformity characterized by the inability to draw the lower lip downward and laterally or to evert the vermillion border. When the patient smiles, the paralyzed side of the lip remains in a neutral position, and becomes flattened and inwardly rotated if the upper lip elevators are functioning.

Conley et al.[16] reported the most complete exposition on this subject. The authors pointed out that when used for facial reanimation the temporalis and masseter muscles lateralize and elevate the corner of the mouth. These muscles are incapable of treating the deformity of the lower lip.

A number of methods have been proposed to treat the deformity of the paralyzed lower lip. One method involves weakening the depressor muscles on the normal side by division or resection of the mandibular branch of the facial nerve in an effort to equalize the deficit and thus camouflage the cosmetic effects. This technique has the disadvantage of further weakening the lower lip. Conley et al.[16] credit Edgerton for first analyzing the problem of marginal mandibular palsy and for proposing a new operation to depress the lower lip. Another approach suggested by Edgerton was to free the anterior belly of the digastric muscle from the mandible and to suture a section of fascia to it.

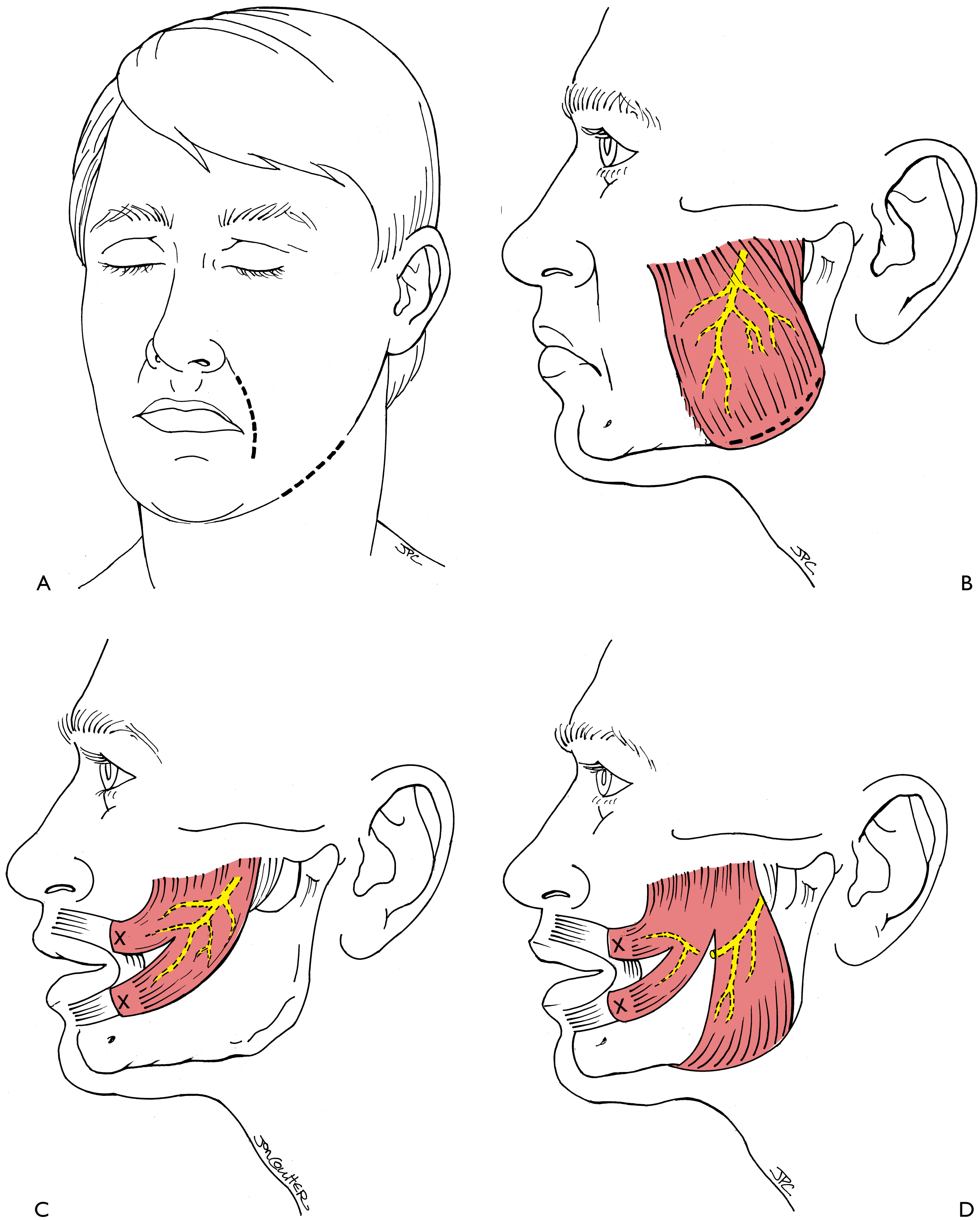


Figure 4–20. Masseter transposition technique. **A**, Incisions. **B**, The masseter muscle is elevated and separated from the mandible attachment. **C**, The masseter is transposed and attached to the lip-cheek crease and/or upper and lower corner of mouth. The technique is similar to that demonstrated for the temporalis muscle (Fig. 4–13). **D**, Be careful not to divide the masseter motor nerve upon splitting muscle.

Figure 4–21. Results of temporalis-masseter muscle transposition to reanimate eye and mouth. Facial paralysis increased progressively over $1\frac{1}{2}$ years as the result of an adenoid cystic carcinoma located at the pes anserinus. The tumor was resected by a total parotidectomy, partial temporal bone resection, and neck dissection. **A**, Attempting to smile with total paralysis. **B**, Inability to close the eye with total paralysis. **C**, Six months following temporalis muscle transposition to the eye and temporalis and masseter muscle transposition to the mouth. Smiling without eye closure. **D**, Eye closure without mouth movement.

This fascia was then threaded superiorly into the lower lip. Edgerton also proposed an alternative technique of suturing a strip of fascia directly to the tendon of the digastric without freeing the muscle from the mandible.

Based on Edgerton's work, Conley et al.[16] designed an operation that consists of transposing the tendon of the digastric muscle into the lower lip and preserving the nerve and blood supply to the anterior belly, which remains attached to the inner aspect of the mandible. This is done through a submandibular approach, using the anterior belly of the digastric muscle and its tendinous connection with the posterior belly. The nerve supply to the anterior belly of the digastric is the mylohyoid nerve. Preservation of this nerve provides the potential for dynamic depression of the lower lip. If the nerve is inadvertently lysed, the operation is still effective; however, the muscle eventually atrophies, producing a static cordlike counterpull.

Conley et al.[16] stressed the importance of including all of the subdigastric tendon because it provides half the length of the transposed segment and permits strategic insertion into the lower lip. This was performed by splitting the end of the digastric tendon and using these two strips to suture to the orbicularis oris muscle at its middle or inferior border.

The goal of this operation is to create normal depressor tension on the lip but not to overcorrect it. Conley et al.[16] reported satisfactory results in 33 of 36 patients. Because this contribution is comprehensive and includes a thorough review, the material will not be repeated. However, it is important to emphasize that on opening the mouth, smiling, or grimacing, the lower lip deformity is conspicuous and the reanimation surgeon is obligated to consider surgical correction of this cosmetic blight. This admonition is particularly compelling, considering that there is a direct, rather straightforward, and highly effective procedure that can improve an otherwise obvious defect.[16]

Author's Experience

In spite of an intense interest and the opportunity to evaluate a large number of patients with facial deformities from injuries to the facial nerve, very few patients were considered candidates for digastric muscle transposition. The digastric muscle transposition procedure is ideal for patients with an isolated injury to the marginal mandibular nerve but not for patients who need total reanimation. If one were to elevate and lateralize the corner of the mouth and combine that with a digastric transposition that results in depression of the lower lip, the outcome would be oral incompetence.

The reanimation surgeon must not be tempted to compromise function for aesthetics. The major function of the orbicularis oris is to serve as a sphincter primarily for handling nourishment taken by mouth and secondarily for speech production. This sphincter is acted upon by four pairs of muscles that elevate the upper lip, four pairs of muscles that depress the lower lip, and two pairs of muscles that draw the corner of the mouth laterally.[16] The orchestrated subtle coordinated movements of these groups of muscles are responsible for human expression but are not vital to the primary role served by the oral sphincter.

Surgical Anatomy and Technique

Anatomy of the digastric muscle and surrounding area as well as the important features of the surgical technique are illustrated in Figures 4–22 and 4–23.

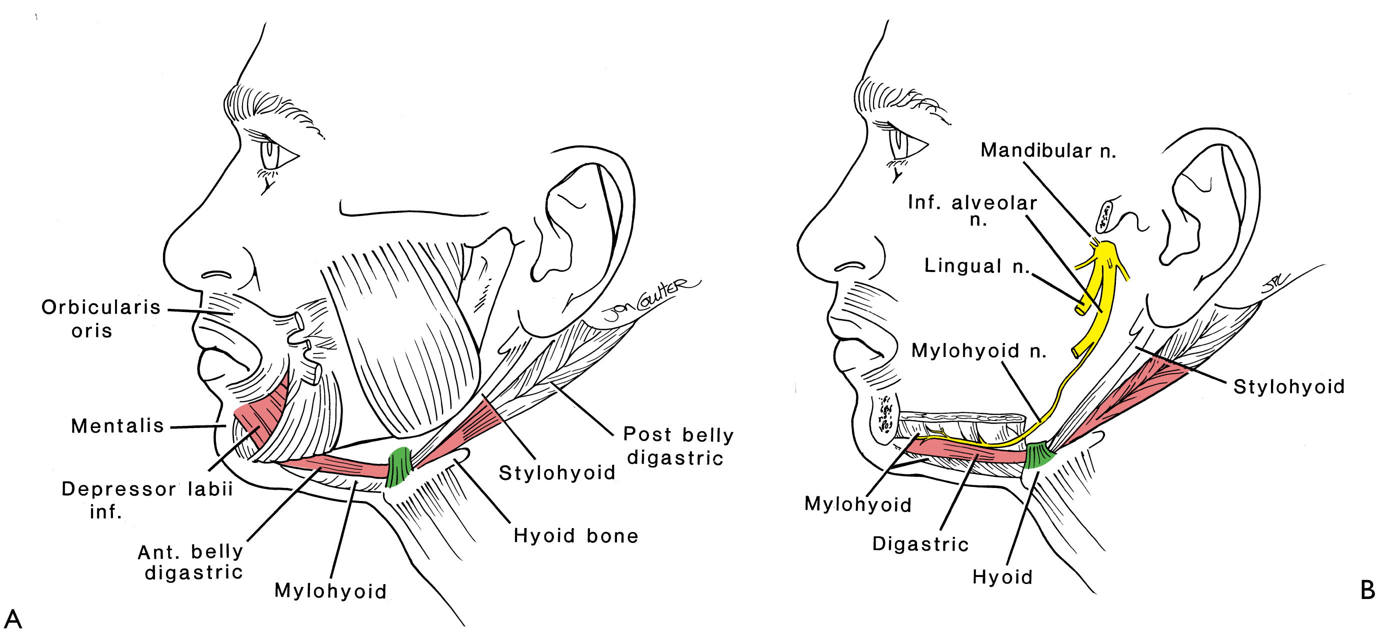


Figure 4–22. Surgical anatomy of digastric muscle. **A**, Note the fascial bridge that envelops and fixes the common tendon of the anterior and posterior belly of the digastric to the hyoid bone. **B**, The mylohyoid nerve provides the motor innervation to the anterior belly of digastric and runs between the digastric and mylohyoid muscles.

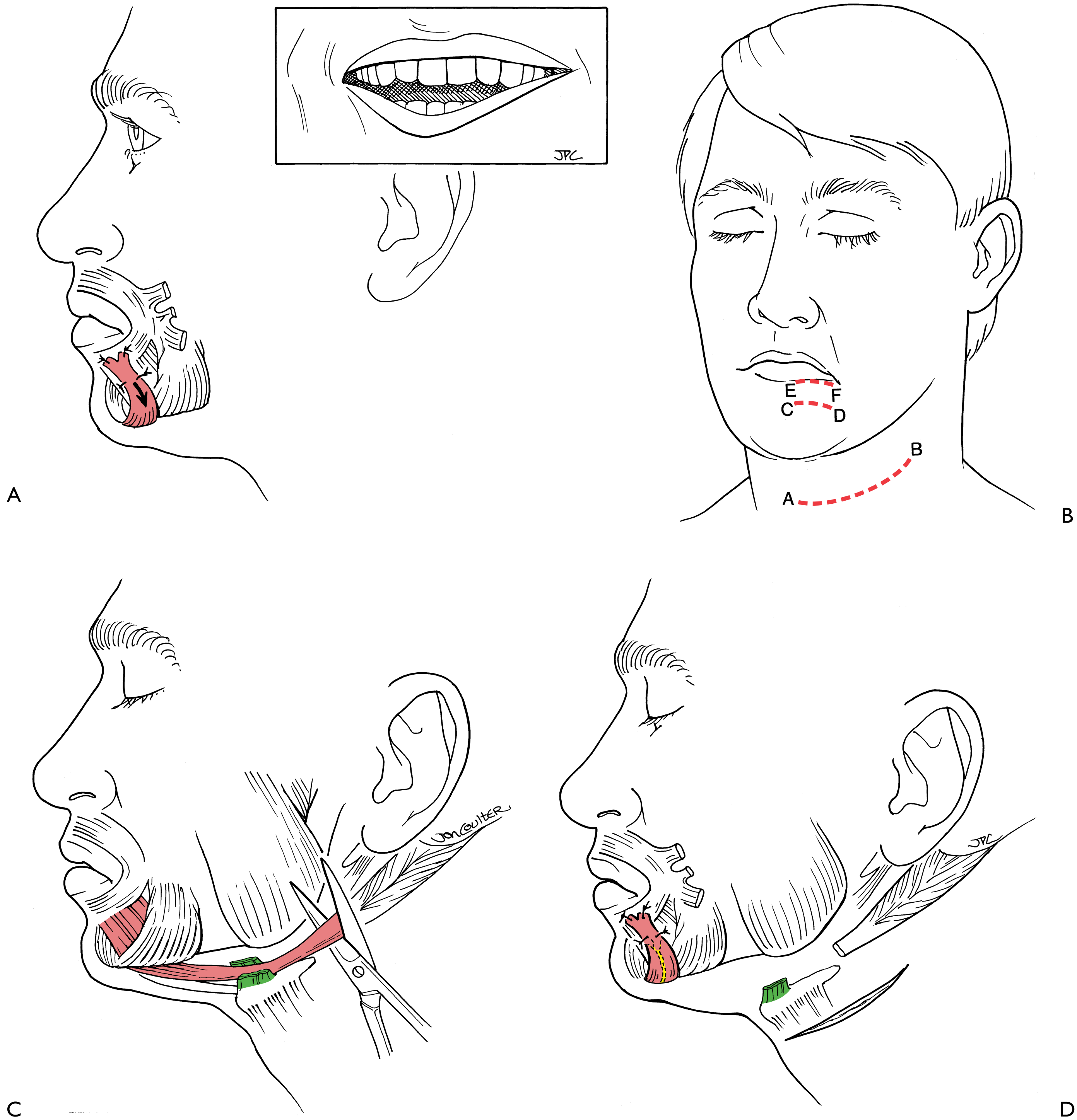


Figure 4–23. Digastric muscle transposition technique. **A**, The transposed anterior belly of digastric provides a vector that counters the lower lip defect due to palsy of the depressor labii inferious. **B**, Incisions. A-B, to free up and transpose anterior belly of digastric muscle. E-F, Vermillion incision and C-D, in chin-lip groove. These last two incisions are to fix the digastric muscle. **C**, The fascial bridge is divided and additional length to the anterior belly of digastric is obtained from the tendon of the posterior belly. **D**, The digastric muscle is freed up and rotated toward the lower lip. The motor nerve supply (mylohyoid nerve) is preserved. The digastric muscle is fixed in two places: the chin-lip groove and the vermillion area. The tendon is splayed out to allow for a broader purchase to the fixation points. The lower lip is retracted down to a neutral position to match the normal side. The excess length of tendon is trimmed, and the incisions are closed. Caution: This procedure is ideal for isolated marginal mandibular nerve injuries and should not be performed in patients with total facial paralysis. Depressing the lower lip in such cases will create oral incompetence.

A, B

Figure 4–24. Five months following marginal mandibular nerve injury during submandibular gland surgery. **A**, Typical marginal mandibular lower lip deformity on left. **B**, Five years following digastric muscle transposition. Note platysma still paralyzed suggesting there has not been spontaneous regeneration of the depressor labii inferioris, but more likely, the result is from the digastric procedure.

Results

In a 14-year period, only five patients were eligible for this procedure. All of the patients were women, and the cause was surgical trauma in four patients and a lower lip deformity that was a sequelae of herpes zoster oticus in the fifth. We were able to achieve an improvement in four of the five patients, and there were no complications. Based on this experience, we would certainly support Conley, et al.[16] who stressed that this procedure in properly selected cases has earned its place in the system of procedures to reanimate the paralyzed face. Dramatic improvement can be achieved with this approach (Fig. 4–24).

This procedure is ideally suited for cases where the marginal branch is intentionally sacrificed, as would occur with cancer surgery. In this event, the muscle tendon transfer should be incorporated into the primary operation. Nerve repair, especially when possible at the time of injury, is the preferred approach to achieve the best possible results. The digastric muscle transposition is certainly not competitive with nerve repair. However, there are times when the two might be combined, particularly in cases where the nerve injury has been present for 3 months or more. As discussed in Chapters 1 and 2, the longer the time between injury and repair, the worse the outcome. Once beyond the ideal time window (from time of injury up to 30 days), combination procedures may produce a better result than the nerve repair alone (see Chapter 8). In cases where the status of the nerve is not known, for example, following a submandibular resection or a face-lift and the patient awakens with paralysis of the lower lip, it is advisable to wait for spontaneous return for an interval of 3 to 6 months. In such cases where improvement is unsatisfactory, the digastric transposition procedure should be considered.

Summary

The author has shared his experience using transposition of regional muscles to reanimate the paralyzed face. Of the three muscles available (temporalis, masseter, and digastric), the temporalis is the most useful. Each of these muscles has a specific role in a crude effort to restore only one of the multitude of vectors created by normal facial function. There are 21 muscles around the mouth responsible for spontaneous and involuntary movement,[15] and the most one can expect to achieve with a muscle transposition is replacement of one of the vectors. The temporalis and masseter muscles provide an upward and lateral pull to the corner of the mouth, while the digastric offers an opportunity to restore loss of the depressor action of the lower lip. Once again, it must be stressed that the ideal way to reanimate the paralyzed face is to repair the facial nerve, substitute the hypoglossal nerve, and rely on muscle transposition to augment the repair and substitution. One must always be mindful that the reanimation surgeon should have a full menu of technique options in order to offer the patient maximum relief of the facial deformities that follow facial nerve injuries. Muscle transposition has not been effective in reanimating the eye compared to other techniques available. It is clear that the most effective use of muscle transposition is to limit its application to the mouth region. Subsequent chapters will deal with the eye (see Chapter 6) as well as the role of combination procedures (see Chapters 7 and 8).

The sophisticated interplay of facial movements that creates the spontaneous subtleties of facial expression and the small coordinated movements of the lips required for fine articulation of human language remain beyond the grasp of the reanimation surgeon. Efforts to reach this goal using a revascularized, reinnervated muscle powered by the facial nerve itself, although capable of restoring voluntary contraction and resting facial tone, have not been able to restore the face to its normal state. In many ways, the transposed regional muscle with its own nerve and blood supply is quite competitive with the transplanted neurovascularized muscle technique. The free neurovascularized muscle is clearly a more sophisticated approach with advantages as well as disadvantages (see Chapter 5).

In spite of the scientific and technological advances, particularly in the past 30 years, one might have predicted that more progress would have been made in our rehabilitative capabilities. Rayment et al.[17] attempted to determine why spontaneous smiles could not be restored. Their discussion is relevant to the materials presented in this section. For this reason, I think it is appropriate to share their observations to help explain our limitations as facial reanimation surgeons. First, one should not expect to be able to restore a spontaneous smile by reinnervating one muscle acting along one vector and expect to replace 10 muscles acting along a variety of vectors. Second, a repaired nerve demonstrates an increase in transit time of impulses. This delay of a few milliseconds is related to the relatively poor myelination and small diameter of the regenerating axons. Third, reinnervation of a muscle is directly related to the numbers of axons that manage to cross the repair site and reach the muscle.

Normal facial muscle has about 25 muscle fibers innervated by one axon. After nerve anastomosis, the number of axons actually reaching these muscle fibers is very small. Even with the most meticulous technique, only 20 to 50% of axons grow across a nerve graft. Finally, a factor relevant to the quality of contraction produced by a reinnervated muscle is the proportion of slow and tonic motor units (histochemical type I, red muscle fibers) and fast or phasic motor units (histochemical type II, white muscle fibers). The former are responsible for tone and the relatively slow, long-lasting contractions, and the latter are responsible for the short bursts of activity. The ratio of fast and slow motor units is determined by individual motor neurons. The final result of reanimation depends on the restoration of the normal proportion of axons to slow-and fast-twitch motor units[16].

In spite of our limitations, great progress has been made, and there is an opportunity to offer every patient suffering from the effects of facial nerve injury an opportunity to improve their situation by one or a combination of procedures.

Considering the limitations of the facial reanimation surgeon, one must not neglect the nonsurgical measures available for the highly motivated patient. These include motor sensory re-education with the help of a physical therapist specialized in facial rehabilitation and the effective use of camouflage in the way of hairstyle, facial cosmetics, eyewear, dental prosthetics, and a variety of other imaginative approaches (see Chapter 9).

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5

Free Muscle Transfers for Facial Paralysis

William M. Swartz, M.D.

Since free muscle transfers were first used for restoring movement in patients with facial paralysis, the current state of the art for free tissue reconstruction has evolved to the concept of a single muscle providing a single function. The single function required most is elevation of the corner of the mouth to affect a smile.

The issues to be addressed in this chapter include the historical development of innervated free muscle transfers, selection criteria of donor muscles and nerves based on case presentation, technical considerations in surgical planning, and an analysis of results as reported by current authoritiesters.

Indications for Innervated Free Muscle Transfer

Patients who desire mimetic dynamic reconstruction are candidates for this technique. The alternatives of static slings or regional muscle transfers, including temporalis and masseter, are described elsewhere (Chapters 4, 7, and 8). Compared with these more conventional techniques, free muscle transfers offer the possibility of a more natural and possibly subconscious smile. Free muscle transfer is indicated when the native facial muscles cannot be reinnervated due to paralysis of at least 2 years' duration or resected for tumor.

An ideal indication for this procedure is in the Möbius patient with complete or almost complete palsy where both the facial nerve and muscles are not available or in cases where the temporalis muscle is compromised, as would occur following skull base surgery. The preferred time to perform free muscle transplantation is when the child reaches age 5 years. By this time, anatomical structures have reached adequate size for surgical identification and manipulation. Furthermore, if a smile can be reconstructed for a child with facial paralysis, the social trauma can be reduced. This is especially critical when the child is entering first grade and meeting new children of various ages. In contrast, surgical rehabilitation should be delayed until the teen years for children with partial segmental facial palsy.

The restoration of normal facial motion following facial nerve loss is beyond the capabilities of modern techniques; however, the replacement of a dynamic smile with symmetry at rest is an achievable goal.

Historical Development

The idea that functional reinnervation would occur with the transfer of muscle tissue was reported first by Thompson.[1] He grafted small segments of skeletal muscle onto wound beds with intact nerves, and demonstrated both engraftment and innervation. His work was not reproduced by subsequent authors, and the technique was abandoned. With the advent of modern microsurgical techniques, Harii et al.[2] transferred the gracilis to the face with both neural and vascular anastomoses, demonstrating functional reinnervation. Harii defined the essential principles of free muscle transfer in his original work (Fig. 5–1). The technique was refined by Manktelow and Zuker[3] who classified muscles by their morphology and identified fascicular territories within the gracilis that could be transferred independently. Terzis demonstrated that transferred or deinnervated muscles regain up to one-half of their power after reinnervation. She and her coworkers evaluated several donor sites for substitution of paralyzed facial muscles, and selected the pectoralis minor for its shape, size, and dual innervation.[4,5] Subsequent authors have refined the technique and added additional donor sites.

Selection of Motor Nerves

Ipsilateral Facial Nerve

The selection of donor nerves for innervating a free tissue transfer begins with the assessment of the ipsilateral facial nerve. In many instances, tumor resection allows preservation of a tumor-free nerve segment in the fallopian canal, thereby permitting use of this original facial muscle innervator for powering the free muscle transfer. This situation occurs when a previous facial nerve graft has failed, rendering the target muscles no longer capable of reinnervation, or when wide resection of a tumor involving the facial muscles is required. Under these conditions, the facial nerve

Figure 5–1. Kiyonori Harii, M.D., Professor and Chairman, Department of Plastic and Reconstructive Surgery, University of Tokyo. Dr. Harii is credited with the first neurovascular free muscle transfer to reanimate a patient with facial paralysis. Professor Harii shares a brief historical note.

The first neurovascular free muscle transfer was accomplished by Tamai and coworkers using dogs in 1970. Reading their paper soon after, I envisioned the procedure as providing a breakthough in treatment of long-standing facial paralysis in humans because we had found it difficult to obtain natural or near-natural smiles using the conventional procedures involving temporal or masseter muscle transfer. I achieved my first successful case in April 1973, in which the transferred muscle was innervated by a deep temporal nerve. One year later, good contraction beyond our expectations had been acquired, and the case was reported, together with another case, in *Plastic and Reconstructive Surgery* in 1976. However, the acquired contraction was not completely satisfactory, as muscle innervation had not been procured by the facial nerve.

The procedure, therefore, soon was modified to a two-stage method in which cross-face nerve grafting is combined. This has become most popular because innervation from the contralateral facial nerve produces an improved smile.

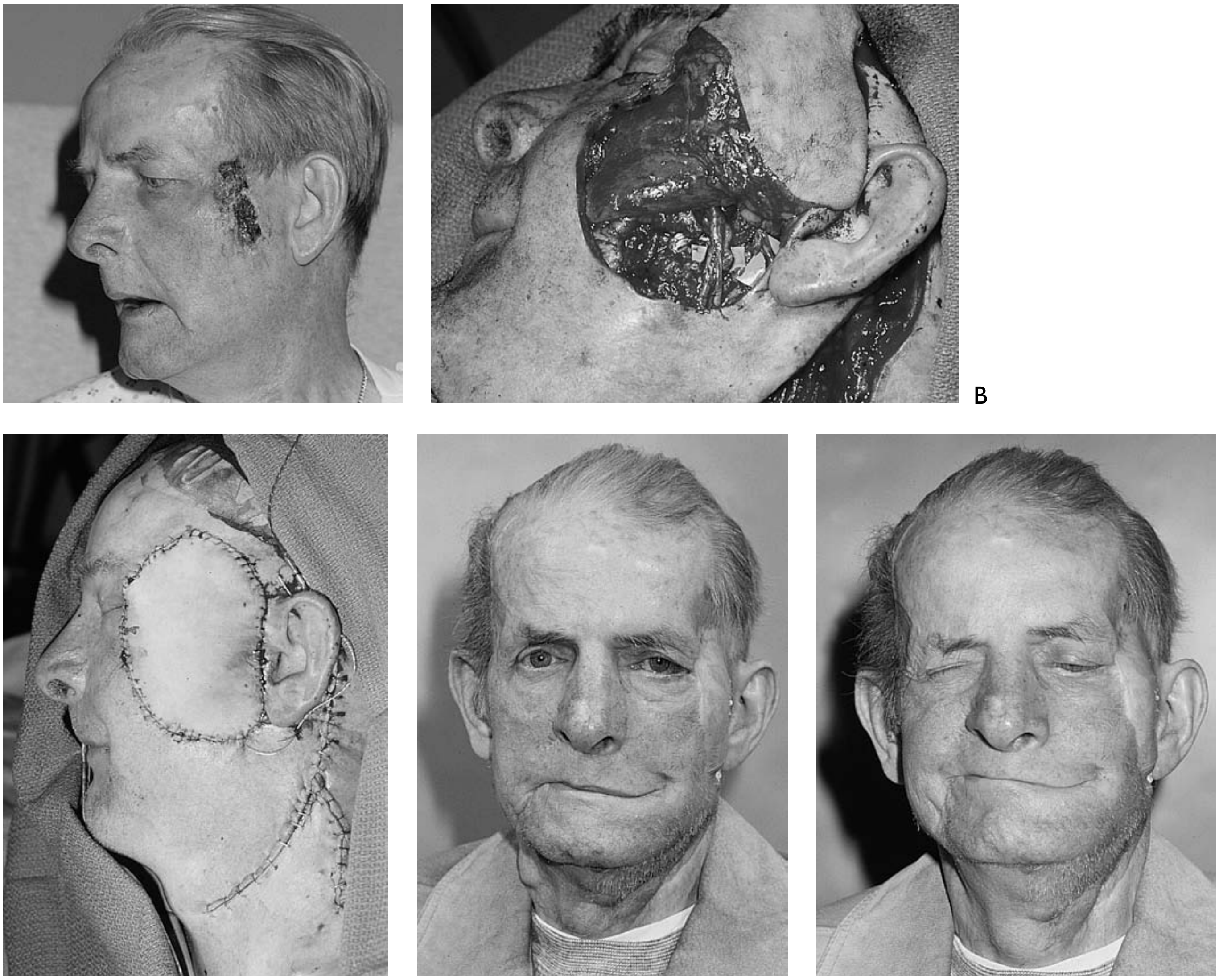
serves as the ideal motor donor site as it provides correct cerebral cortical orientation and substantial motor neurons to innervate the transferred muscle. The primary neural anastomosis provides early motor reinnervation of the transferred muscle without need for staged procedures. For reconstructions requiring external soft tissues as well as support for the corner of the mouth, a primary musculocutaneous reconstruction can be performed, which provides all of the elements of the needed reconstruction in one stage (Fig. 5–2).

Contralateral Facial Nerve

When the ipsilateral facial nerve is not available for use, usually due to the treatment of an acoustic neuroma, alternative donor nerves must be recruited. The most common procedure today employs the two-stage procedure of a cross-facial nerve graft followed by a free muscle transfer as originally described by Harii et al.[2] A sural nerve graft is anastomosed to contralateral facial nerve branches after intraoperative assessment of redundancy in the area of the zygomaticus branches. The rationale for this technique is that the contralateral facial nerve innervation will permit a mimetic smile, which can be accomplished subconsciously in a near-normal fashion and does not require cortical reorientation or conscious effort to activate the free muscle transfer. The principal drawback of this technique is that a two-stage procedure is required, as nerve regeneration must proceed across the long nerve graft prior to the transfer of the free muscle. While sacrifice of a portion of the uninjured facial nerve is required, this weakness usually improves the result, allowing the philtrum and nasal base to relax somewhat. The drawbacks of this procedure, however, are that an extended period of time is required between procedures, usually 1 year, and that the regenerated terminal branches of the facial nerve do not provide a large number of axons to the end of the nerve graft at the time of free muscle transfer. A second nerve repair is required, which further diminishes the number of available axons for the transferred muscle. In the final assessment, it is unclear whether the advantages of mimetic innervation outweigh the advantages of a single-stage operation with a greater number of motor axons available with other nerve donors. This author's impression is that using the opposite facial nerve as a donor nerve is effective in children and young adults (under 30 years) in producing a mimetic smile (Fig. 5–3). For older patients, however, alternative donor nerves such as the hypoglossal are preferred due to the length of time required for reinnervation and the relatively weaker muscle power.

The Hypoglossal Nerve as Donor Nerve Tissue

The hypoglossal nerve has enjoyed widespread use for facial reanimation, particularly in cases when the facial musculature has been recently denervated and the facial nerve has been sacrificed, as in acoustic neuroma resections. The XII-VII hypoglossal nerve transfer provides facial symmetry at rest and some degree of voluntary smile.[6] However, complications of this technique have included significant dyskinesias and hemiglossal paralysis, which lead to an unsatisfactory result in some patients. This technique is discussed in detail in Chapter 3. The hypoglossal nerve can be used to power a free muscle transfer effectively in a single-stage operation. By using a portion of the hypoglossal nerve, a high-density nerve regeneration can occur through the motor nerve of the transferred muscle, providing early motor recovery.[7] These procedures are primarily indicated for bilateral, congenital facial paralysis where facial nerves are unavailable on both sides. Zuker's experience in five patients with nine muscles



A B C–E

Figure 5–2. Use of innervated gracilis musculocutaneous free flap for reconstruction of radical cheek resection including facial nerve. **A**, Extensive squamous cell carcinoma invading parotid gland and facial nerve. **B**, **C**, Composite reconstruction. The gracilis muscle was used to suspend the corner of the mouth, reinnervated by the stump of the facial nerve. **D**, **E**, Postoperative result at 6 months showing static support of the corner of the mouth and satisfactory cosmesis. The patient died before reinnervation was effective.

resulted in eight muscles achieving an excursion of 4 to 10 mm with a good or very good results. One patient achieved a 1-mm excursion with a poor result. When only one third of the cross-section of a portion of the hypoglossal nerve is utilized, there is little deficit noted in tongue function (see Chapter 3). The donor site morbidity can be minimized further by using the distal most fibers that innervate the suprahyoid muscles.* This procedure is contraindicated in patients who have injuries to the hypoglossal, vagal, or glossopharyngeal nerves due to trauma, cancer extending to the cranial base, or congenital deficiency. Speech and swallowing function must be assessed carefully prior to sacrificing the hypoglossal nerve that might be critical for these functions. In appropriately selected patients, however, the bilateral partial hypoglossal nerve-free muscle transfers have proved to be exceptionally useful in the treatment of congenital facial paralysis while preserving tongue function (Fig. 5–4). The use of this nerve also affords the option for a one-stage facial reanimation with free muscle transfer and primary nerve anastomosis. The advantages of this procedure are that it avoids a two-stage operation with a 1 year period of time in between and provides high-density nerve reinnervation of the transferred muscle. In this author's experience, the strength of motor reinnervation is considerably greater than with the cross-facial nerve graft. The drawbacks of this operation center around the need for re-education of speech patterns utilizing control of tongue motion to effect a smile. With a postoperative course of structured physical therapy, we believe that this one-stage operation can provide effective facial reanimation (Fig. 5–5).

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*Editor's note: See Chapter 3. The technique is described for using fibers of the hypoglossal nerve with tongue sparing. Splitting the hypoglossal nerve or using its distal most branches is discouraged because of the high incidence of tongue morbidity.

A, B

C, D

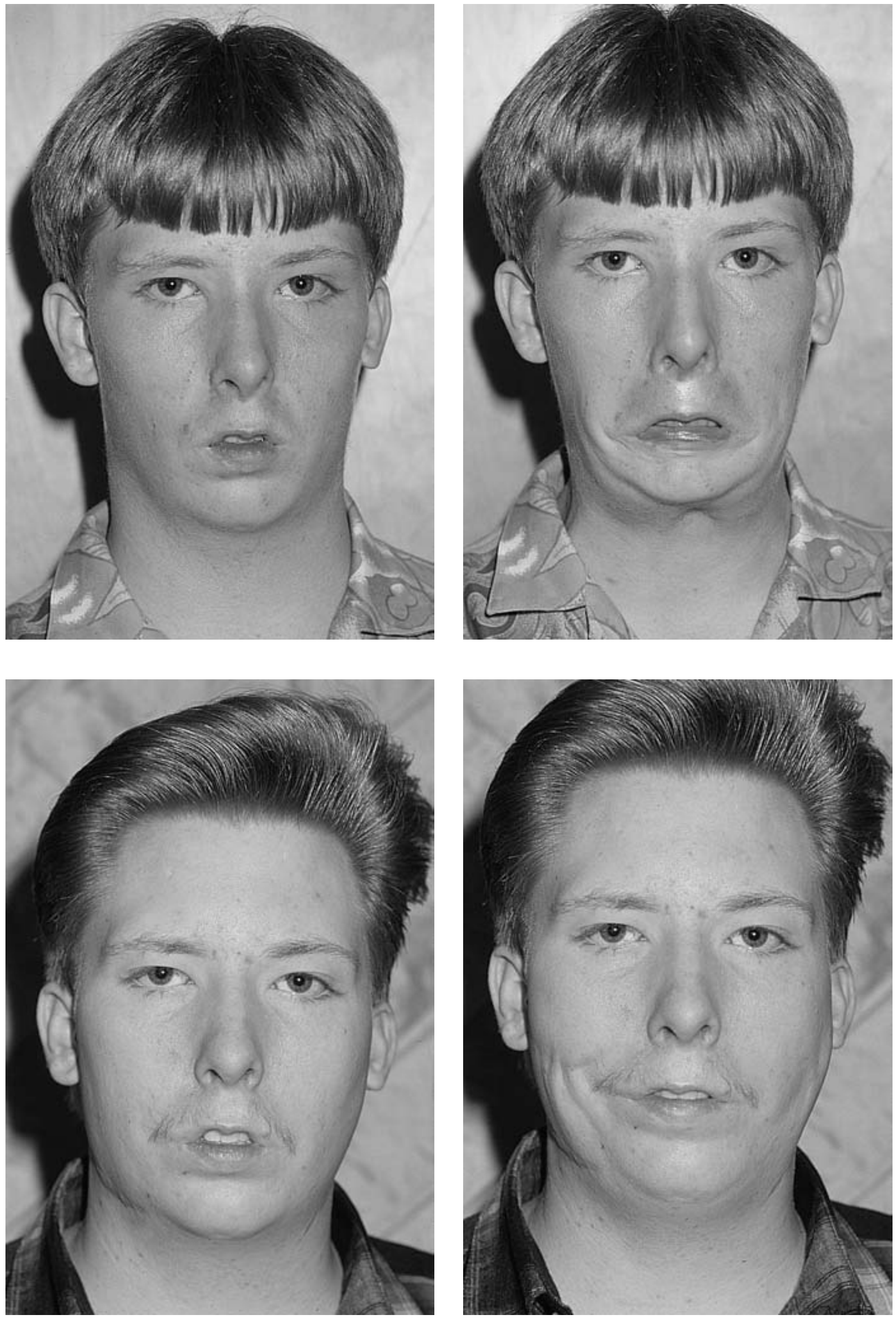
Figure 5–3. Facial reanimation using cross-face nerve graft. **A**, **B**, The operative views of a 7-year-old child with left congenital facial palsy. **C**, **D**, Postoperative views 2 years after gracilis muscle free flap and cross-face nerve graft were performed at the same setting.

Fifth Cranial Nerve

Zuker and Manktelow[8] have championed the use of the motor nerve to the masseter muscle on the affected side to power free muscle transfers in a one-stage procedure. The masseter motor nerve, which controls mastication, has the advantage of being in the immediate vicinity of the transferred muscle thus allowing a short reinnervation distance. These authors have found that motor reinnervation is effective and similar to the use of the tongue for the activation of motion. The use of jaw motion to similarly affect facial smile can be controlled with education. The principal advantage of this procedure over the cross-face nerve graft is that it is a one-stage operation. Further, using the masseter motor nerve offers advantages over the hypoglossal nerve, mainly sparing tongue function and preserving swallowing. In addition, hypoglossal nerve involvement is more often associated with congenital facial paralysis than is fifth nerve involvement. Nevertheless, potential donor cranial nerves must be fully investigated prior to their use.

In summary, the selection of donor nerve tissues depends largely on the reconstructive requirements and the nerves available for use. At this time, controversy continues to exist as to whether a one-stage operation that employs nerves from either the tongue or the jaw has advantages over the two-stage operation for mimetic innervation.

In elective unilateral reconstructions (non-cancer), Zuker, Harrison, Harii, Buncke, and Terzis (personal communication, 1997) prefer the two-stage procedure employing



A, B

C, D

Figure 5–4. Bilateral facial reanimation in Möbius syndrome using hypoglossal nerve. **A**, **B**, An 18-year-old male with congenital Möbius syndrome. **C**, **D**, Postoperative views 2$\frac{1}{2}$ years after bilateral gracilis muscle transfers were innervated by hypoglossal nerve. "Smile" is done subconsciously.

the contralateral facial nerve. Their results are assessed below. When patients are affected bilaterally (Möbius syndrome) or in primary cancer reconstructions, the partial hypoglossal nerve as recipient is selected. These authors acknowledge that the speed of nerve regeneration and the strength of the transferred muscle when powered by the hypoglossal nerve is greater than that of the cross-facial nerve graft, but feel that the mimetic result with the cross-facial nerve graft is superior overall. In bilateral Möbius cases, however, a degree of mimetic spontaneous movement has been observed in young patients. As yet, a controlled comparison of the two techniques has not been performed.

Selection of Donor Muscles for Transfer

A variety of muscles have been chosen by numerous authors for free tissue transfer in facial reanimation. In descending order of frequency, these include the gracilis, pectoralis minor, latissimus dorsi, serratus, extensor digitorum brevis of the foot, platysma, abductor hallucis, and rectus femoris. The criteria for selection of such a muscle include a fiber length that corresponds to the action of the zygomaticus major muscle, approximately 6 to 8 cm in length, a suitable vascular architecture, and a donor nerve

A–C

D, E

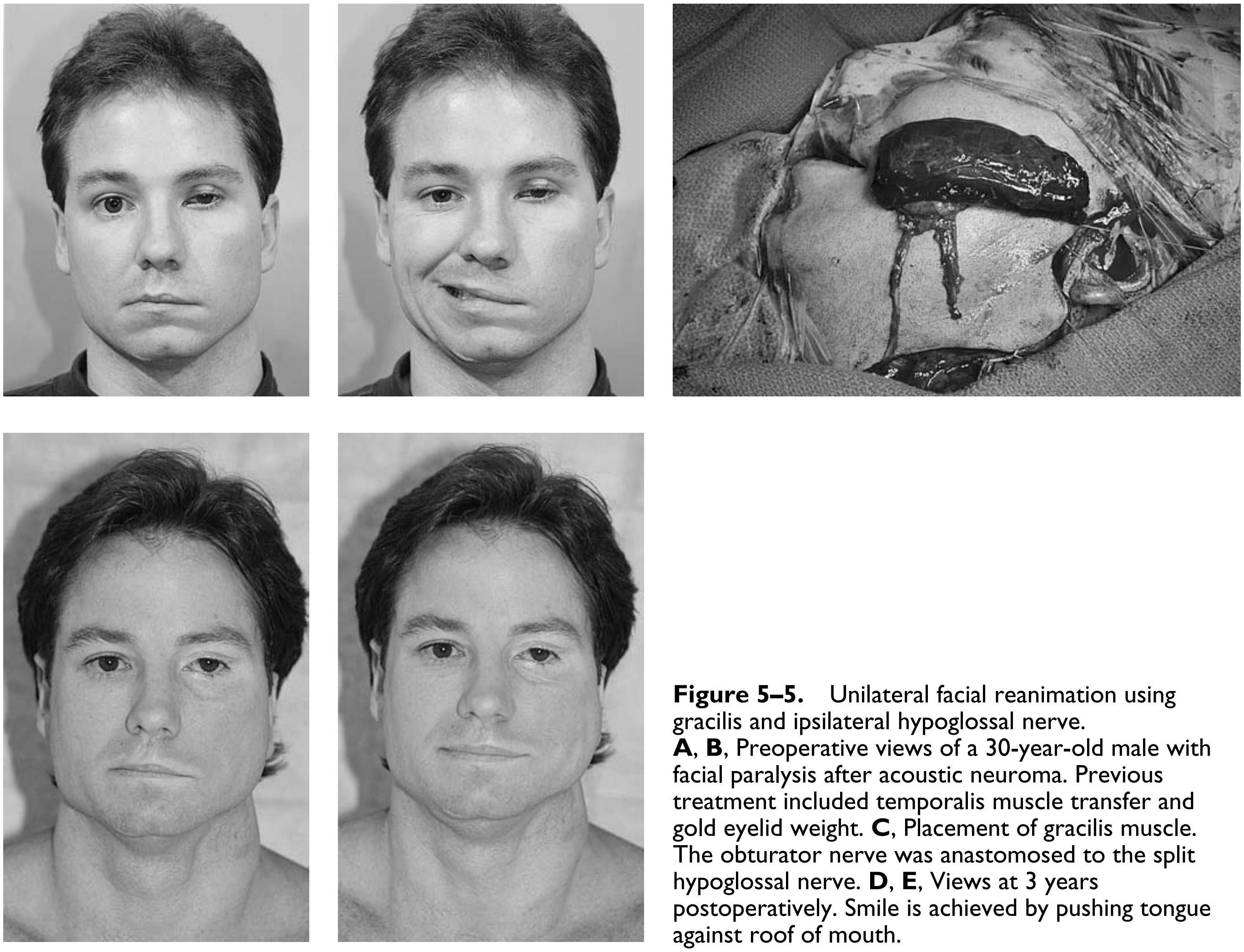


Figure 5–5. Unilateral facial reanimation using gracilis and ipsilateral hypoglossal nerve. **A**, **B**, Preoperative views of a 30-year-old male with facial paralysis after acoustic neuroma. Previous treatment included temporalis muscle transfer and gold eyelid weight. **C**, Placement of gracilis muscle. The obturator nerve was anastomosed to the split hypoglossal nerve. **D**, **E**, Views at 3 years postoperatively. Smile is achieved by pushing tongue against roof of mouth.

long enough to reach the hypoglossal nerve or previous cross-face nerve transfer. The loss of the muscle in question must not produce a significant donor site morbidity, either from the loss of the muscle per se or the scar required to obtain the muscle. Terzis has further set a criteria for density of motor nerve axons available for reinnervation, a so-called "smart muscle." In her study of a wide variety of muscles, the pectoralis minor most closely met the ideal.[5] Additional considerations include the location and orientation of suitable suture anchor points, such as tendon insertions and origins, which would be advantageous in muscle placement. The following muscles will be analyzed with regard to the above criteria.

Gracilis Muscle

Following the introduction of the gracilis muscle for facial reanimation by Harii and others,[2] numerous authors have reported on the use of this muscle.[3,7] It remains today this author's most favored muscle. Manktelow and others have refined the use of the gracilis and demonstrated the intramuscular anatomy, permitting dissection of the gracilis muscle within a discrete nerve and vascular supply corresponding to the precise anatomy required for reproducing the zygomaticus major function.[3] The principles enumerated in his work can be applied to other muscles in a similar fashion. The vascular pedicle of the gracilis muscle is derived from the medial femoral circumflex artery and provides a pedicle length of approximately 6 to 8 cm. The obturator nerve, which supplies this muscle, divides along with the fascicular pattern of the muscle into anterior and posterior divisions. The length of this nerve, harvested from the obturator foramen, is approximately 10 to 12 cm. The advantages of the gracilis muscle include the fact that the donor site is distant from the head and neck, thus permitting two-team dissection during surgery. Additionally, the donor site scar is hidden in the medial thigh. There is no functional disability noted with sacrifice of the gracilis muscle. For patients who require additional soft tissue reconstructions of the cheek, such as a radical parotidectomy resection with overlying skin, a skin island may be harvested with the flap thus providing both innervated muscle and overlying skin for wound closure (Fig. 5–2).

Pectoralis Minor Muscle

The pectoralis minor has been used extensively by Harrison[9,10] and Terzis[5] for facial reanimation procedures. It originates from the third, fourth, and fifth ribs and from the fascia overlying the intercostals. The insertion of this muscle is the tendon that is attached to the coracoid process of the scapula. The vascular supply emanates from the axillary artery but may consist of up to three smaller vessels originating from the lateral thoracic or the acromiothoracic vessels. The nerves that supply this muscle include the medial and lateral pectoral nerves, which penetrate the pectoralis minor prior to going on to innervate the pectoralis major muscles. The pedicle length of this muscle is somewhat short, being approximately 3 to 4 cm, and the dissection is tedious. However, the advantages of this muscle are that the size of the muscle is appropriate for restoration of an active smile and the tendinous insertion provides a strong anchor point. The dual nerve supply offers theoretical possibilities for performing simultaneous smile and eye sphincter restoration.

Latissimus Dorsi Muscle

The latissimus dorsi muscle has enjoyed wide popularity for reconstruction of a variety of extremity and head and neck defects. To reanimate the face, however, a small portion of this muscle can be harvested, based on divisions of the thorocodorsal nerve. In fact, two to three slips of the muscle can be designed on a single neurovascular pedicle. The advantages of this technique are similar to that of the gracilis muscle. The anterior portion of the muscle can be isolated on a branch of the thoracodorsal neurovascular pedicle and sized as desired, leaving the remaining latissimus muscle innervated by the larger trunk of the thoracodorsal nerve and its circulation provided by intercostal perforators. This technique has been used extensively by Dellon and Mackinnon.[11] More recently, Harii has modified this technique to provide a long recipient nerve[12] (see below), permitting a one-stage procedure utilizing the contralateral facial nerve as donor.

Other Motor Donor Sites

The serratus muscle, also based on the thoracodorsal arterial and venous systems, has been reported for use in facial reanimation procedures.[13] The nerve supply, however, is the long thoracic nerve, which enters the muscle more anteriorly than the vascular supply. By dissecting the long thoracic nerve into its component parts, individual slips of serratus muscle can be harvested with a single arterial and venous anastomosis. Theoretically, this offers the opportunity to provide more than one motor function, for example, eye sphincter closure as well as smile restoration. To date, however, the goal of separate eye closure and smile restoration has not been realized. (See Chapter 6 for eye reanimation.)

The abductor hallucis muscle also has been reported for facial reanimation.[14] This muscle, which originates in the medial aspect of the foot, has a blood supply originating from the posterior tibial artery and vein and a nerve supply originating from the medial plantar nerve. The total length of this muscle is approximately 13.5 cm, and the bulk is suitable for use in facial reanimation surgery. The length of the motor nerve available for transfer is short, approximately 1.7 to 2.0 cm. By performing an intraneural splitting, a long recipient nerve can be obtained. The advantages of this motor unit are that the muscle length is ideal for restoration of a lateral smile and that the origin and insertion of the muscle have excellent fixation points, leaving no residual deformity. Two operating teams can easily work simultaneously. As yet this technique has not enjoyed widespread use.

Author's Preferred Technique: Gracilis Muscle Transplantation

The gracilis muscle is chosen to illustrate the technical aspects of muscle inset. Each of the other described muscles are treated similarly. The details of flap harvest can be gleaned from the referenced papers or microsurgical texts. After identifying the medial thigh fascia posterior to the saphenous vein, the fascia is opened and gracilis muscle identified. The oblique orientation of an obturator nerve to the medial femoral circumflex vessels confirms that this is indeed the gracilis. In the proximal one-third, the medial femoral circumflex artery and vein, and the obturator nerve are dissected to their origins. The muscle is trimmed to include the anterior or posterior one half, and the nerve is stimulated to ensure proper innervation. At resting length, silk marking sutures are placed at 1.0-cm intervals to insure proper resting tension later at the inset. Finally, the muscle is detached and cooled with crushed ice and then kept cold until revascularization is achieved.

In the cheek, the preauricular incision is extended just beneath the angle of the mandible to permit dissection of the facial artery and vein. The previously placed cross-facial nerve is identified and a specimen submitted for histologic confirmation of viable axons in the nerve stump. The hypoglossal or masseteric nerve may be alternatively dissected. Placement of the gracilis muscle is guided by preoperative vector analysis of the patient's contralateral smile. This angle should be reproduced as closely as possible when insetting the muscle. Practically speaking, the vector of pull is placed as vertically as possible along the zygomatic arch.

Prior to muscle placement, static suspension of the corner of the mouth to the zygoma and malar eminence is provided by freeze-dried fascia lata graft. The rationale of this maneuver is to take tension off the free muscle transfer during the 6 months required for reinnervation, thus allowing the muscle to begin its pull from a position of facial symmetry. While autologous fascia lata, palmaris tendon, and temporalis fascia have a more permanent effect, the temporary suspension of the modiolus is all that is required.

The gracilis muscle is next sutured to the modiolus with the nonabsorbable merselene sutures used to secure the fascia lata graft. The muscle is stretched to its original resting tension using the silk marking sutures as a guide, and then secured to the zygoma and/or malar eminence as determined by the preoperative vector analysis. Vascular anastomoses are performed, and then the nerve coaptation is performed as close as possible to the muscle hilum. Postoperatively, the patient is kept on a liquid diet for 5 days and then a soft diet for 3 weeks. The drain is removed at 2 to 3 days. Monitoring of the microcirculation has proven difficult as the muscle is completely hidden from view. The 20 mHz ultrasonic implantable Doppler placed directly on the outflow vein has provided a continual direct monitoring of flap circulation, permitting early detection of vascular thrombosis.[15] The probe is removed by percutaneous extraction at the time of discharge.

Movement is anticipated at approximately 6 months. At that time, active exercises are started under the supervision of a trained therapist. During this time, daily exercises are encouraged, using a mirror for visual feedback. Continued improvement in muscle control and excursion occurs over the subsequent 18 months. In selected patients, botulinum toxin may be used to weaken the contralateral side, thereby facilitating the recruitment of the transposed muscle. This selective paralysis also may assist in defining the need for neurectomy or myectomy for facial balance at a later date.

When alternative donor nerves are used, particularly the hypoglossal, temporary alteration in speech or swallowing are experienced. Provided only part of the nerve is used, these disturbances of function are minor and resolve within several months.[8]

Assessment of Results

The technique of free muscle transfer for re-creating the smile has been remarkably successful in accomplishing its stated goal. In the above-cited authors' reported series as well as in our own, the percentage of muscle survival and reinnervation is collectively greater than 95%. Failures can be attributed to vascular thrombosis (if detected), lack of reinnervation, or both. Optimal results, however, depend more on the subtleties of muscle inset, bulk, and power of reinnervation. These variables are affected most importantly by the density of nerve ingrowth to the transplanted muscle.

Two-stage Procedures with Cross-Facial Nerve Grafts

Ueda et al.[16] assessed the density of axons in sural nerve stumps by light microscopy in 8 patients during the second-stage procedure. They also examined 20 healthy facial and sural nerves. The average density of myelinated fibers in intact sural nerves was 4894 $\pm$ 1951 fibers/mm^2, and that of regenerated myelinated fibers in the distal stumps of the cross-facial nerve grafts was 379 $\pm$ 358 fibers/mm^2. The number of regenerated fibers was 13 to 15% of the number in intact facial nerves, and the diameter of regenerated myelinated fibers was approximately 60 to 70% of the diameter of intact facial nerves. They also found that the ends of regenerated cross-facial nerves showed perineural fibrosis and increased endoneural connective tissue. Despite the reduced number of axons in the regenerated cross-facial nerve graft, sufficient axons cross the two nerve repairs to power the transplanted muscle.

Jacobs et al.[17] studied 30 biopsies of sural nerve grafts immediately prior to performing the second-stage free muscle transfer 5.5 to 14.5 months after grafting. The mean number of myelinated fibers was 426 $\pm$ 437, and the total number of axons (11,469) was found to be about twice the number of axons in the buccal branch of the facial nerve (5589). Thus, these two quantitative studies[16,17] suggest that a large number of axons regenerate through the long sural nerve graft. A small proportion are myelinated at the time of grafting; however, a large number of unmyelinated fibers regenerate. It is postulated that as the nerve grafts innervate functioning muscle, a greater population of nerve fibers eventually become myelinated. It is also interesting to note that there was no correlation between nerve fiber regeneration, age, and regeneration time.

Following the two-stage procedure, denervation potentials are seen in the transplanted muscle from 10 days to 9 months postoperatively, and low amplitude action potentials are noted approximately 4 months after surgery. In Ueda et al.'s study,[16] the motor nerve conduction velocity increased over a 3-year period to reach near normal levels for the sural or facial nerve. This experimental data mirrors our clinical experience in that the strength of muscle contractures continues to improve after 2 years postoperatively.

An assessment of the clinical results of this two-stage procedure was provided by Harii (personal communication, November 1996). Of 278 free muscle transfers, 210 were powered by a cross-facial nerve graft. Using a grading scale of 0 to 5, 206 of 278 total transfers achieved a score of 4 or more achieving satisfactory reinnervation of the transferred muscle. Half of these achieved natural or near-natural animation. The other half had noted problems with too much bulk, contractions that were too weak or too strong, or problems with the muscle attachment.[18]

Harrison,[10] in a review of 183 pectoralis minor muscles for unilateral facial paralysis, noted an 86% "good" result and 14% with "fair" or "poor." The average age was 13, and there was no donor site morbidity associated with the contralateral buccal branch sacrifice. Sixty percent produced "really good symmetry." He also noted that surgery performed on younger patients is more likely to produce good results (personal communication).

Single-stage Procedure: Hypoglossal Nerve

Using the partial hypoglossal nerve as a recipient motor source, Ueda et al.[7] reported 17 cases. Of the 17, 13 achieved acceptable voluntary contractive, synchronous, and natural expression with emotional facial movements, a good outcome according to their evaluation criteria. In this group, facial movement was noted 4 to 9 months postoperatively. With respect to tongue function, some atrophy was seen in all patients. Functional problems with speech were noted in all cases with the exception of those where the lowermost fibers to the suprahyoid muscles were utilized. Stagnation of food during swallowing was noted in nearly all patients; however, only two complained of swallowing difficulties. The authors concluded that the effect of hypoglossal nerve sacrifice is most noticeable when fibers to the posterior tongue are sacrificed, and least noted when the more distal fibers to the strap muscles are used.

Single-stage Procedure: Contralateral Facial Nerve

The transfer of a muscle with a long neural pedicle that could be anastomosed to the contralateral facial nerve in a single stage offers the opportunity to combine the best features of previous techniques. Hua et al.[14] introduced the abductor hallucis muscle flap supplied by a motor branch of the medial plantar artery, for this purpose. This tibial nerve is split proximally to gain sufficient length (19 cm) to reach the contralateral nerve branches. Six patients were reported in their series; four achieved "excellent" results using this technique and realized mimetic smiles. In the two with lesser results the ipsilateral trigeminal nerve was used as the recipient nerve, and only voluntary facial motion was achieved. The authors note the near-ideal shape and size of this muscle for replacement of the paralyzed face and minimal donor site morbidity encountered. Koshima et al.[19] described the rectus femoris muscle as a new donor site for one-stage reconstruction. Based on the lateral femoral circumflex artery and vein and innervated by a branch of the femoral nerve, the rectus muscle can be harvested with a 20-cm length of nerve. Seven patients were reported, all reaching "good" or "very good" results with reinnervation occurring 8.2 months (average) after surgery. No donor site morbidity was observed. A technical advantage of this muscle is the presence of fascia at both ends, permitting a reliable anchor point for sutures. Segmentalization of the large muscle is required to obtain a muscle unit of size suitable for facial restoration. Harii et al.[12] have revisited the latissimus dorsi muscle with the idea of performing a one-stage reconstruction. By dissecting the thoracodorsal nerve distally into the muscle, a segment of muscle can be obtained with a 15-cm pedicle length of nerve, sufficient to reach the contralateral facial nerve buccal branch. Fourteen patients were reported using this technique. "Good," "satisfactory," "fair," and "poor" results were reported in 10, 2, 1, and 1 patients, respectively. This one-stage procedure is now his procedure of choice (K. Harii, personal communication, November 1996).

Each of these three different motor units have the possibility of providing recipient nerve of sufficient length to reach the contralateral facial nerve. The advantages of this approach are the reduced total recovery time, the single-stage procedure, and the possibility of mimetic movement. A significant factor in these improved results is the match of nerve size with the peripheral facial branches, an improvement over the sural nerve graft, which is usually considerably larger (see Chapter 2). Axon drop-out may still be a problem, however, if the muscle is segmentalized such that only a small part of the dissected nerve supplies the muscle flap.

Summary

Free muscle transfers powered by cross-facial nerve grafts or ipsilateral donor nerves such as the motor branch of the trigeminal or the hypoglossal nerves for end-organ facial paralysis have proven themselves to be an effective method of restoring that essential characteristic of humanness—the smile. In selected patients, they provide dynamic, mimetic movements that are not matched by static techniques. This procedure is still evolving. Techniques that employ long nerves to be co-opted to the contralateral facial nerve with a single repair site offer promise over the more widely utilized two-stage procedures. Research related to the neurophysiology of the "mimetic smile" may ultimately elucidate whether seventh nerve-based procedures are superior to twelfth nerve-innervated muscle transfers. Such factors as the ratio of slow twitch to fast twitch fibers in transferred muscles that have undergone reinnervation and the number of muscle fibers that ultimately become activated are the subject of ongoing research[19].

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6

Eye Reanimation Techniques

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"Guard them like the pupil of an eye"*

Abnormalities of eyelid position and defective tearing are the two major causes of eye symptoms associated with paralysis. This chapter will deal with the medical and surgical management of these problems. In addition, this portion of the book will cover treatment of excessive as well as deficient tearing. For the sake of comprehensiveness, aberrant tearing (crocodile syndrome) and sweating (Frey's syndrome) will be included as the mechanisms for both involve faulty regeneration of the parasympathetic system following facial nerve injury. However, abnormalities in lid position due to hyperkinetic disorders causing an inability to open the eyelids such as blepharospasm, hemifacial spasm and synkinesis following faulty regeneration will not be covered because they are included in Chapters 23 through 27.

Patients with facial paralysis may have eye problems ranging from slight ocular irritation to corneal ulceration, perforation, and blindness (Figs. 6–1 through 6–4).[1] The severity of these complications is related to the degree and duration of the paralysis. The major factors leading to these problems include incomplete eyelid closure (referred to as lagophthalmos; Fig. 6–5), paralytic ectropion of the lower lid (Fig. 6–6), loss of corneal sensation, decreased tear production, and absence of reflex rolling up and out of the cornea with efforts to close the eyelids (known as Bell's phenomenon; Fig. 6–7). In this chapter, a systematic approach to the evaluation and medical management of these factors will be stressed. Surgical techniques to reanimate the eyelids should only be considered for those patients in whom medical management fails or for patients with total or permanent paralysis in whom lasting corneal protection and correction of malpositioned eyelids is necessary.

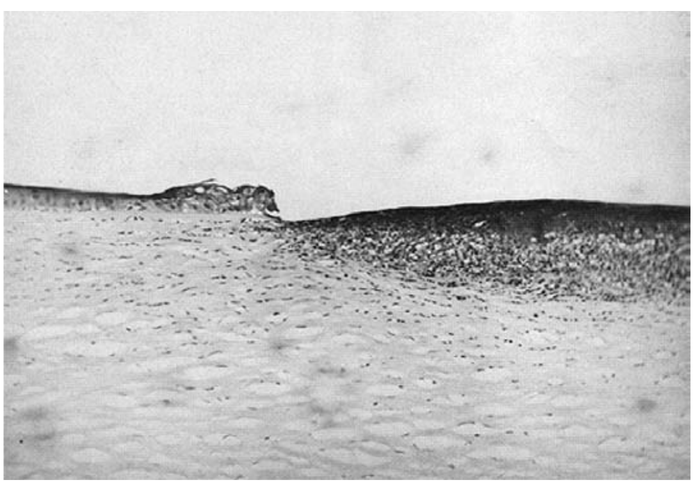


Figure 6–1. Right, cornea with exposure keratitis resulting in ulceration. Normal cornea is seen at left. Note loss of epithelium and Bowman membrane and marked inflammatory reaction in stoma at right (H&E, X65). (From Levine RE.[1] With permission)

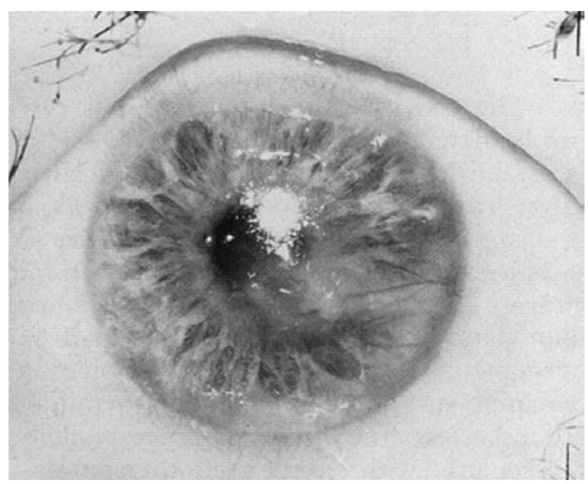


Figure 6–2. Recurrent neurotrophic ulceration with marked vascular ingrowth. (From Levine RE.[1] With permission.)

* Taken from a prayer ("We beg you!" pleading with the Lord) recited in the Jewish morning service ascribed to Rabbi Nechunia ben Hakanah, considered to have profound mystical significance.

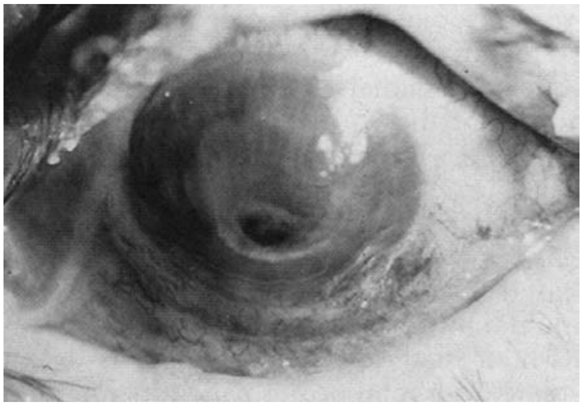


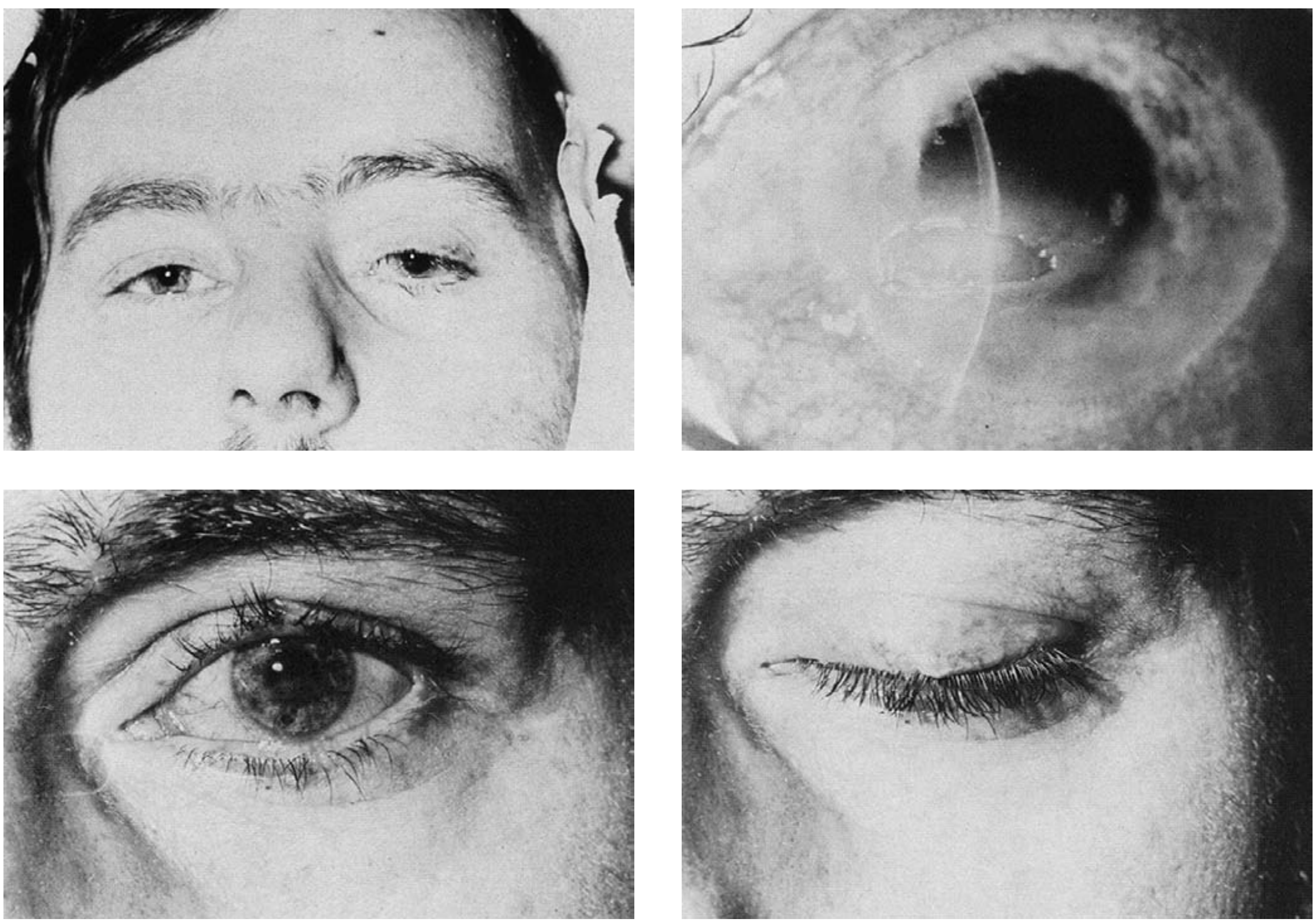
Figure 6–3. Patient with marked fifth and seventh cranial nerve impairment following resection of a large acoustic schwannoma. Eight months later, severe neurotrophic and exposure keratitis progressed to corneal perforation, and keratoplasty was required.

Evaluation and Medical Considerations

Ophthalmologic Evaluation

The cause, duration, and severity of the patient's ophthalmologic problem must be determined. This is done by taking a careful patient history and performing a thorough physical examination.

History Prior to planning treatment, every effort must be made to find the cause of the facial paralysis. Once this is established, the duration of the facial paralysis can be predicted, and the severity appreciated. For example, if the facial nerve was sacrificed during surgery to resect a tumor and no effort was made to graft the nerve, paralysis will very likely be total and permanent. In such a case, aggressive and dynamic surgical rehabilitative techniques are indicated. In contrast, if the nerve defect was repaired with a nerve graft, paralysis would be total postoperatively, but recovery might be expected in 6 months to 1 year, and for such patients, medical management might



A B C D

Figure 6–4. Results of eye reanimation using eye spring. **A**, Patient post-acoustic tumor surgery showing the BAD syndrome: loss of *B*ell's phenomenon, *A*nesthetic cornea, and a *D*ry eye. **B**, Within 10 days of acoustic surgery, a corneal ulcer developed. **C**, With appropriate ophthalmologic care, the ulcer healed, and the eyelid was reanimated with a spring implant. In this photograph, the spring is in place with the eyelids opened. **D**, Eyelid closure achieved with the eye spring.

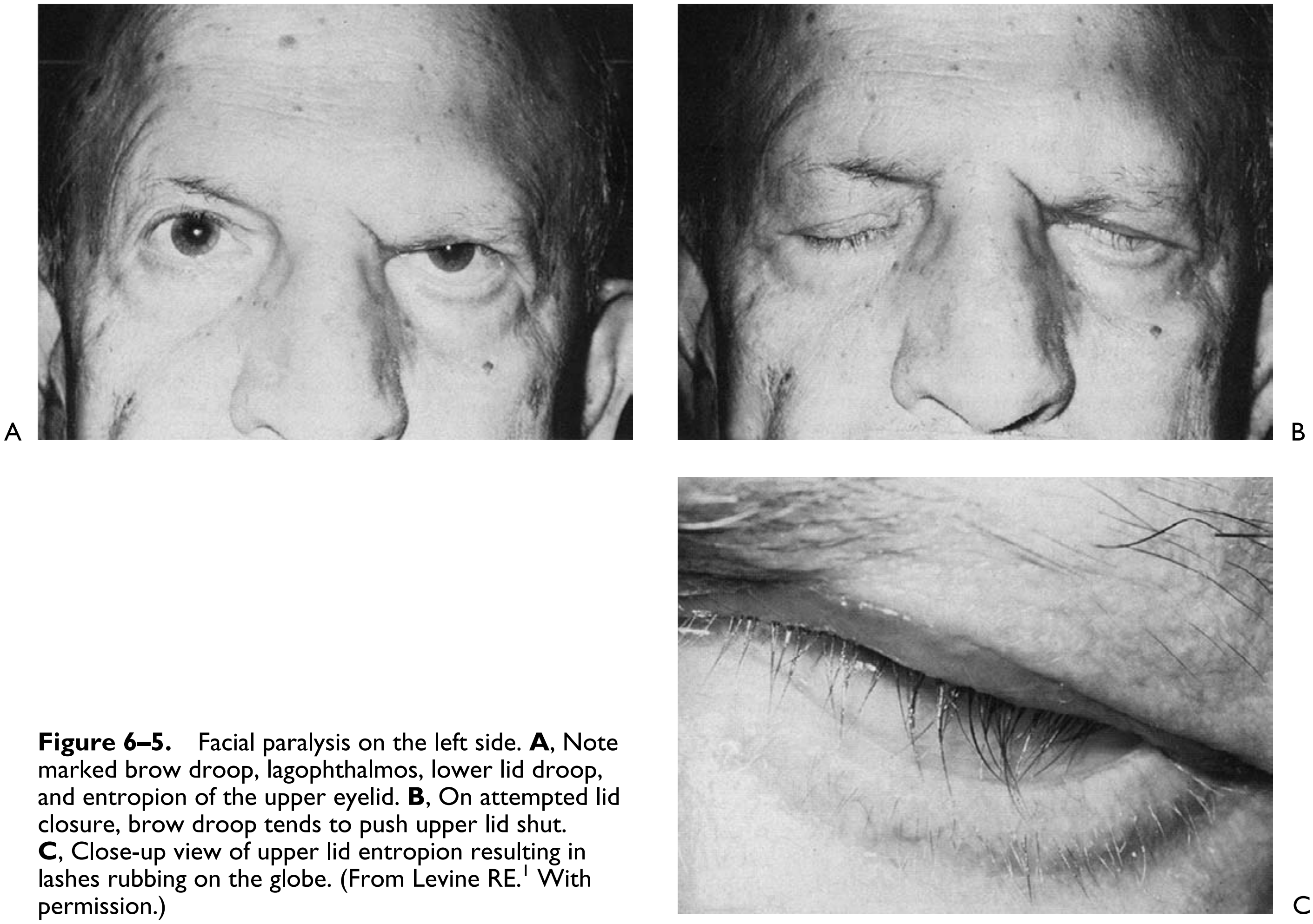


Figure 6–5. Facial paralysis on the left side. **A**, Note marked brow droop, lagophthalmos, lower lid droop, and entropion of the upper eyelid. **B**, On attempted lid closure, brow droop tends to push upper lid shut. **C**, Close-up view of upper lid entropion resulting in lashes rubbing on the globe. (From Levine RE.[1] With permission.)

be more appropriate. Finally, if the patient had acute Bell's palsy and facial nerve involvement was incomplete, the prognosis would be quite favorable for complete recovery within 6 weeks to 3 months, and the most conservative form of treatment would be indicated.

Once the cause of the paralysis has been ascertained, the patient should be questioned about ocular problems since the onset of the facial paralysis. These may include redness, irritation, dryness, photophobia, or blurred vision. A history of ocular problems unrelated to the facial paralysis may affect management of the presenting condition. For example, bilateral refractive errors may be aggravated by poor tearing or using ointment in an eye affected by facial palsy. In addition, treatment may be affected by preexisting monocular vision, chronic lid infection, or ptosis; if the eye with the best visual acuity is the one on the side of the facial paralysis, extreme caution must be taken to protect this eye and preserve vision. Finally, the physician should elicit any history of prior corneal ulceration or ophthalmologic surgery, and should find out what previous attempts may have been made to treat the paralyzed eyelids.

Physical Examination The physical examination of the patient with facial paralysis includes evaluation of visual acuity and visual fields; the level of the eyebrows; eyelid approximation with involuntary blink and voluntary effort; extraocular muscle function; pupil size, symmetry, and response to light; and funduscopy. The conjunctiva and cornea are examined for inflammatory changes, and fluorescein is applied to the surface of the globe to identify areas of early epithelial damage or loss. Ideally a slit-lamp examination should be done to determine the degree of any corneal involvement (Figs. 6–2 through 6–4).

The presence of the BAD syndrome calls for aggressive medical therapy since eye complications almost always occur in patients with this syndrome (Fig. 6–4). The BAD syndrome consists of lack of Bell's phenomenon, which may lead to poor corneal coverage and lack of tear distribution; corneal anesthesia, due to exposure or fifth nerve deficit, as may occur in resection of a large posterior fossa tumor; and dryness, due to loss of tear production, as with lesions at or proximal to the geniculate ganglion.

Visual Acuity Perhaps the most important part of the examination is to determine visual acuity because this is a sensitive indicator of corneal change. Each eye is tested separately by having the patient read letters from a standard Snellen distance chart or a card of the Rosenbaum or Jaeger type (Rosenbaum Pocket Vision Screener, Cooper Vision Pharmaceuticals Inc., San German, Puerto Rico).

Eyebrow Brow ptosis can be evaluated by noting the level of the brow on the involved side compared to that on the normal side at rest and with elevation (with wrinkling

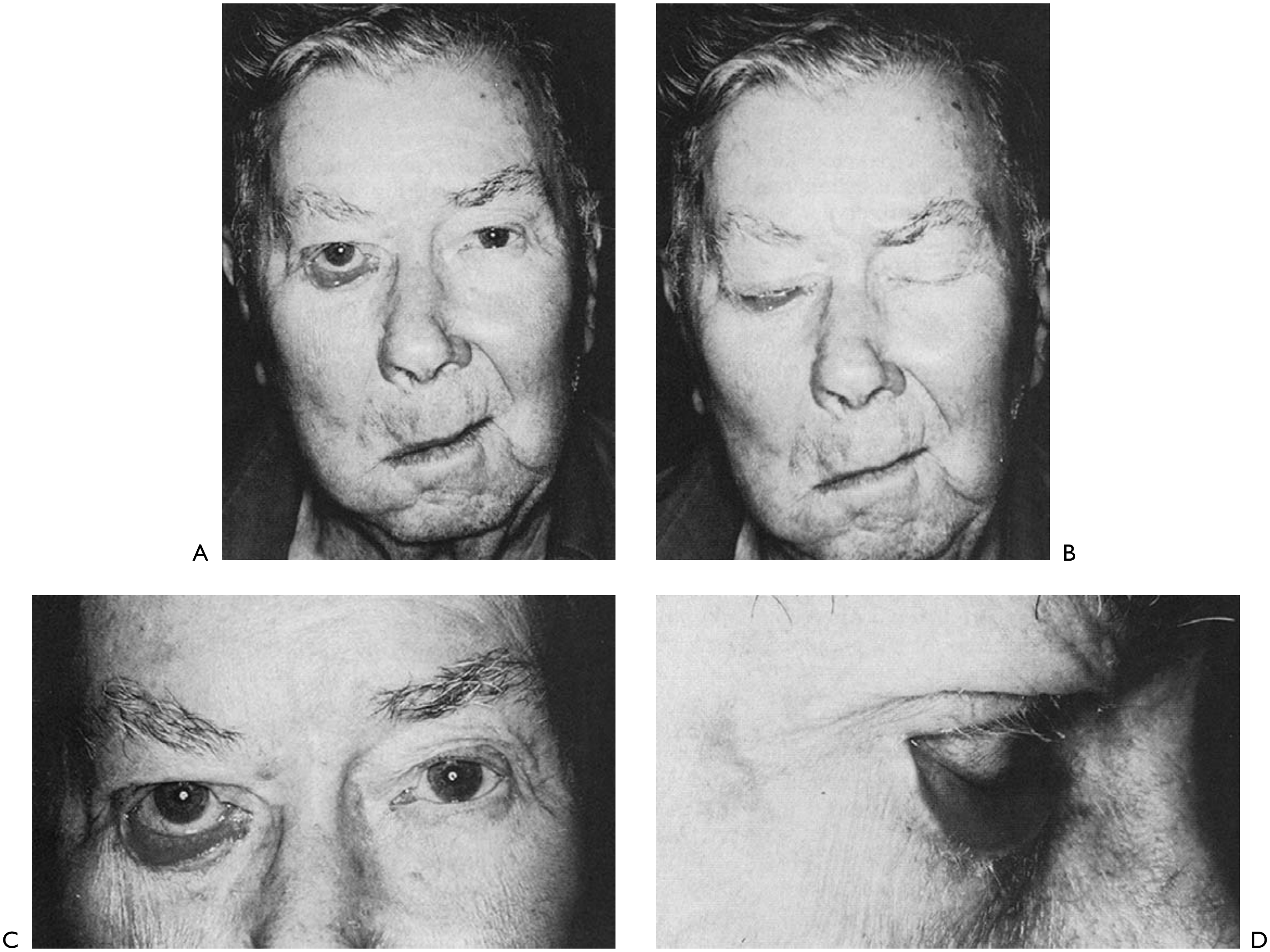


Figure 6–6. **A**, Complete facial paralysis 1 week following Bell's palsy. Note severe sagging of the involved side on the right. **B**, Significant lagophthalmos due to ectropion. **C**,**D**, Severe ectropion and conjunctival reaction.

the forehead). In addition, paralysis of the frontal muscle may cause severe impairment in upward gaze as a result of severe brow ptosis (Fig. 6–5).

Eyelids The upper eyelid is examined for its ability to cover the cornea with efforts to blink involuntarily and with voluntary eyelid closure. The patient with a partial facial palsy may be able to approximate the eyelids with a voluntary effort, but the cornea is left exposed with reflex blinking because of incomplete eyelid closure and absence of the Bell's phenomenon (Fig. 6–7). In addition, the presence of lagophthalmos or lack of upper and lower eyelid approximation should be noted. Eyelid approximation is primarily a function of the upper eyelid since its downward movement is 5 to 7 mm compared to the lower lid, which only elevates 0.5 mm. However, although lack of lower lid elevation may not play a significant role in lagophthalmos, the presence of paralytic ectropion leads to punctal eversion and may be responsible for excessive epiphora, corneal drying, and lower conjunctival inflammation and scar retraction (Figs. 6–6 and 6–7B).

Lid Lash Droop Sign Lid lash droop has been recognized by the senior author (MM) as one of a constellation of physical sequelae of complete facial paralysis. To our knowledge, however, this phenomenon has not been reported previously. In addition to drooping, the lashes grow in an irregular disrupted fashion, tend to collect mucus, and become matted. The drooping lashes of the upper lid may contact the cornea causing irritation and abrasion (Fig. 6–8). Whitnall[2] suggests that the ciliary bundle of the orbicularis oculi muscle exerts pressure on the lash follicles and it is this pressure that is responsible for determining the angle at which the lash curves away from the globe. It is likely that the eyelash droop is caused by loss of resting tone in this muscle group as the result of facial paralysis.[3] This is an important sign for two reasons: (1) it is associated with long-standing complete denervation of the facial nerve and suggests a poor

A

B

C

Figure 6–7. Bell's phenomenon. **A**, Patient with good Bell's phenomenon protecting the cornea despite very poor lid closure. **B**, Incomplete Bell's phenomenon demonstrating normal oculogyric reflex with globe rotating up and out in an effort to protect the cornea. **C**, Absence of Bell's phenomenon with complete exposure of cornea with voluntary efforts to close the eyelids. (From Levine RE.[1] With permission.)

prognosis for spontaneous recovery, and (2) the drooping lashes may prolapse against the cornea causing irritation and possible abrasion calls for corrective measures. Conservative treatment requires keeping the eyelashes clean. We suggest that patients clean the eyelashes with a dilute solution of baby shampoo (1 part baby shampoo to 1 part water). A cotton tip applicator dipped into the solution is used to gently swab the lashes from the roots to the tips at least twice a day. An eyelash curler is of limited value, offering relief for a very short time. When this condition becomes symptomatic and does not respond to conservative measures, a surgical procedure to evert the eyelashes is effective and will be discussed in the section on surgical management.

Conjunctiva The conjunctiva is inspected for injection, irritation, or infection.

Cornea Corneal clouding, scarring, and neovascularization can be determined by oblique illumination with a bright light (Figs. 6–2 through 6–4). Corneal sensation is tested with a wisp of sterile cotton applied to the cornea, or at the time that tear production is tested with Schirmer paper. When the cotton or paper is placed over the cornea, the patient should be asked if the feeling is equal or decreased in the involved side compared to the normal side. When corneal anesthesia is present and tear production is absent, the ophthalmologist should be consulted, as the combination of anesthesia and lack of tearing almost always leads to severe ocular complications. Patients with corneal anesthesia experience little or no discomfort from even a severely traumatized or desiccated corneal epithelium and have decreased ability to maintain or heal their corneas because of lost "neurotrophic" factors. Next the cornea should be evaluated by application of fluorescein dye, which will help to define any area of corneal dullness or opacity. Ideally a slit lamp should be used to define the depth of corneal involvement, but a pen light with a cobalt blue filter (Smith, Klein and French) works quite well. By examining the cornea with a magnifying loupe or binocular operating microscope and the cobalt blue filter light, areas of corneal erosion or ulceration may be identified as green fluorescent areas with a blue background. When such areas are present, ophthalmologic consultation is imperative because the integrity of the eye is in jeopardy.

Tearing Evaluation of tear production by Schirmer's tear test (Smith Miller and Patch Division, Cooper Laboratories Inc., Wayne, New Jersey) is one of the most important aspects of the ocular evaluation, as lack of tearing is a common finding in patients with lagophthalmos or incomplete eyelid closure associated with facial paralysis, and usually is accompanied by loss of interpalpebral corneal punctate epithelium. Such loss is manifested by a red line of hyperemic conjunctival vessels running from the medial to the lateral canthus that stains positively with fluorescein dye.

Pupils The pupils are examined for size, symmetry, and response to light. A miotic or small pupil is a sign of corneal irritation, while an irregular small pupil may be due to

A C

B D

Figure 6–8. Lid lash droop sign. **A**,**B**, Normal appearance of eyelashes. **C**,**D**, Lash droop associated with aging causing senile laxity.

severe anterior chamber inflammation with synechiae formation. Unless there has been significant corneal involvement, such inflammation suggests a cause (e.g., sarcoid) other than Bell's palsy.

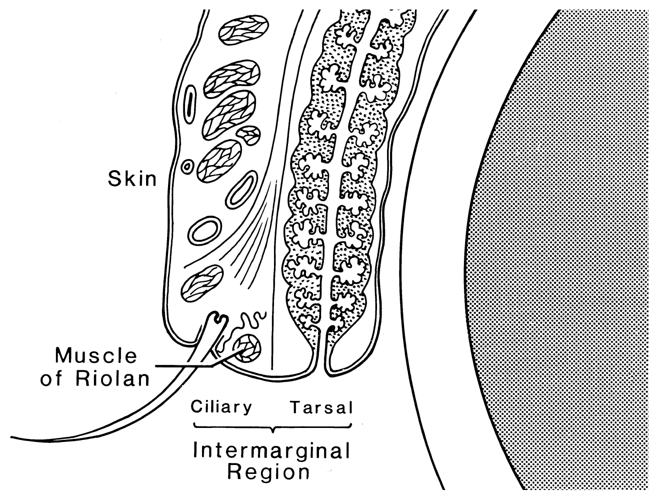
Extraocular Muscles Evaluation of extraocular movements may detect lack of ability to rotate the eye on the involved side to the lateral position, indicating sixth cranial nerve involvement. When facial paralysis is accompanied by a sixth cranial nerve deficit, another disease process may be present. One of the most common disorders associated with this combination is diabetic neuropathy. Diabetic patients may present with facial paralysis and a third cranial nerve palsy resulting in diplopia and upper eyelid ptosis. In such cases, it is critical to evaluate not only extraocular movement but also the response of the pupil to light, as diabetic neuropathy can be distinguished from a retrobulbar compressive lesion by the preservation of pupillary response to light in the former. Small vessel disease associated with diabetic neuropathy spares the fibers that run with the third cranial nerve to innervate the pupil.

Nystagmus The presence of nystagmus is another finding that indicates a disorder other than Bell's palsy. Vertical or rotary nystagmus suggests that a central deficit is present. Alternating nystagmus in lateral gaze is diagnostic of a lesion involving the medial longitudinal fasciculus and is most commonly associated with a demyelinating disorder such as multiple sclerosis.

Ophthalmoscopic Examination Ophthalmoscopic examination evaluates the cornea, anterior chamber, lens, posterior chamber, and fundus. A survey of these structures can detect corneal changes, anterior chamber inflammatory processes, a dense cataract responsible for impaired vision, or funduscopic evidence of systemic disease such as diabetes, which may be contributing to the paralysis. In addition, papilledema, possibly indicating the presence of a life-threatening intracranial lesion, may be detected in this way.

Tonometry Tonometry may be useful in detecting pathology unrelated to the facial paralysis such as glaucoma but

E F



G

Figure 6–8. *(continued)* **E**,**F**, Lash droop associated with long-standing total facial paralysis. Nine years following resection of facial nerve schwannoma. Note lashes not only droop, but they lose their parallel orientation and have an irregular matted appearance. **G**, Diagram of location of muscle of Riolan. According to Whitnall,[2] the ciliary bundle of the orbicularis muscle exerts pressure on the lash follicles and is responsible for maintaining the normal lash curvature away from the globe. In cases of long-term, complete denervation, it is conceivable that atrophy and fibrosis of this muscle band is responsible for the drooping and disorganized appearance of the lashes as noted in **E** and **F**.

important in the management of the eye on the paralyzed side. However, tonometry must be performed with extra caution when the cornea is vulnerable to injury due to exposure and dryness, and the examiner should be aware that the tension in the eye on the paretic side is usually 2 to 3 mm lower than that on the normal side, possibly as the result of lack of orbicularis oculi muscle tone.[4] Another observation worthy of note is the change in intraocular tension in patients with cerebellopontine angle tumors: on occasion tension on the affected side has been found to be 5 to 7 mm lower than that on the normal side. The reason for this is not known.

Medical Management

A number of factors favor medical rather than surgical management of paralyzed eyelids, and these are listed in Table 6–1. In general, medical treatment of these ophthalmologic problems is directed at humidification of the eye, which may be accomplished by use of eye drops and ointments, artificial methods of closing the eye, protective devices, or maintenance of the eye's natural moisture. Each of these will now be discussed in detail.

Eye Drops and Ointment The simplest way to protect the cornea and keep it moist is with artificial tears and ointments. The numerous preparations on the market differ in their major ingredients, viscosity, and preservatives (Table 6–2), and it is useful to be aware of the variety of preparations because patient tolerance of each is variable. If one preparation is not suitable because of irritation, then another can be chosen. The products vary primarily by their major ingredient, which may be polyvinyl alcohol, methylcellulose, or hypotonic salt solution. Lubricant additives include mineral oil, petrolatum, or boric acid.

There are some guidelines that will help to select the preparation that will be most effective in a given patient.

Table 6–1 Factors Favoring Successful Medical Management of Paralyzed Eyelids

1. Favorable prognosis (early recovery expected)
2. Residual facial function
3. Static lid tone preserved
4. Normal tear function
5. Normal Bell's phenomenon
6. Corneal sensation intact
7. Lids effectively closed by tape
8. Corneal integrity maintained
9. Patient able to keep appointments for periodic re-evaluation

Table 6–2 Artificial Tear Preparations and Eye Ointments

Trade Name	Ingredients
Artificial Tears	
Long-acting, high viscosity	
Celluvisc	Carboxymethylcellulose 1%*
Murocel	Methylcellulose 1%
Visculose 1%	Methylcellulose 1%
Long-acting, medium viscosity	
Adsorbotear	Hydroxyethylcellulose, povidone 1.67% with water soluble polymers
Cellufresh	Carboxymethylcellulose 0.5%
Medium duration, medium viscosity	
Isopto Tears	Hydroxypropyl methylcellulose 0.5%
Lacril	Hydroxypropyl methylcellulose 0.5%, gelatin A 0.01%
Liquifim Forte	Polyvinyl alcohol 3%
Lubrifair Solution	Hydroxypropyl methylcellulose, Dextran 70
Lytears	Cellulose derivative
Moisture Drops	Hydroxypropyl methylcellulose 0.5%, Dextran 30
Tearisol	Hydroxypropyl methylcellulose 0.5%, boric acid
Tears Naturale II	Hydroxypropyl methylcellulose 0.3% in water-soluble polymeric system
Tears Naturale Free	Hydroxypropyl methylcellulose 0.3% in water-soluble polymeric system*
Visculose 0.5%	Methylcellulose 0.5%
Short duration, low viscosity	
AKWA Tears Solution	Polyvinyl alcohol
Hypotears	Polyvinyl alcohol 1% in Lipiden polymer
Hypotears PF	Polyvinyl alcohol 1% in Lipiden polymer*
Liquifilm	Polyvinyl alcohol 1.4%
Methulose	Methylcellulose 0.25%
Ocu-Tears	Polyvinyl alcohol
Refresh	Polyvinyl alcohol 1.4%, povidone 0.6%*
Tearfair Solution	Polyvinyl alcohol
Tears Plus	Polyvinyl alcohol 1.4%, povidone 0.6%
Ocular Lubricants (Ointments)	
AKWA Tears Ointment	White petroleum, mineral oil*
Duolube	White petroleum, mineral oil*
Duratears Naturale	White petroleum anhydrous liquid lanolin*
Lypotears Ointment	White petroleum, light mineral oil*
Lacri-lube NP	White petroleum, mineral oil*
Lacri-lub SOP	White petroleum, mineral oil
Lubrifair	White petroleum, mineral oil, liquid lanolin
Ocu-Lube	White petroleum
Petrolatum	White petroleum
Refresh PM	White petroleum, mineral oil, lanolin*
Tearfair	White petroleum, mineral oil, lanolin, derivatives
Slow-release Lubricants (Inserts)	
Lacrisert	Hydroxypropyl cellulose

(* indicates preservative-free preparation)

Because the lower viscosity solutions have shorter durations of action, patients who must instill drops frequently would benefit from using a more viscous solution. Thus hypotonic salt solutions are short-acting, while 1% methylcellulose is a long-acting solution. However, although a more viscid preparation affords longer corneal protection, it does cause more blurring of vision, which may be objectionable in some patients, so a medium-viscosity solution may be chosen. Alternatively, a wetting agent such as polyvinylpyrrolidone may be added to a methylcellulose preparation to help bond the artificial teardrop to the cornea and thereby prolong its effect. A patient with impaired lid function and decreased tearing may thus be started on 0.5% methylcellulose drops as often as needed, from four times a day to every hour. If the eye is still dry, a more viscous preparation such as 1% methycellulose should be tried, and finally a wetting agent may be added. If this therapy is not successful in relieving symptoms or in eliminating corneal staining, ointment may be used at bedtime in addition to the hourly drops. Because ointment stays on the surface of the eye for hours, it is effective in keeping the eye moist, but it has the disadvantage of blurring vision. Nevertheless, when used at bedtime, it is generally cleared from the eye by morning and helps to keep the eye closed during sleep by sticking the lashes together. A bland ophthalmic ointment may be used, such as 5% boric acid ointment or a sterile white petrolatum such as Lacrilube. Antimicrobial preparations have the added advantage of protecting against infection, with sulfa-containing drops or ointments being preferred to preparations with neomycin or tetracycline because these latter two medications are associated with a high incidence of allergy. If the use of drops during the day is insufficient to adequately protect the eye, supplementary daytime use of ointment may be necessary. If the blurring from the ointment is unacceptable, other ways must be sought to enhance the moisture of the eye.

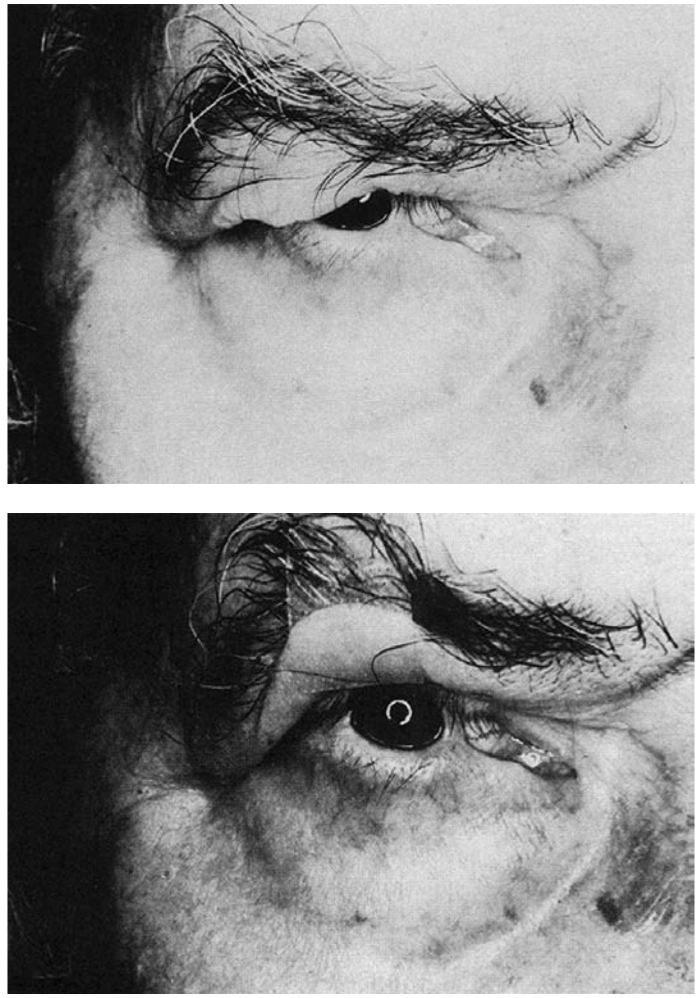


Figure 6–9. Patient 3 months following resection of an acoustic schwannoma and sacrifice of the facial nerve on the right side. **A**, Severe paralytic brow droop with limitation of upward and lateral gaze; a tarsorrhaphy web is also present. **B**, The upper lid and brow are held in an upward position with tape in an effort to improve vision.

Artificial Eye Closure

Tape Tape may be used to keep the eyes open for vision (Fig. 6–9) or to keep the eyelids closed to protect the cornea. In particular, if there is significant incomplete eyelid closure (lagophthalmos), the eyelids may need to be taped shut to protect the cornea during the night. However, when an ointment is to be used prior to taping the eyelids shut, care must be taken to keep the skin surface free of medication or the tape will not adhere.

Transpore tape (1-in width, 3M Co.) has been found to work quite well for taping the eyelids closed. The patient should be supervised during eyelid taping to ensure that the eye is closed properly so that the tape does not rub against the globe: patients with hypesthetic or anesthetic corneas may not be able to determine when the lids have been closed adequately. If supervision is impossible, the patient should be told to ensure that no light can be detected by the affected eye after the lids have been taped.

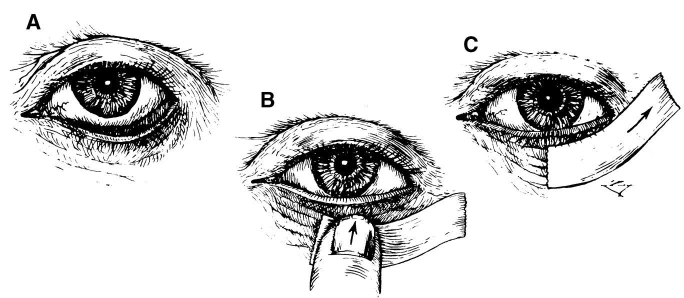


Figure 6–10. Technique of supporting lower lid with tape. **A**, Drooping lower lid. **B**, Tape is applied to center of lower lid. **C**, Tape is secured with tension directed up and laterally. (From Levine RE.[1] With permission.)

To support a drooping lower lid, the end of the tape should be applied to the center of the lower lid with the upper edge about 1/8 in below the lashes. The tape should then be pulled up laterally and secured to the lateral orbital rim (Figs. 6–10 and 6–11).

Trial and error will demonstrate the best way of eliminating lid droop in a given patient. Normalization of lower

Figure 6–11. Patient with Bell's palsy and BAD syndrome (inadequate Bell's phenomena, anesthesia of cornea, and dry eye) with exposure keratitis. **A**, Corneal stain with fluorescein. **B**, Application of tincture of benzoin. **C**, Lower lid splinted with Transpore tape (manufactured by 3M). **D**, Enhanced eye closure.

lid position will bring the reservoir of tears into contact with the cornea and will decrease the palpebral aperture, thus limiting abnormal evaporation of tears and reducing irritation of the palpebral conjunctiva caused by ectropion. The palpebral aperture can be further narrowed by limiting opening of the upper lid. This can be accomplished easily by placing a small crescent of tape over the tarsal-supratarsal fold in the upper lid (Figs. 6–12 and 6–13) to act as a splint to limit excessive opening of the lid. On the other hand, in some cases an eyelid crutch may be placed in the tarsal-supratarsal fold (Fig. 6–14) to keep the eyelids open for vision.

Pressure Patch A pressure patch is another device that may be used to effect lid closure temporarily. It is difficult to ensure eyelid closure with a simple eye patch, but a pressure patch, consisting of two eye pads skillfully placed, is generally effective. However, if the cornea is anesthetic and the eyelids remain slightly open, the eye pad can abrade the cornea. This can be prevented by taping the eyelids shut first and then reinforcing the closure with the pressure patch.

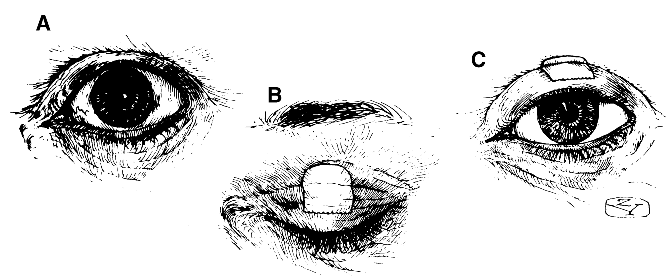


Figure 6–12. Technique for improving upper lid position with tape. **A**, Note widened palpebral aperture due to orbicularis weakness. **B**, Crescent piece of tape is placed to override lid fold. **C**, Note how tape splints upper lid and helps to normalize palpebral aperture. (From Levine RE.[1] With permission.)

Lid Sutures When the eyelids are difficult to tape shut, placing lid sutures may be preferable. However, this technique is reserved for those patients who do not respond to the other medical methods, and is the last resort before considering surgical techniques. A simple and effective

Figure 6–13. Technique of improving upper lid position with tape. **A**, Note widened right palpebral fissure owing to orbicularis weakness. **B**, Incomplete eyelid closure. **C**, Crescent of tape is cut. **D**, Tape placed to override lid fold and to assist lid closure. **E**, Appearance with eyes opened.

means of lid closure is to place a 5-0 nonresorbable suture through the skin of the upper eyelid and then to tape it to the cheek (Fig. 6–15). Such a suture should be used whenever temporary lid closure is indicated and taping is inadequate to keep the lids shut. The eyelids may still be opened easily to check pupillary reflexes and corneal integrity as often as necessary, and should the surgeon choose to leave the lids open at intervals, the ends of the suture may be taped loosely to the forehead. Generally, such a suture can be left in place for 4 to 6 weeks; thereafter, it tends to extrude. The lid suture is a satisfactory technique for managing difficult cases and ensures that the paretic lids will remain firmly closed beneath a pressure dressing. This technique is useful in patients with deeply recessed eyes, or in patients with strong lid retraction due to an overactive levator superiorus.

When a lid suture is being secured, the patient should be instructed to attempt to close both eyes. Enough tension should be exerted on the suture to pull the lid shut slightly more than is normal, then the suture should be taped in place and the patient asked to open the eye. If the lids can be opened even slightly, the suture should be retaped under increased tension. To prevent loosening of the suture, its free ends should be brought up over the edge of the tape and secured with a second piece of tape placed over the first. A small amount of antimicrobial ointment

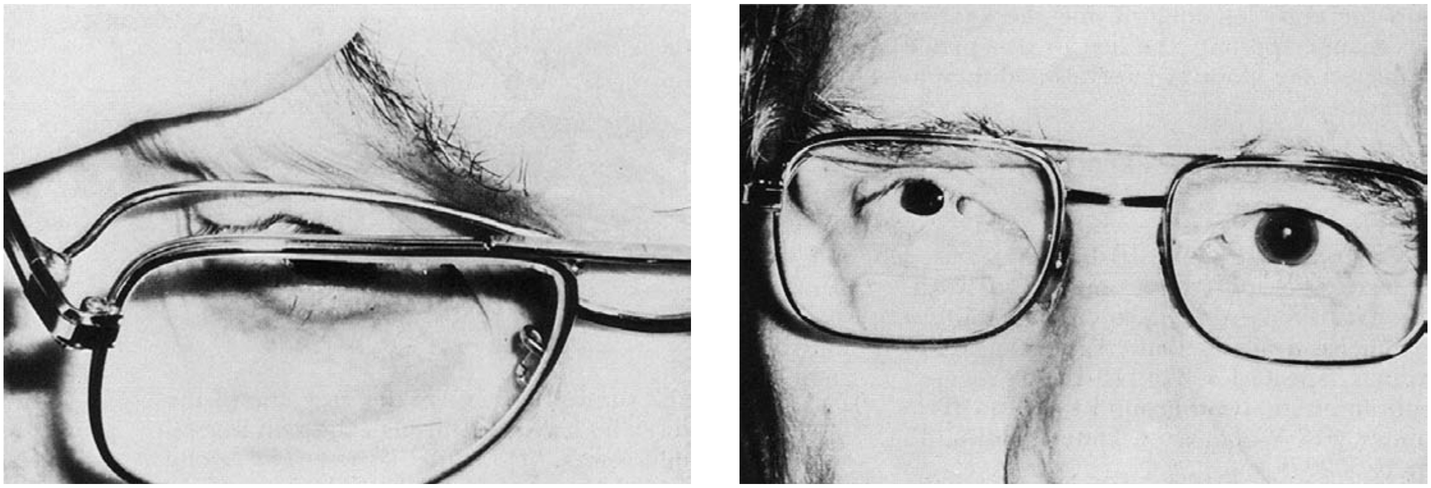


Figure 6–14. Same patient as depicted in Figure 6–9. An effort was made to correct the defect with an eyebrow crutch. **A**, Note crutch, attached to eyeglass frames, fits in the region of the tarsal-supratarsal fold. **B**, Patient wearing eyeglasses to show how the eyelid crutch holds the upper lid away from the upper lid margin.

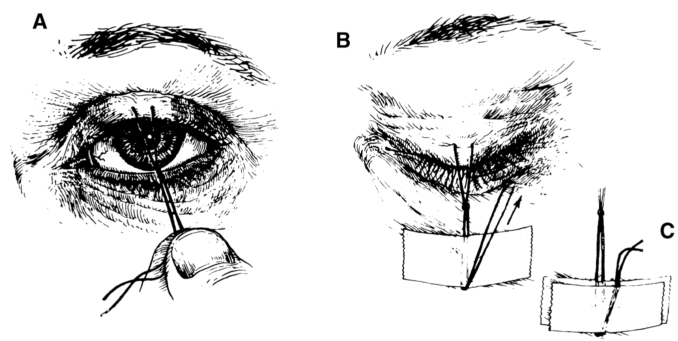


Figure 6–15. Technique of placing lid suture. **A**, Nonresorbable suture is placed through upper lid skin, tied, and pulled downward to close the lid. **B**, Suture is taped to cheek. **C**, Second piece of tape is placed to keep suture from slipping. (From Levine RE.[1] With permission.)

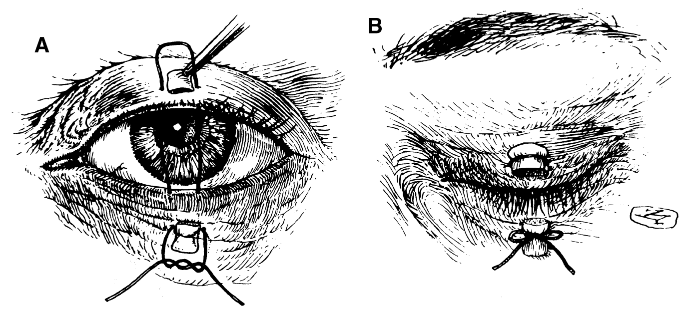


Figure 6–16. Technique of suturing eyelids together. **A**, Suture has been sewn through both lids. **B**, Suture is tied in a bow to permit opening and reclosure of the lids. (From Levine RE.[1] With permission.)

placed at the entry and exit sites of the suture three or four times daily helps to prevent infection.

A second type of lid suture is useful in situations in which the lids are to be kept closed for several days or more (Fig. 6–16). Each arm of a 4-0 nonresorbable suture is sewn over a cotton pledget to enter the skin of the upper lid several millimeters above the lashes and to emerge at the grey line.

The suture then enters the grey line of the lower lid and exits through the skin several millimeters below the lashes. The globe should be protected during the passage of these sutures. The ends of the sutures are then tied over a cotton pledget. The first knot is a surgeon's tie, and the second is a bow, with the ends left long. Tying the knot in this manner permits the lids to be opened to inspect the globe at intervals and then to be reclosed.

Botulinum A Toxin Botulinum toxin injection into the supratarsal fold area is an effective alternative treatment for patients with exposure keratitis who do not respond to the approaches mentioned and offers a medical option with a temporary effect for a condition that has a favorable prognosis for spontaneous recovery. Botulinum injection into the levator palpebrae superioris to induce ptosis has been reported for treating exposure corneal ulceration.[5,6] Ninety percent of the ulcers completely healed with this technique. The cornea was covered completely by the lid in all but one case. Complete ptosis was produced in 75% of the cases in an average of 3 days, and lasted for 16 days before recovery began. Superior rectus muscle paresis was seen in 68% of patients, but recovered in all cases in an average of 6 weeks. Botulinum has also been used to treat corneal problems from Grave's ophthalmopathy.[7]

Smet-Dieleman et al.[7] reported use of botulinum toxin in patients with facial palsy for treatment of incomplete eyelid closure. Initially, patients with severe corneal problems were treated; later, botulinum toxin was used for partial relaxation of the levator muscle in cases of incomplete eyelid closure even without major corneal problems.

In our experience 10 units of botulinum injected into the supratarsal fold was effective to create ptosis without any extraocular muscle deficit. This pharmacologic "tarsorrhaphy" was noted the day following the injection and was effective for 6 weeks (Fig. 6–17). Although the use of botulinum toxin seems attractive, disadvantages include restric-

Figure 6–17. Botulinum toxin "chemical" tarsorrhaphy. Patient with Bell's palsy. There is severe lagophthalmos with absence of Bell's phenomenon. **A**, The affected eyelid stays open in spite of volitional effort to squeeze the eyelids tightly shut. The patient suffered from exposure keratitis in spite of medical efforts. A gold weight insert extruded. A spring implant also extruded. **B**, A "chemical" tarsorrhaphy was achieved with 5 units of botulinum toxin injected into the tarsal-supratarsal crease. **C**, Three days postinjection with eyes open. **D**, Six months later, recovery of facial function with synkinesis is noted. The effect of the botulinum lasted 3 months, about the time facial recovery was sufficient to provide eye coverage. **E**, Eyes opened. **F**, Eyes closed demonstrating the "chemical" tarsorrhaphy was effective during the critical 3 months. Now there is full recovery from the effects of the toxin.

tion of vision due to upper lid ptosis, possible paresis of the superior oblique muscle, and delay in onset of up to 3 days for full effect. Patel and Anderson[8] have abandoned using botulinum toxin in patients with an acute seventh nerve palsy as vertical diplopia persisted in one patient for 9 months after injection before it cleared.

Protective Devices Protective lenses, wraparound sun glasses, or goggles (Fig. 6–18) may be used to decrease evaporation from the eye. In addition, a simple and inexpensive moisture chamber is available that can be attached to ordinary spectacles (Fig. 6–19) or secured with an elastic band around the head (Pro-Optics, 371 Wood Work Lane, Palatine, Illinois 60067).

Soft Lenses Soft lenses have also proved to be useful in selected patients to protect a neurotrophic cornea. Unfortunately it is difficult to keep soft lenses in place in patients who have marked lower lid droop or marked impairment of lid closure. Further, soft lenses require a moist eye in

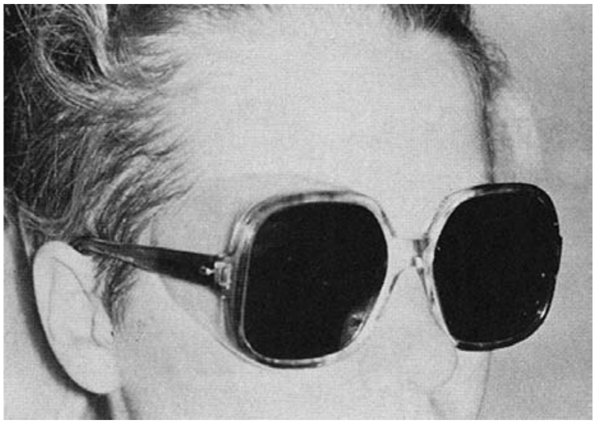


Figure 6–18. A plastic moisture chamber has been fabricated on a pair of ordinary sunglasses to provide extra protection for the involved eye.

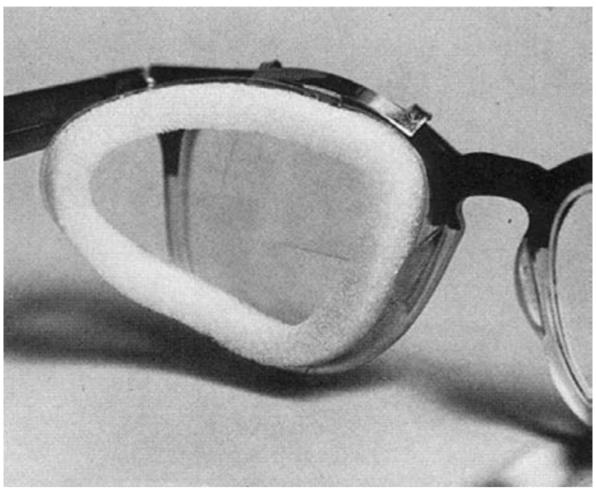


Figure 6–19. Moisture chamber which can be slipped on ordinary spectacles to form one-sided goggle. (From Levine RE.[1] With permission.)

order to remain pliable and maintain their position on the eye. Thus, use of soft lens does not eliminate the need to keep the eye moist, so they have limited value in managing the patient with paralyzed eyelids.

Scleral Shells Although scleral shells have been useful in some cases,[9] in Levine's experience, patients frequently found them to be bothersome and uncomfortable. Despite the availability of expert technical assistance in fitting the shell, the period of adjustment to the shell and the multiple fittings needed to achieve good vision may require months. Further, when the patient has reduced corneal sensitivity, there is a real hazard of corneal damage from the shell.

Maintaining Humidification (Table 6–3)

Room Humidifiers Evaporation of tears is acclerated by low humidity. Thus using a room humidifier to maintain high room humidity may be of significant benefit to patients who spend many of their waking hours in a single room.

Table 6–3 Instructions to the Patient for Eye Protection in the Paralyzed Face

1. Use skin tone elastic tape to partially close the upper and lower lids. The tape must never be used vertically across the lids. Use horizontally on the upper to lower lids. It is important to cover the skin with tincture of benzoin or other skin protection or tape adherent so as to protect the skin from the tape. You must be very careful not to get the tincture of benzoin in the eye, because it will sting.
2. Apply Tears Naturale (or any other substitute) every 2 hours. Two drops in the nonclosing eye can be applied as often as necessary for irritation or redness.
3. Use an ocular lubricant (Lacri-Lube or substitute) placed inside the lower lid at bedtime. The disadvantage of the ointment is that it will temporarily reduce the visual acuity. Repeat as necessary.
4. Protect the eye from drafts by the use of glasses or a swimming goggle taped over the affected eye.
5. Increase environmental humidity with a cold steamer in the bedroom.
6. Close the lids mechanically with the fingers any time the eye seems irritated.
7. Administer home physiotherapy by massaging the face from the middle of the forehead back towards the ear, from the mid third of the face at the side of the nostrils back to the ear, and from the lower third of the face at the middle of the chin along the jaw back to the ear. Prior to this, a moist towel with a heating pad which is just comfortably warm should be applied to the face for 15 minutes. It is also helpful to use a skin moisturizer, which can be obtained at the cosmetic section of any drug or department store.

If you have any questions about the eye becoming reddened, or uncomfortable, or about a change in vision, you are to call for further instructions.

(From Smith MFW, McElveen J: Neurological Surgery of the Ear: Eye Protection in the Paralyzed Face. St. Louis, Mosby-Year Book Inc., 1992, pp 127–130. With permission.)

Voluntary Blinking In addition, patients can help to keep the eye moist by periodically and intentionally closing the eyelids, either by muscular action if possible or by using the back of the thumb to pull the upper eyelid down over the cornea. By this action, the tears are distributed across the front surface of the eye. Because even patients with facial paralysis who have good lid closure may have impaired involuntary blinking, they should be encouraged to voluntarily blink as often as necessary and at least six times per minute to keep the eye moist. Patients with poor upper eyelid closure but good Bell's phenomenon should also blink voluntarily by rolling the eye up so that the edge of the upper lid distributes the tears.

Avoiding Ocular Irritants An anesthetic eye with impaired eyelid closure is subject to injury from irritants such as fumes, aerosols, cosmetics, and chlorinated pool water, and to drying by wind, sun, or air conditioning; therefore, suitable precautions must be taken to protect the eye against such possible damage. For example, anesthetic corneas may be denuded of epithelium by contact with ordinary shampoos. Thus, patients should be advised to use Johnson's Baby Shampoo, which is less irritating. In addition, the hair should be washed with the head held back over a sink rather than in the shower so that shampoo is less likely to enter the eye, or perhaps the eye might be protected with a patch or swim goggles.

Ophthalmologic Re-Evaluation

Patients should be re-evaluated every few days if there is evidence of the BAD syndrome, and more often in the presence of early corneal changes. In the event that there is evidence of progression of corneal deterioration, the cornea must be protected by some method of eyelid closure, and if medical means fail to adequately protect the cornea from breakdown, surgical methods must be considered. However, patients who seem to be free of eye problems must also be examined frequently to avoid the development of such sequelae.

When a patient who had previously been free of eye problems later presents with an inflamed eye, the patient should be completely re-evaluated. The nature and extent of the current problem must be determined, and its relation to the facial paralysis is evaluated. It is possible, for instance, that uveitis or even glaucoma may develop independent of the facial paralysis, but ocular inflammation developing in association with facial paralysis may also signal the presence of sarcoidosis or a disseminated neoplastic process.

The delayed onset of eye inflammation may be due to progressive loss of facial muscle tone, possibly resulting in increased lagophthalmos or progressive paralytic ectropion. Another reason why such problems may occur later in the course of the disorder is relaxation of compliance with the recommended medical treatment. Frequently, the patient may become lax in use of prescribed medications, or may be exposing the eye to environmental irritants. Has the patient returned to work in an air-conditioned office? Is the patient swimming without wearing goggles or allowing the affected eye to be exposed daily to the wind while waiting for the bus? Only by performing a complete re-evaluation of the patient can the significance of these factors be determined and the treatment plan modified appropriately.

However, regardless of the cause of the late onset of eye problems, they must be treated. Generally, keeping the eyelids shut until the cornea has recovered is the treatment of choice, and if this cannot be accomplished by means of tape alone or a lid suture, then a surgical approach should be considered.

Brow, Upper Lid, and Lower Lid

Surgical Management When medical methods fail, surgical measures must be considered. Ideally, lid reanimation surgery should be performed before corneal damage occurs. Based on a thorough review of the history of oculoplastic surgery (1896–1996), Patel and Anderson[8] state that "partial tarsorrhaphy," first described by von Walther in 1826, remained the mainstay of eyelid rehabilitation in facial palsy for nearly 150 years. The tarsorrhaphy still remains the "gold" standard among practicing general ophthalmologists. This is in spite of its limitations: the procedure restricts vision, produces a grotesque appearance, and in some cases, does not even protect the cornea from exposure and subsequent breakdown. Further, if the patient's facial palsy recovers, reversal of the tarsorrhaphy may cause entropion, trichiasis, eyelid margin notching, and formation of epithelial cysts. The main purpose of this section is to emphasize that methods available to reanimate the eye region should displace the tarsorrhaphy and relegate it to a procedure that is used as a last resort (Figs. 6–20 through 6–22).

Figure 6–20. A 72-year-old patient presented with multiple tarsorrhaphies performed following her acoustic tumor surgery. Note that although the eye is nearly sewn shut, the cornea is still not well protected, even with attempted lid closure. Corneal ulceration and scarring have been noted in such cases in spite of tarsorrhaphy. Therefore, periodic corneal evaluation must be continued even after performance of a tarsorrhaphy.

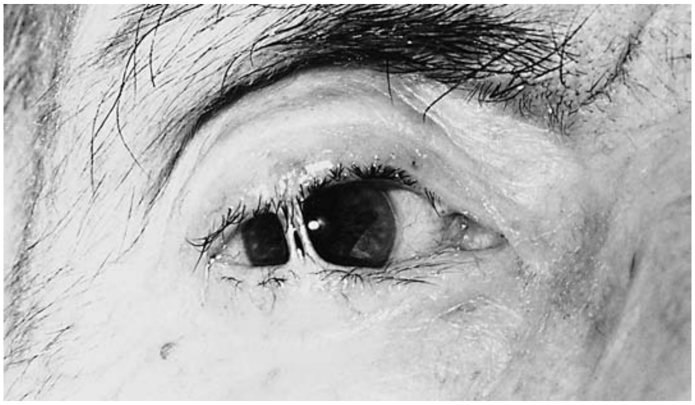


Figure 6–21. Note stretching of tarsorrhaphy bar that forms an unsightly adhesion band. This tarsorrhaphy attempt failed to protect the cornea, limited vision, presented a cosmetic blight, and deformed the lash line disrupting the lashes (see Figs. 6–22 and 41).

General Indications for Surgery A number of factors make it difficult to manage the problems associated with paralyzed eyelids by medical means alone. Patients who lack one or more of the factors listed in Table 6–1 should be managed surgically as soon as it becomes apparent that medical management is ineffective. A prime candidate for surgery would be a patient with the BAD syndrome, while other factors that suggest surgical management include increased age and poor static lid tone; marked lagophthalmos with severe lower lid paralytic ectropion; strong upper lid retraction in a deeply recessed eye, making it difficult to tape the eyelids shut; monocular vision with the patient depending on the involved eye; difficulty with balance when the eye on the paralyzed side is taped shut; and social factors that make periodic re-evaluation difficult.

Goals of Surgical Therapy The basic goals are to preserve or improve vision, decrease or eliminate exposure irritation, and maintain or improve appearance. Vision is impaired or threatened by the presence of one or more of the following: (1) marked lagophthalmos of the upper and/or lower lid, and/or ectropion or entropion of either lid; (2) poor static lower lid tone, particularly in an older patient who presents with severe ectropion; (3) impairment of tear function resulting in a dry eye; (4) ineffective coverage of the cornea with eye closure as noted with lack of Bell's phenomenon; (5) loss of corneal sensation due to either exposure hypesthesia or fifth nerve impairment as may occur following resection of an acoustic tumor; (6) progression of staining or other signs and symptoms of irritation of the cornea in spite of maximal medical therapy; and (7) brow droop and/or upper eyelid lash droop.

Figure 6–22. Patient with sixth and seventh nerve paresis following acoustic tumor surgery. **A**,**B**, Central tarsorrhaphy originally had been placed to protect cornea and prevent diplopia. Note stretching of tarsorrhaphy bar. When sixth and seventh nerve function failed to return after 2 years, patient asked to have tarsorrhaphy opened. **C**,**D**, Appearance of patient after opening of tarsorrhaphy, implantation of palpebral spring in upper lid, and correction of medial ectropion of lower lid. A muscle transposition procedure was also performed to straighten the eye. Note that the spring was left slightly loose to provide a normal palpebral aperture in the primary position. As a result, there is minimal residual lagophthalmos. (From Levine RE.[1] With permission.)

A cosmetic blight can be caused by one of the aforementioned findings, including asymmetry of the interpalpebral space.

The ideal surgical procedure restores lid position and function as well as improves or maintains tear production, distribution, and drainage. This can be accomplished by restoring facial nerve continuity with nerve grafts or using the hypoglossal crossover technique (see Chapters 2 and 3). However, when function is restored by one of these techniques it may take 6 months or longer for neural regeneration to take place, and in the meantime, the cornea is poorly protected and subject to drying. Therefore, the eyelid should be reanimated surgically in such cases to re-establish protection immediately and until the nerve graft or anastomosis begins to function. Further, the patient will benefit from the immediate improvement in eyelid function, and when the results of nerve repair are fully appreciated, the eye reanimation efforts will enhance the final result. Surgical reanimation efforts should be considered even in patients with a favorable prognosis such as Bell's palsy, if medical measures are not adequate to protect the integrity of the cornea.

Surgical Techniques There are a variety of surgical procedures directed toward improving lid function and appearance when problems in lid closure result from facial paralysis. The reanimation surgeon must be capable of analyzing the variety of problems presented by the patient with facial paralysis and design an approach that will best suit the patient rather than applying his or her favorite procedure for every patient. For organizational purposes, this section will be organized into correcting problems related to the forehead, brow, upper lid, and lower lid, and lacrimation disorders resulting in epiphora as well as the dry eye. The indications, techniques, advantages, disadvantages, results, and complications of each procedure will be discussed with reference to personal experience whenever possible.

The materials and instrumentation used for the most common procedures performed are listed in Tables 6–4 through 6–9, and the way in which the senior author (MM) reports our results is illustrated in Figure 6–23. Table 6–10 indicates the senior author's experience with a variety of procedures used to reanimate the paralyzed eye region. The frequency that certain procedures were performed are in keeping with May's preference based on results achieved.

Forehead

Absence of forehead creases and lack of dynamic expression on the involved side is of greater concern for patients who incorporate eyebrow movement and forehead wrinkling as part of their facial language gesturing. In such cases, conservative management including hairstyle, eyeglasses, and brow makeup is usually adequate (see Chapter 9). The activity of the forehead on the normal side can be toned down or eliminated by botulinum A toxin injections or definitively by a forehead lift approach with

Table 6–4 Equipment for Brow Lift

Special Equipment
- Bipolar Bovie console

Special Instruments
- Bard-Parker no.15 scalpel blade (skin incision)
- Stevens scissors (#2611) (deep dissection)
- Microbipolar jewelers forceps

Special Supplies
- Weck-cel spears 00-8680
- Marking pen
- Contact lenses

Sutures
- 4-0 Prolene clear monofilament (Ethicon Co.) #8603 on P5-4 cutting needle (to approximate the deep aspect of lower wound edge to periosteum under upper wound edge)
- 4-0 chromic gut (Ethicon Co.) 744 on M-1 cutting needle (for deep wound edge closure)
- 5-0 Prolene (Ethicon Co.) on PS-4 cutting needle (for subcuticular running skin closure)
- 6-0 fast-absorbing plain gut (Ethicon Co.) #1916G on R-1 cutting needle (for skin closure)

Table 6–5 Equipment for Gold Weight Implantation

Special Equipment
- Bipolar Bovie console

Special Instruments
- Eyelid set–Wescott scissors, iris scissors, small 4 pronged rakes (× 2), small skin hooks (× 2)
- Jewelers bipolar forcep

Special Supplies
- Marking pen
- Weck-cel spears 00-8680
- Contact lenses
- Gold weight 0.6 to 1.2 g (Meddev Corp., P.O. Box 1352, Los Altos, CA 94002)

Suture
- 8-0 Ethilon #1714G (Ethicon Co.) on TG100 8 plus needle (to fix the gold to the orbital septa and tarsus)
- 7-0 Vicryl #J546G (Ethicon Co.) on TG 1408 plus needle (subQ closure)
- 6-0 fast-absorbing plain gut #1916G on PC-1 cutting needle (skin closure)

Table 6–6 Equipment for Lid Spring Implant

Special Equipment

Bipolar Bovie console

Special Instruments

Eyelid tray–Wescott scissors, iris scissors, small 4 pronged rake (× 2), skin hook (× 2)

Jewelers bipolar forcep

Microcutter (#800-506) (to cut wire*)

Tweed loop plier (800-404); bar light wire birdbeak plier (#815-416); bar utility plier (#815-401); How plier offset (804-4-7) (to fashion spring*)

Small Gelfoam press (Storz #N1705-91) (to compress Dacron when it is placed in the autoclave)

Special Supplies

Dacron patch fabric (cat #CH-001628 V. Mueller Co.)

Marking pen

Contact lenses

Weck-cel spears 00-8680

Microsurgical blade 1/5 mm 15° (Foresight Visions Systems P7511)

0.01 orthodontic round wire (216-100) (to make spring)

Spinal needle #19 (B-D and Luer Lok #5183) (to pass wire through upper eyelid)

Sutures

7-0 Vicryl J566G (subQ closure)

5-0 Supramid 2LA-50W (to fix fulcrum of wire and upper limb of spring)

8-0 Ethilon 1714G (to fix wire over upper lid to Dacron patch fabric)

6-0 fast-absorbing plain gut #1916G on PC-1 cutting needle (for skin closure)

* The wire, pliers, and cutter can be purchased from Unitek Cork, Monrovia, CA 91016.

Table 6–7 Equipment for Lower Lid Tightening Procedure

Special Equipment

Bipolar Bovie console

Special Instruments

Eyelid set–Wescott scissors, iris scissors, small 4 pronged rake (× 2), small skin hooks (× 2)

Jewelers bipolar forceps

Resection clamp (custom made)–a small misquito clamp may be used

Special Supplies

Weck-cel spears 00-8680

Marking pen

Contact lenses

Sutures

4-0 Dexon 7704-31 on "S" PR-1 (Davis and Geck Co.)

6-0 fast-absorbing plain gut (Ethicon Co.) #1916G on PC-2 cutting needle (for skin closure)

Table 6–8 Equipment for Cartilage Graft

Special Equipment

Bipolar Bovie console

Special Instruments

Eyelid set–Wescott scissors, iris scissors, small 4 pronged rake (× 2), small skin hooks (× 2)

Jewelers bipolar forcep

Special Supplies

Weck-cel spears 00-8680

Marking pen

Contact lenses

Sutures

8-0 Ethilon #1714G (to suture cartilage)

7-0 Vicryl J566G (subQ closure)

6-0 fast-absorbing plain gut (Ethicon Co.) #1916G on R-1 cutting needle (for skin closure)

resection of the frontalis muscle on the normal side and brow suspension on the involved side.

Eyebrow

Brow drooping may impair vision when the patient attempts upward gaze. Further, drooping of the brow tends to increase sagging of the supratarsal fold, which in turn may impair upper lid retraction and even overhang the edge of the lid creating a hooding effect. This leads to decreased vision not only in the upward gaze but in the foreward gaze as well.

The drooping eyebrow is corrected with a brow lift. The objective of the brow lift is to provide static symmetry with the normal eyebrow, while avoiding impairment of eyelid closure, which can result from an aggressive brow lift on the paralyzed side. The brow lift also effectively treats lateral hooding caused by the paralytic eyebrow and upper eyelid skin hanging over the upper lash line that may interfere with visual fields of the affected eye. Prior to performing the eyebrow lift, the surgeon must manually evaluate its effect on eyelid closure. Importantly, caution must be taken when combining brow lift with an upper lid blepharoplasty. One may achieve an excellent cosmetic result, but impair eyelid closure. Such errors in judgment have been noted by well-respected colleagues who were not forewarned due to lack of experience with this specialized problem of reanimating the paralyzed eyelid.

Table 6–9 Equipment for Lacrimal Gland Resection

Special Equipment
- Bipolar Bovie console

Special Instruments
- Eyelid set–Wescott scissors, upper lid retractor (Casey)
- Jewelers bipolar forcep
- Lacrimal probe and punctal dilator set

Special Supplies
- Contact lenses
- Xomed Treace accu-temp cautery 84-4200
- Weck-cel spears 00-8680
- Cotton tip applicators (to sponge, roll upper lid, and push lacrimal gland towards conjunctiva)

Sutures
- None

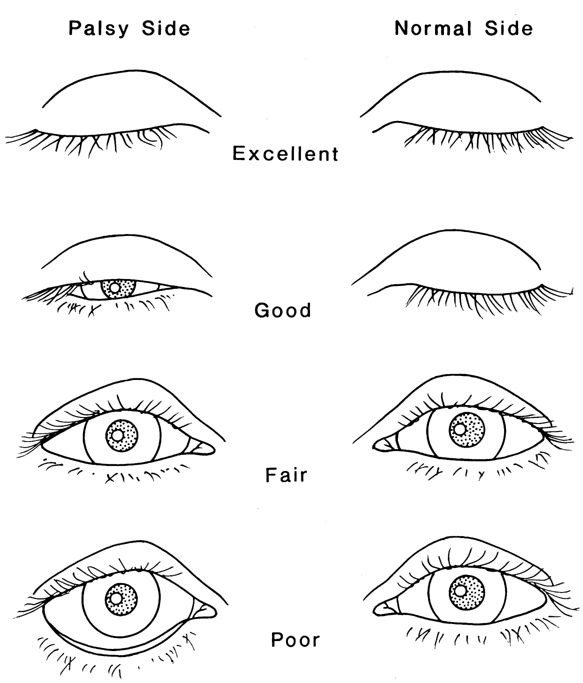


Figure 6–23. Classification system to evaluate results of eyelid reanimation surgery.

A useful part of the preoperative planning is to manually hold the paralyzed drooping brow in its normal position and observe whether that impairs eyelid closure. Following this maneuver, it is helpful to gently pinch the excessive skin fold in the upper lid and hold the brow up to see if that impairs eyelid closure. If eyelid closure is not impaired, then this maneuver is repeated in the operating room prior to performing the surgical procedure. These recommendations require that the surgery be done under local anesthesia so that the patient can demonstrate voluntary movement. Usually a gold weight or spring implant is placed into the upper lid following a conservative brow lift with or without a limited upper lid blepharoplasty. The surgeon should not expect the gold or spring to overcome the compromised lid closure created by an aggressive brow lift and/or blepharoplasty procedure.

Table 6–10 Eye Reanimation Procedures Performed 1963–June 1996

		Total
Upper Lid		807
Gold	482	
Spring	325	
Lower Lid		438
Tighten	241	
Cartilage strut	176	
Tarsorrhaphy	21	
Lacrimal System		27
Partial resection lacrimal gland	10	
DCR	10	
Parotid duct transposition	7	
Other		337
Forehead lift		
Brow lift		
Temporalis transposition		
Lid wedge resection		
Closed eyelid spring transposition flaps		
Lysis tarsorrhaphy		
Blepharoplasty		
Punctal plugs		
Punctal cautery		
Lash epilation		
Entropion correction		
Silastic encircling		
Medial canthoplasty		
Inferior retractor recession		
Total		1609

There are a number of techniques described to correct the drooping brow that include a direct, a midforehead, or a coronal approach.[10–13]

Direct Brow Lift

Techniques The direct brow lift approach is our preferred technique to manage the drooping brow in patients with facial paralysis. The technique was first described by Beard[10] and is illustrated in Figure 6–24. Johnson et al.[11] presented and illustrated the technical details of this approach. Clearly the advantage of this technique over the other options is the

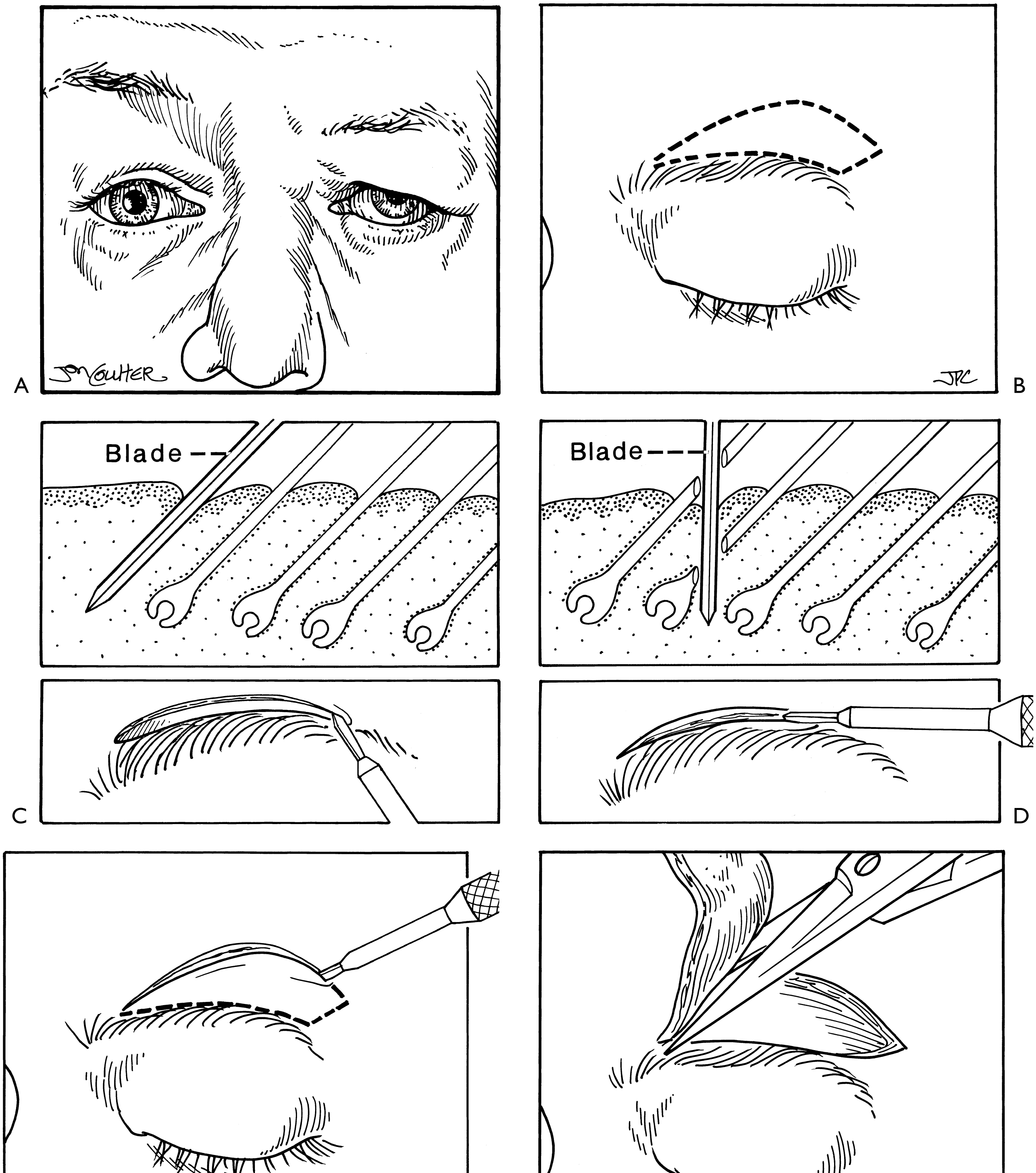
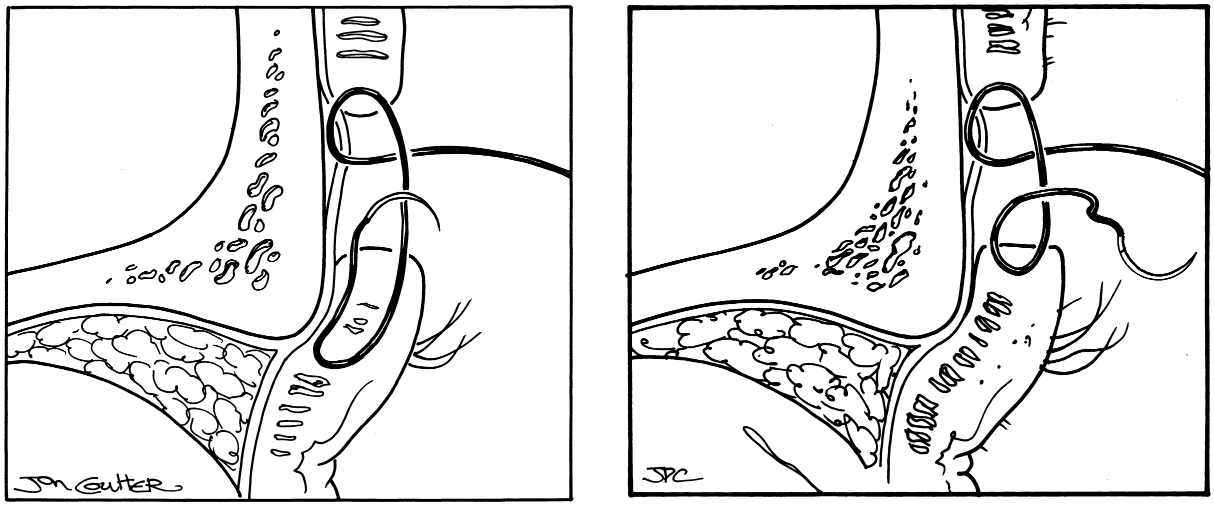


Figure 6–24. Brow lift technique (see Table 6–4 for instrumentation.) **A**, The level of the brows and the condition of the supratarsal folds are evaluated with the patient in repose and in the upright position. The goal of brow lift is to achieve symmetry at rest between the normal and paralyzed side without impairing eyelid closure. The orbital rim is an excellent fixed landmark to determine the level for brow fixation. Therefore, note is made preoperatively of the relationship of the normal brow to the orbital rim with the patient in repose and in the upright position. This relationship is used to determine point of fixation for the paralyzed side at time of surgery. **B**, The procedure is performed under local anesthesia. The incision is outline with a marking pencil. Skin resection is not routine and only used in elderly patients with pronounced skin laxity. Usually the incision is limited to just above the brow. The incision should not extend to the lateral or medial limits of the brow to limit scar visibility. **C**, Correct beveling as demonstrated will protect the integrity of the brow hair follicles as opposed to **(D)** where loss of brow hair in the incision line will increase scar visibility. **E**, The incision is made. **F**, The skin, subcutaneous tissue, and frontalis muscle, if present, are excised down to the suprabrow muscles, thus sparing the supraorbital nerve and vessels.



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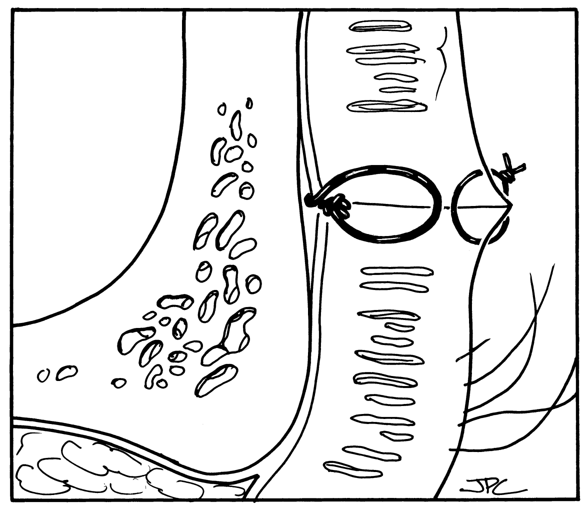


I

Figure 6–24. *(continued)* **G**, 4-0 Nurolon is used to fix the lower margin of the wound to the periosteum at a level that corresponds to the orbital rim determined preoperatively. This suture is key to securing the paralyzed brow to a level that will match the normal side. The supraorbital fold is suspended, if required, by incorporating this periosteal fixation suture with the supraorbital fold and periorbicularis oculi muscle as recommended by Luxenberg (1973).[62] Two or three of these sutures are placed to recreate the horizontal configuration of the normal side. **H**, The closure for patients without supratarsal fold droop. **I**, The wound is closed with subcuticular running sutures, and then the skin is closed with a running locking 6-0 chromic suture. Note the wound edges are everted. Steri-strips are then applied. The pull-out subcuticular suture is removed in 14 days. In patients with facial paralysis, the brow lift is usually combined with upper and lower lid procedures. *A word of caution*: *Be conservative in the amount of brow lift in patients with facial paralysis* as opposed to patients operated for cosmetic purposes. Be sure the brow lift does not impair eyelid closure. One must preserve function even if appearance is compromised (see Fig. 6–25).

ability of the surgeon to better control the position and shape of the brow. This is especially advantageous in unilateral brow droop because the surgeon has an opportunity to match the involved side with the normal side. The authors[11] demonstrated that the strategic position of the excised skin over the brow, whether it involves the lateral two thirds or is shifted medially, will influence the final position of the brow.

There are three surgical tips to minimize the scar: (1) bevel the incision in the line that coincides with the direction of the hair follicles, (2) meticulous wound edge closure and eversion, and (3) avoid extending the incision to the medial or lateral extent of the eyebrow hair.

Once the position of the brow is determined, the next key to success is to fix the lower wound edge with 4-0 clear monofilament permanent suture material to the periosteum under the edge of the upper incision line. The periosteal fixation was stressed by Beard.[10] Two or three sutures are placed to ensure that the new level of the suspended brow will be maintained.

Care must be taken when dissecting medially to expose and not disrupt or unnecessarily traumatize the neurovascular bundle of the supratrochlear and supraorbital nerves and vessels. Meticulous wound closure ensures that the resulting scar will be barely preceptible.

Drooping or sagging of the supratarsal fold can be corrected to some degree by including a portion of the orbicularis oculi muscle or soft tissue under the supratarsal fold. The orbicularis oculi muscle underlying the supratarsal fold is included with the needle and suture just before it passes through the tissue of the lower wound edge. Then, upon tying down the suture, the supratarsal fold will be suspended with the new position of the brow.

As a general rule the orbital rim is a good landmark for placing the brow; in men, the brow should be placed on the orbital rim, while in women, the brow should be placed above the rim. The actual position of the brow as well as its form should match the normal side in the position of rest and should be determined with the patient in the upright position. Preoperative photographs placed where they can be viewed by the surgeon during the procedure is quite helpful as a reference to achieve the best results.

Complications A noticeable scar in the hair line along the incision can occur but can be avoided when the recommendations provided have been followed. In the event that the scar is noticeable, it can be easily covered with a pencil liner or hairstyle in the case of women, and eyeglass wear is always an effective camouflage measure in men.

Another complication of brow lift is overcorrection. This can be revised by going back and releasing the fixation sutures in order to reposition the brow so that the paralyzed side and normal side have a more symmetrical appearance. In Figure 6–25, a patient post-Bell's palsy was referred to correct problems created by the referring surgeon. The combination of an aggressive brow lift and upper and lower eyelid blepharoplasties impaired the patient's ability to approximate the eyelids on the paralyzed side.

Hematoma and infection have not been a problem in any of the cases.

Results Overall this is a very rewarding procedure to achieve brow symmetry and help restore supratarsal fold position (Figure 6–26).

Endoscopic Brow Lift We have successfully used an endoscopic technique developed by Patel and Anderson[8] to elevate the brow in 12 patients with facial palsy. We use a two-incision approach with a paracentral radial incision and a circumferential incision over the temporalis fossa. A wide subperiosteal dissection is performed through the paracentral incision. The temporal dissection is between

A–C

D

E

Figure 6–25. Complication of overly aggressive surgery for patient post-Bell's palsy. Brow lift and upper and lower blepharoplasties were performed to improve appearance, but impaired eyelid closure. The patient had chronic exposure keratoconjunctivitis. **A**, Repose. **B**, Smiling. **C**, Attempting to close eyes. Note upper lid retraction on involved left side. Surgical correction was performed with Dr. George Buerger. **D**, Through tarsal-supratarsal fold incision, scar tissue was removed exposing levator palpebral superioris muscle. This muscle was recessed to allow more upper lid downward excursion. **E**, An eyelid spring was implanted to counter the tendency for the lid to retract.

F

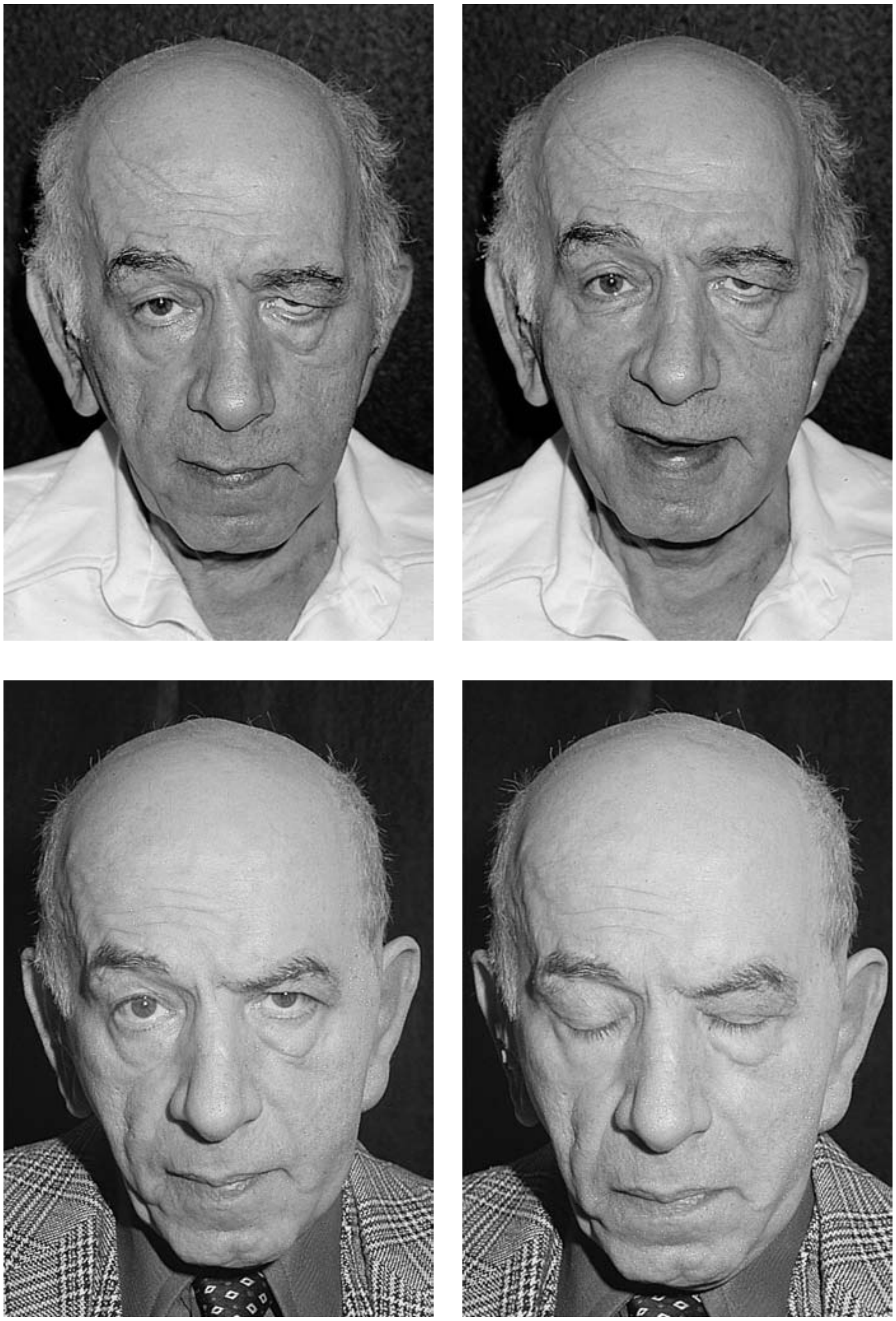
G

H–J

Figure 6–25. *(continued)* **F**, A pedicled flap was transferred into the upper eyelid to replace tissue removed by previous blepharoplasty. **G**, Wound closed. **H,I,J**, Results 2 months postsurgical correction. This case is a reminder and a warning to the reanimation cosmetic surgeon that the brow and eyelid in patients with compromised facial motor function require special consideration.

the superficial and deep temporal fascia. Two planes are connected over the temporal fusion line. The endoscope is used to divide the periosteum from the entire supraorbital rim. This release is extended over the lateral orbital rim as well, thereby forming a composite flap that is freely mobile. The endoscopic method of brow elevation relies on complete mobilization and refixation of the mobilized flap in the new position. Release of the periosteum, which is important in all endoscopic brow elevations, must be especially complete in patients with facial palsy. The superficial temporal fascia is firmly attached to the lateral orbital rim and has been called the orbital ligament. This attachment limits the cephalad movement of the superficial temporal fascia and needs to be completely released. In some patients, we dissect over the superior and lateral orbital rim via an upper eyelid skin crease incision, and ensure the creation of a completely mobile flap. This approach is particularly useful in men with heavy forehead tissues.

Once the composite flap has been mobilized, fixation in the new position is necessary. We have tried many fixation systems in functional, cosmetic, and facial palsy brow ptosis correction. The method that works best for us and for our patients with facial palsy is the use of the Mitek screw and suture system (see Chapter 7 for more details regarding the Mitek suture system). The screw is a self-retaining system with a suture attached to it. Once the screw has been placed, free needles are used to insert the sutures into the composite flap and elevate it to the required height. Other methods that also work well for fixation include the use of absorbable screws around which the sutures are tied and drilling a cortical tunnel through which the sutures are passed and tied. We generally aim to overcorrect the position of the brow in patients with facial palsy, as some degree of descent of the forehead and brow always occur. Additional sutures from the released superior orbital rim periosteum may be sutured to the Mitek



A, B

C, D

Figure 6–26. Results of brow lift with elevation of supratarsal fold and upper and lower eyelid blepharoplasty. The correction was for facial paralysis following a partial temporal bone resection for cancer of the external ear canal. **A**, In repose. **B**, Raising eyebrows. Only normal right side elevates. Note the marked sagging of the supratarsal fold that covers the upper half of the cornea in forward gaze. One month post-reanimation: **C**, In repose. **D**, Closing eyes. Note marked improvement (see Fig. 6–41).

screws or to the periosteum and galea posterior to the scalp incisions. The lateral aspect of the brow is elevated by suturing the superficial temporal fascia of the mobilized flap to the fixed deep temporal fascia. It is important to remember that the contraction of the occipitofrontalis that is thought to contribute to the mobilization and refixation of the forehead in the form of an extensive myocutaneous flap particularly pertinent. To date, we have had excellent results with this system in most patients. In our earlier patients, we tended to lift the forehead and brow as with cosmetic patients, and this invariably led to an undercorrection. Since then, in spite of an attempt at marked overcorrection, we have yet to see an overcorrection (Fig. 6–27). We have had no infections or palpable screws.

Advantages of this method include the presence of small scars on the scalp and temple where they may be hidden by hair. Even when there is no hair, the scars are barely visible. Disadvantages include the need for expensive, specialized instrumentation and the lack of long-term results.

Upper Eyelid

There are a number of approaches to improve upper eyelid closure. The nonsurgical approaches have been discussed in the medical treatment section. In addition to the most common techniques including gold and spring implantation, there are other adjunctive measures that may be done alone or in combination, including levator muscle recession or, even in some cases, plication, muscle of Mueller resection, medial and lateral canthoplasty, or modified tarsorrhaphy.

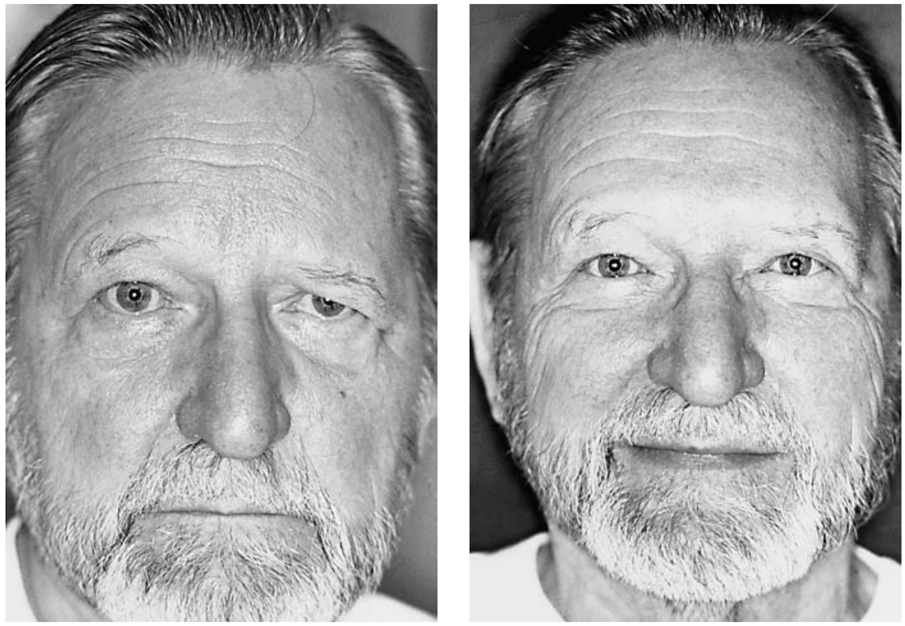


Figure 6–27. Endoscopic brow lift in facial palsy. **A**, A 67-year-old male with a left facial palsy which has been present since the age of 4 years. Note the marked forehead ptosis with severe brow ptosis, secondary hooding of the upper eyelid, lash ptosis, and visual obstruction. **B**, Six months following a left endoscopic brow elevation. A paracentral incision, a temporal incision, and an upper eyelid crease incision were used to mobilze the composite forehead flap.

A, B

Resection of Müller's muscle has been recommended for the treatment for thyroid related upper eyelid retraction.[14] Based on this information, one might consider combining resection of the Müller's muscle with or without recession of the levator papebral superioris aponeurosis to overcome upper lid retraction in the process of reanimating the paralyzed upper eyelid. There are an anatomical and physiologic bases for resection Müller's muscle in thyroid lid retraction, but none in cases of facial paralysis without thyroid disease.

Gold Weight Implantation In 1950, Sheehan[15] inserted a band of tantalum into the upper eyelid to affect closure and referred to this as lid loading. Illig[16] is credited with the first gold weight insertion, and almost 10 years later, an English surgeon Smellie[17] reported his experience using the gold weight to reanimate the upper eyelid. Jobe[18] was the first American surgeon to report using the gold weight and is responsible for popularizing the procedure in the United States. Implantation of a weight worked quite well in principle and was appealing because of its simplicity.

However, as one would expect with the implantation of a foreign body in the upper eyelid where the skin is so thin and delicate, extrusion is a problem. Many efforts have been made to overcome this shortcoming. Suggestions have been made to encase the gold weight in silicone rubber,[19] to customize fabrication of the gold implant prosthesis for each patient's needs,[20] and as suggested by Kaplan et al.,[21] to customize the weight, size, and shape of each implant before surgery in order to achieve the best results. Barkley and Roberts[22] presented in great detail their laboratory technique used to manufacture the gold weight implant. They stressed that of all of the implant materials available, gold is preferred because it is inert, has a high tissue tolerance, and is quite malleable and easily manipulated to form into the required shapes. The density of the gold weight allows a relatively small volume to achieve eyelid closure, and the 24-carat gold used for implantation has a satisfactory color and tends to blend with the skin tone.

Professor Micheli-Pellegrini[23] commented that he had already published three papers on this subject in the Italian literature. In his 1967 article, he stressed the importance of fenestrating the gold implant in order for tissue to grow through it and prevent subsequent extrusion, as already reported by Jobe.[18] Jobe emphasized the importance of fitting the patient with the proper weight and made available a standardized kit containing different weights that had holes drilled in the prosthesis for suture fixation and details of surgical technique that ensured a high success rate.

In spite of Jobe's report, the gold weight procedure intially did not gain popularity because of a high failure rate and complications noted by other surgeons. Pickford et al.[24] reported their experience with 54 patients. Five suffered spontaneous loss of their gold implants, and 16 reported problems attributable to the weight itself: (1) unsightliness due to bulging through the lid, (2) redness of the upper eyelid skin, (3) distortion of lid shape, and (4) soreness, particularly after minor trauma. Two patients reported that their implant had shifted medially within the lid. It was interesting that two out of the five patients in whom the implant extruded had undergone previous lid surgery, suggesting that there is a greater risk in such cases. A small number of their patients required revision surgery to replace the implant with a lighter one. Patients developed a drooping eyelid that was thought to be due to a condition referred to as levator fatigue. In an attempt to explain their high complication rate, the authors stressed the importance of a correct plane for the pocket into which the implant is placed and suggested that a superficial placement may contribute to ulceration or migration.

The gold weight implant used by these authors did not have fenestrations for suture fixation, and the design of the weight has been modified by making it somewhat longer and flatter in an attempt to reduce the unslightly bulging.

It is quite possible that their high complication rate was related to the design of their implant.

A report by Kelly and Sharpe[25] reported an extrusion rate of 43% and an overall complication rate of nearly 70% in 31 patients. This unacceptable rate of morbidity could possibly be attributed to the lack of adherence to the principles outlined in Jobe's original article.[18]

Jobe's Recommendations We have achieved a high success rate and low incidence of complications by paying meticulous attention to the details in Jobe's 1974 article. Jobe stressed the importance of *preoperative fitting* of the prosthesis by testing the lid with different weights. He described temporarily cementing the gold weight to the patient's lid with tincture of benzoine. The patient was sitting upright for the procedure, and was asked to look up and down. The size of the weight was changed until the desirable prosthesis was determined by noting which size held the lid about 1 mm lower than the normal lid when the patient looked straight ahead. The overcorrection was in anticipation of levator palpebral superioris strengthening once the weight was in place. Finally, when a proper weight has been chosen, it must be cleaned with soap and water, rinsed thoroughly, and then autoclaved in preparation for use.

In his classic article, Jobe highlighted the surgical procedure.[18] He suggested that the prosthesis be centered at the juncture of the medial and central third of the lid. We have found that this is a key point because the eyelid closes from lateral to medial. Unless the gold is placed just medial to the midline, a common problem is persistent *exposure of the medial third of the globe*. Jobe stressed that the plane into which the prosthesis is to be placed is on the surface of the orbital septum, and the tarsal plate and the lower edge of the prosthesis should be a few millimeters above the lid margin. This prevented extrusion of the gold through the lid. Further, if the prosthesis was placed in this deep plane, there was maximum tissue to cover the implant. This not only decreased the likelihood of extrusion, but also made it less likely that the gold would *show through the thin tissues*. By placing the gold a few millimeters above the lid margin, the very thin, tightly adherent skin of the lower margin of the tarsus is avoided. In addition, the likelihood of the gold migrating inferiorly and prolapsing over the lashes was prevented.

Another reason for *extrusion and migration* was failure to suture the prosthesis to the orbital septum with nonabsorbable suture. Finally, the skin as well as the orbicularis oculi muscle must be closed. In the event that the patient has long-standing facial paralysis and the muscle is fibrotic or there is only a fascial layer between the skin and the tarsus, this layer must be closed. In other words, there should be a two-layered closure over the prosthesis.

Jobe has continued to champion the use of gold weights and is responsible for the commerical availability of this product through the Meddev gold eyelid implants. As medical director of Meddev Corporation, Jobe responded to a report by Biar et al.[26] regarding three cases with *gold sensitivity* following insertion of gold eyelid weights. Jobe conceded that sensitivity, even to pure gold produced by the Meddev Corporation, had been observed on a rare occasion. These cases can be successfully treated with either corticosteroid injection, or as reported by Biar et al.,[26] in one case, with replacement of the gold weight with a Meddev implant constructed of pure platinum. We have had one case out of 482 implants where the gold had to be removed because of tissue intolerance or perhaps a patient sensitivity to the gold.

Combined Procedures Combining other reanimation procedures with the gold weight insert should be considered as part of a total program in rehabilitating eyelid closure. Jobe[18] commented that in patients with long-standing facial paralysis, the gold weight implant patient may require augmentation with other procedures such as lateral canthoplasty, brow lift, lower lid shortening procedures for ectropion, lower lid supporting procedures with fascia slings, or medial canthoplasty. In addition to lower lid tightening procedures, Gilbard and Daspit[27] enhanced their results by adding recession of the lower lid retractor muscle, placement of fascia lata combined with a lateral tarsal strip tightening procedure, and sectioning of the muscle of Müller as a reliable approach for mimicking involuntary blink without ptosis.

Possible Contraindications In their discussion, Linder et al.[28] mentioned glaucoma as a contraindication for lid-loading devices, although there appears to be no significant alteration of the intraocular pressure with this technique as reported by Kartush et al.[29] They also mentioned the concern for the effect of magnetic resonance imaging (MRI) on patients after gold weight insertion, considering that many of these patients require reanimation following acoustic tumor surgery and MRI is the most useful method for following acoustic patients postoperatively. This problem was studied by May et al.[30] and Marra et al.[31] Based on these two reports, MRI is not a concern for patients with gold weight insertion because the gold is not magnetized. Patients may be aware of some increased heat, and this can be easily countered during the MRI examination with application of a eye patch saturated with water and placed over the involved eye.

Gold Weight for Patients with Other Procedures So far no mention has been made of a gold weight implant for patients who have a tarsorrhaphy in place or the effects of other procedures that would influence eyelid movement such as a Silastic encircling procedure.[32] Liu[33] discussed this problem and made some important observations regarding case selection. First, the author stressed the importance of determining which eye is dominant because this will influence height of the reanimated eyelid. Second, in order to obtain an accurate weight of the implant needed, the restrictive effect on the eyelid from the previous surgery, such as tarsorrhaphy or encircling band, must first be eliminated. Third, he stressed the importance of evaluating the patient's lacrimal function, Bell's phenomenon, and levator function in order to predict the best result as well as the patient's likelihood of significant improvement in eye comfort. The goal of eyelid implantation is to improve upper lid position in order to protect the otherwise exposed cornea. In the process, a mild amount of ptosis may occur. This may be acceptable as long as it does not interfere with vision. Factors such as the height of the upper eyelid will be influenced by which eye is dominant, the effect of the previous procedure, and finally the function of the levator muscle.

Liu[33] in an effort to explain the role of the dominant eye introduced the concept of *Hering's law* of *equal innervation*. If the level of the eyelid interferes with vision in the dominant eye, then the patient tries to raise that eyelid. As a result, there is extra innervation going to both upper eyelids. Consequently, the palpebral fissure of the normal eye will be wider than its normal width. When the first procedure is undone as would occur if a tarsorrhaphy was taken down, the vision in the dominant eye would not be interfered with and the extra innervantion would no longer be present. In such a case, the normal nondominant eyelid would lower.

The same effect would occur if a gold weight implant was placed in the paralyzed eyelid, and the level of the lid with the gold was lowered to the point where it interfered with vision. Then Hering's law of equal innervation would come into play, causing the normal eyelid to retract. Even with the increased innervation to the involved side, the levator muscle would not be able to overcome the forces of the gold. Thus, the normal eye would be wider, and the involved eye with the gold weight would be ptotic.

Therefore, when the gold weight is placed, it is important to first determine which is the dominant eye. It is also important not to place a weight that will lower the lid to the point where it interferes with vision. This well-known phenomenon among ophthalmologic surgeons is not one that is commonly known outside of that specialty, and for that reason, it is included in this general discussion of gold weight implantation.

It should be obvious that one cannot evaluate the effect of the gold implant by pasting it on the eyelid until the first procedure is undone. The tarsorrhaphy or the encircling band will hold down the upper eyelid, and in such a case, it would seem that less weight is needed to close the eyelid. Evaluation of the proper weight as well as levator function cannot be evaluated as long as the restrictive effect on the lid is in place. Therefore, the correct approach is to take down the tarsorrhaphy first and then re-evaluate not just the proper weight of the gold but what procedure or procedures would be best for the patient (Figure 6–28).

Timing of Reanimation Surgical treatment for the paralyzed eyelid should be delayed following facial nerve injury. There are changes that occur over the first 14 days following total facial paralysis that must be taken into account when considering reanimating the eye region. Following total interruption of the facial nerve as occurs with acoustic tumor surgery, the patient seems to be able to close the eye in the immediate postoperative period. This suggests that the injury to the facial nerve is incomplete and is a source of misinterpretation. The eyelids will almost approximate during this time period based on maintenance of the integrity of facial muscle tone. Complete Wallerian degeneration takes 10 to 21 days, at which time the periorbicularis oculi muscles will begin to lose their tone and gravity will begin to affect the position of the lower lid leading to ectropion. At this time, it will become obvious that the lids are not approximating. Therefore, it is best to wait until the effects of denervation have occurred and, in the meantime, manage the patient with medical measures as discussed earlier in this chapter.

Author's (MM) Experience with Gold Implants The first gold implant was placed in February 1983 under the direction of Dr. Bill Swartz. Until that time, the wire spring implant taught to me by Dr. Bob Levine was my preferred approach to upper eyelid reanimation. My experience with the gold placement procedure in terms of its simplicity, the commercial availability of the prosthesis, and the consistently favorable outcome achieved, convinced me that this technique had many advantages over using a spring. It is interesting to note that in 1987 we reported our experience with gold weight and wire spring implants as alternatives to tarsorrhaphy.[34] A total of 139 wire springs and 90 gold weights were implanted in 202 patients. Now, 10 years later, the preference for gold over the spring is reflected in Table 6–10, where the accumulated experience shows 482 gold implants compared to 325 spring implantation procedures. The material previously reported in 1987[34] will be updated in this section (Table 6–11).

Patient Selection The ideal candidate for gold implant (Fig. 6–29) has the following characteristics:

1. The patient has facial paresis rather than total paralysis. In such cases, the patient can achieve partial closure of the eyelids.
2. The patient has total paralysis with some lowering of the upper lid with an effort to close the eyes.
3. The supratarsal fold is prominent and allows for placement and coverage of the gold implant.
4. The upper lid approximates or at least covers the cornea with a properly chosen gold weight pasted on the involved eyelid with the patient in the upright position and the lid position is symmetric with the normal side when the lids are opened.
5. The eyelids approximate when the patient is lying down with the head on two pillows and the gold weight is pasted on the involved upper eyelid.
6. The patient has a good Bell's phenomenon (Fig. 6–7), tears are present, and there is normal corneal sensation (absence of the BAD syndrome).
7. The patient is compliant regarding eye care and practicing suggested maneuvers that improve the eye closure effect of the gold weight (looking down when attempting to blink or "think blink" and reading with material held at eye level to control involuntary ptosis).

Now that we have presented the characteristics of the ideal patient, one can predict who would be a poor

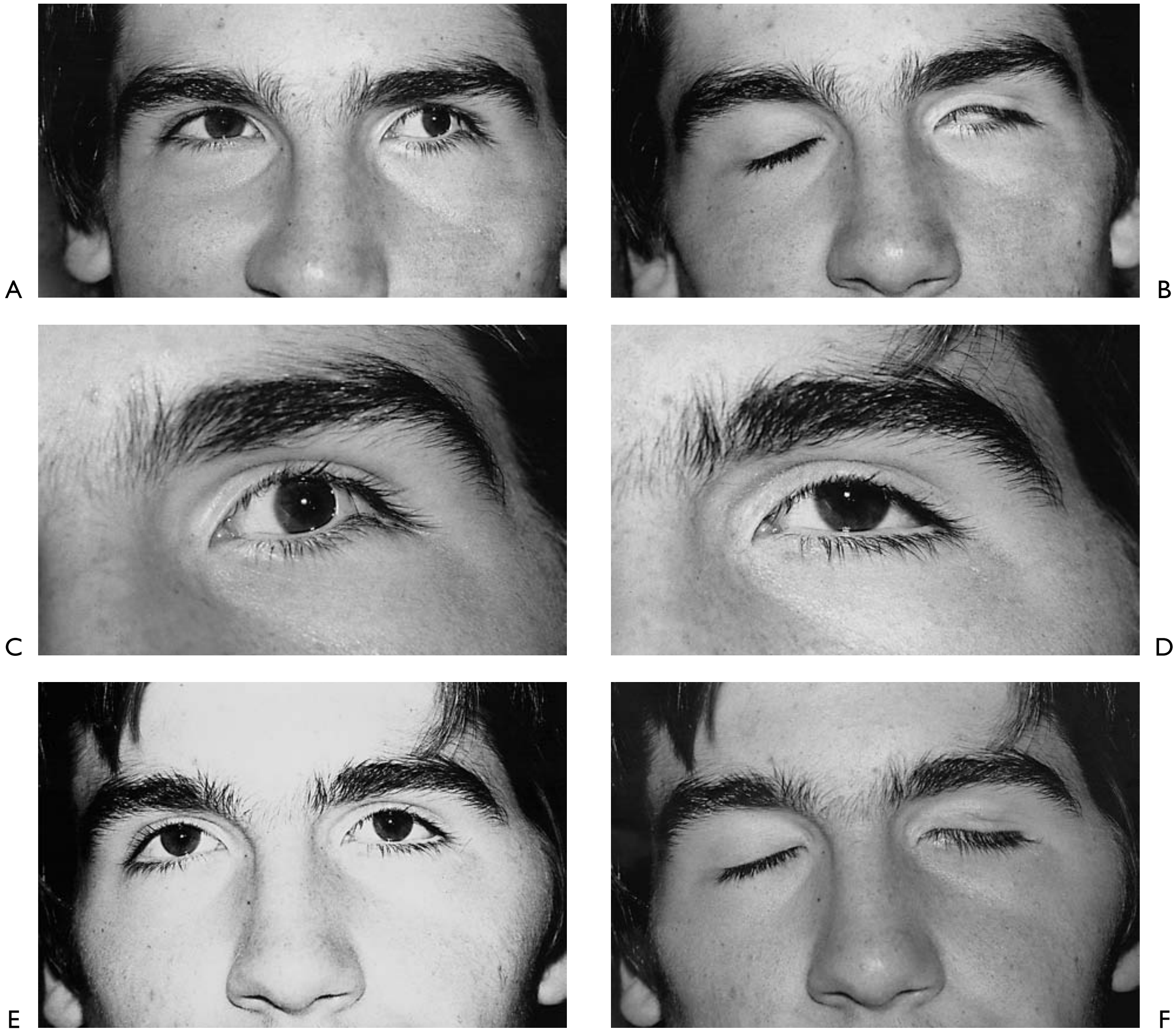


Figure 6–28. Patient with tarsorrhaphy. The tarsorrhaphy must be taken down to determine if gold will be useful. **A**, Patient 4 years post-cerebellar atriovenous malformation surgery left side with multiple cranial nerve deficits (VI,VII,VIII, and X). Note unsightly webbed lateral tarsorrhaphy. **B**, Incomplete eyelid closure with tarsorrhaphy in place. Patient wanted tarsorrhaphy removed because it was "ugly." The ophthalmologist warned not to remove it because it protected his eye. There is an adage "once a tarsorrhaphy always a tarsorrhaphy." This is based upon the difficulty achieving a successful tarsorrhaphy that does not come apart or require revision. Further, there is concern that if a "successful" tarsorrhaphy is opened, it may have to be redone to reduce exposure keratitis. **C**, Close-up of the "ugly" lateral band web that had formed. Note how this limits vision in lateral gaze. **D**, The tarsorrhaphy was taken down in the office setting after application of topical and a small infiltration of local anesthetic. Note that the tarsorrhaphy caused deformation of the lid margin. **E**, Eyes opened after gold implant. **F**, Eyes closed after gold implant.

Table 6–11 Summary of Experience with Gold Implant 1983 - June 1996

First implant	1983
Longest in place	13.5 years
Total implants	482
Results successful	434 (90%)
Total removed	98 (20%)
CN VII recovered	50 (10% of total)
Failures	48 (10% of total)

candidate (Fig. 6–30). Keep in mind that the factors are additive, and one alone will not exclude a patient for a gold implant. The factors include patients who have a total paralysis, lid retraction, no Bell's phenomenon, exophthalmic or prominent protruding eyes, absence of a supratarsal fold, and thin atrophic senile skin over the upper lid, and patients who are interested more in how the eye looks than improving function. This last characteristic is more common among women who usually will not tolerate lid asymmetry even though the gold weight in place improves comfort. Finally, patients who have the BAD syndrome rarely achieve relief of their condition with a gold weight implant alone.

A B C D E F

G

Figure 6–29. Ideal candidate for gold weight implant. Patient 2 years post-acoustic tumor surgery. The facial nerve was preserved, but only tone has returned. There is no facial movement on left side. **A**, Slight lid retraction of the upper eyelid due to action of levator palpebral superioris muscle unopposed by orbicularis oculi muscle causing widening of interpalpebral fissure. Note prominent supratarsal fold that will be quite adequate to cover and camouflage the gold weight implant. **B**, There is downward excursion of upper lid with effort to close eyes. Note closure is incomplete. **C**,**D**, Close-up of involved eye opened and closed showing features already described. **E**, The gold weight is pasted to the upper lid as a trial prior to surgery. The upper eyelid approximates the lower lid providing complete eyelid closure. **F**,**G**, The gold weight was surgically implanted. Result 1 week later. Eyes opened and closed.

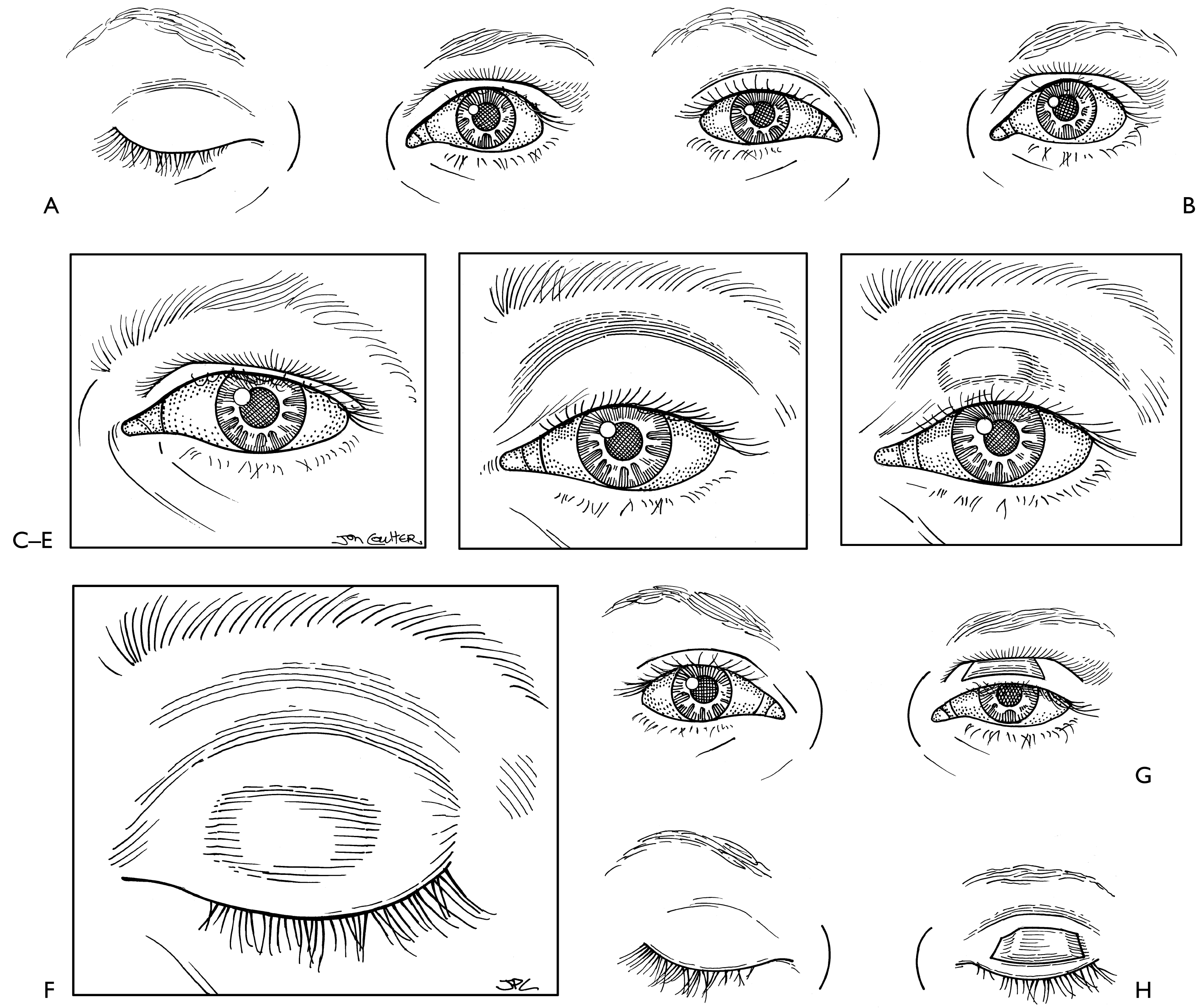


Figure 6–30. Gold weight. Selection of the ideal patient and choosing size of gold implant. **A**, The ideal candidate has symptomatic lagophthalmos. In this case, the Bell's phenomenon is absent with effort to close involved left eye. Some evidence of upper lid closure would be a more favorable sign. **B**, Note the presence of a prominent supratarsal fold. **C**, This fold offers excellent coverage for the implanted gold weight and prevents the problem of a prominence or show of gold through the lid skin. **D**, Compare to **A**. A patient with a deep supratarsal sulcus usually common in women as opposed to men where it is less common. **E**, Note the prominence of the gold weight that is a common feature when gold is implanted in patient who lacks a heavy supratarsal fold. **F**, This is particularly noticeable with the eyelid in the closed position. **G**, The ideal size of gold weight is one that creates little or no ptosis when pasted on the lid, and **(H)**, achieves complete eyelid approximation with an effort to close the eyes.

Gold Weight Selection (Fig. 6–30) Based on a review of the literature, a common cause of failure with the gold implant was directly related to the size, form, and weight of the gold used. For the most part, these problems can be avoided by using the commercially manufactured and available gold weights through the Meddev Corporation. They are 24-carat machine-smooth for maximum tissue tolerance and come in a variety of sizes for accurate fitting, and there are three holes in the gold weight for tissue fixation. The patient helps select the proper weight by looking in a mirror and reviewing a videotape taken while trying a variety of sizes. Because they cannot see what the eye looks like when it is closed, the videotape is ideal for this purpose. A gold weight weighing between 0.6 and 1.2 g is pasted on the paralyzed upper eyelid, and the patient is asked to close the eyes. The patient then reviews the videotape and decides which weight seems best in terms of comfort, appearance, and function (Fig. 6–29).

The Meddev Corporation external eyelid weights are made of pure tantalum metal and are nearly as heavy as gold, can be secured to the upper eyelid with a special adhesive tape. These weights are available in four flesh-tone

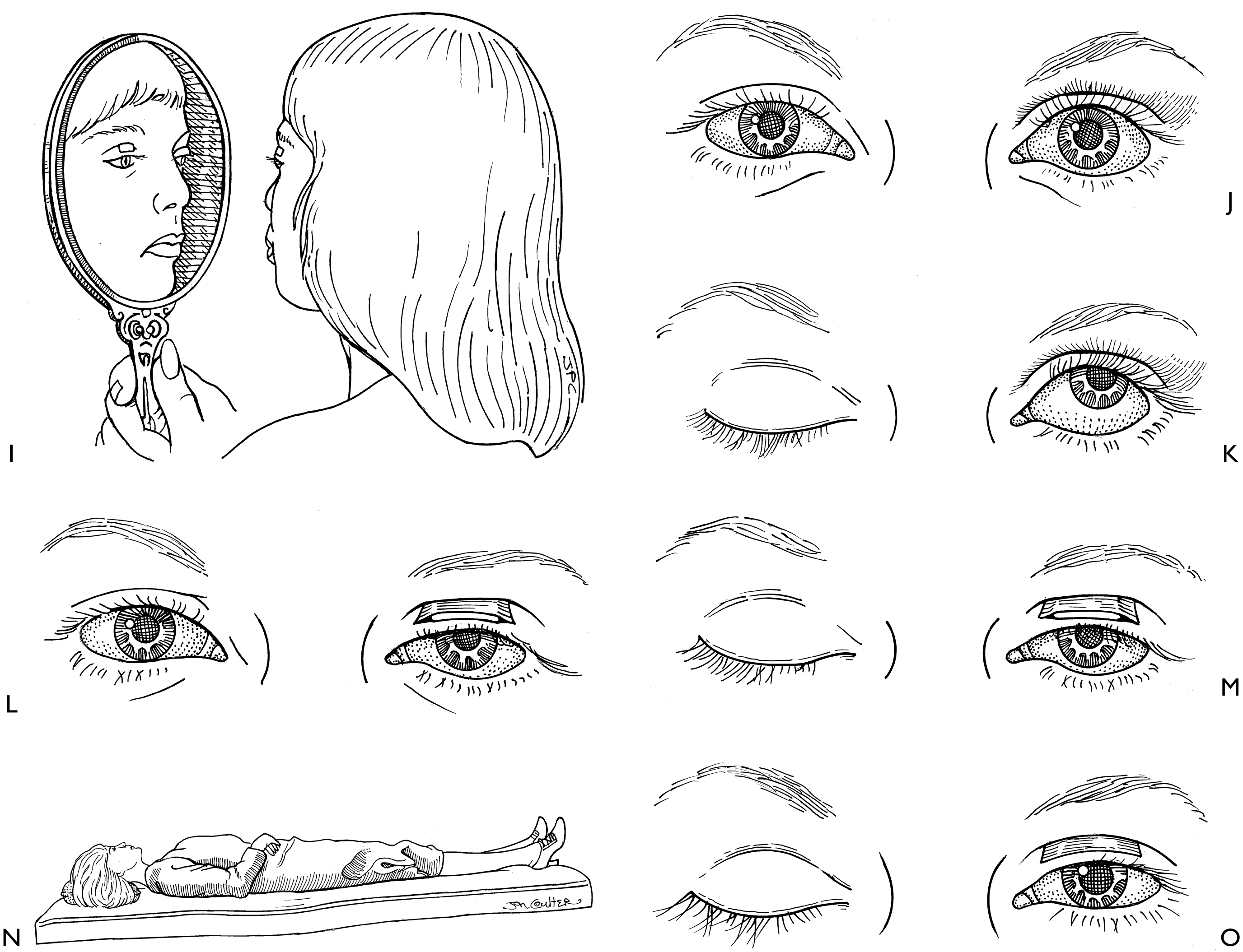


Figure 6–30. *(continued)* **I**, After a suitable weight is chosen, the patient is asked to look in the mirror with the weight pasted to the lid to determine if the appearance is satisfactory. Women in particular are unhappy if there is any lid drooping on the involved side with eyes opened. The patient usually decides to have the gold implanted if the eye is more comfortable and the appearance is acceptable. **J**, Lid retraction may not be corrected with the gold weight. Note the retraction on involved left side. **K**, Usually a gold weight will not overcome the retraction when it is more marked with an effort to close the eyes. This is caused by the reflex interaction between the extraocular muscles rolling the globe up and out and the levator palpebral superioris which is supposed to relax but is unopposed by the periorbicularis oculi muscles. This observation has been noted with faulty regeneration where, in addition to lid retraction, the brow elevates further impairing eyelid closure. **L**, Note even with a weight heavy enough to create noticeable ptosis with eyes opened, **M**, it is not sufficient to overcome the lid retraction. A lateral tarsorrhaphy and levator palpebral superioris lengthening in addition to the gold may provide desired result. Combining these procedures with lower lid tightening or elevation (cartilage implant) further augments results. In cases where the brow elevates due to faulty regeneration, a brow release by a selective myectomy is useful. **N**, Finally, the effect of the weight is checked with the patient lying on one or two pillows to be sure that the effect of gravity will not pull the eyelid open while sleeping. **O**, If that is the case, the patient would not be a good candidate for the gold weight implant without some precautions. Such a patient would require taping, a shield, or eye ointment at bedtime. The procedures described in **L** might overcome this problem.

colors, and are designed to treat patients with temporary paralysis or can be used as trial weights. There is a considerable cost-saving for the patient who is willing to wear the prosthesis rather than have it surgically implanted. In my experience, patients who will require a gold weight for a prolonged or indefinite period of time would much prefer to have it implanted, providing a more permanent solution. The Meddev Corporation has a pure platinum implant available for patients who have a sensitivity to gold.

Surgical Technique (Fig. 6–31 and Table 6–5) The description of the surgical procedure is based on the original report of Jobe[18] and subsequent correspondence with him, review of the literature,[15–33] and accumulated personal experience.[34]

Postoperative Care Table 6–12 outlines the important aspects of the postoperative care and summarizes the material that has already been presented. However, it should be stressed that if the patient used eye medications prior to

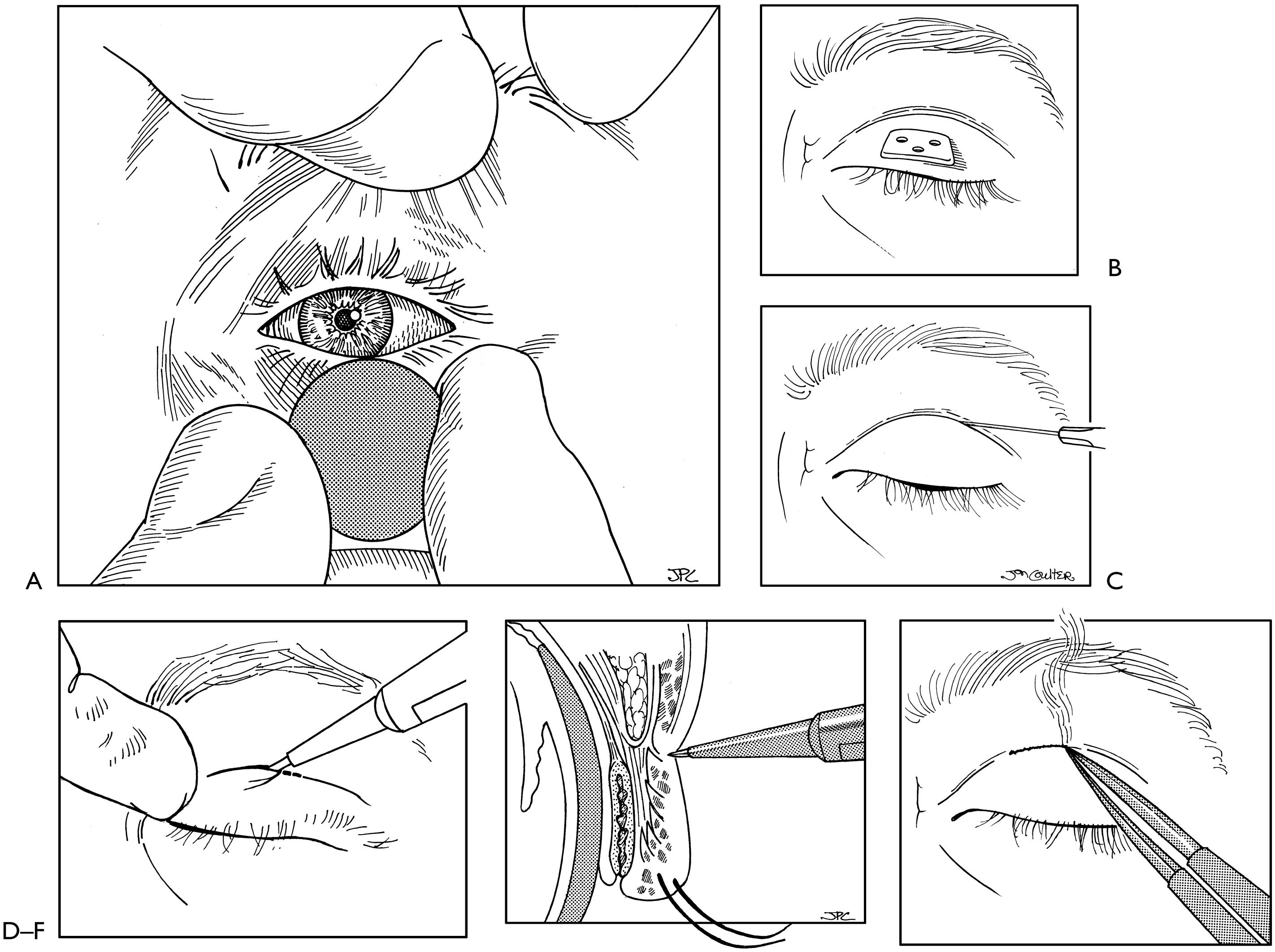


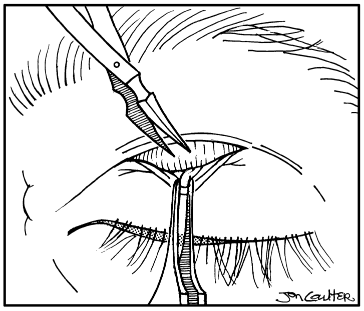
Figure 6–31. Gold weight implantation technique (see Table 6–5 for instrumentation). The procedure is performed with local and topical anesthesia. **A**, A contact lens is inserted. **B**, The gold weight selected prior to surgery (see Fig. 6–30) is once again tested for its ability to close the eye, with the patient lying down and the head elevated on pillows. **C**, A minimal amount of local anesthetic is infiltrated into the tarsal-supratarsal fold, and 10 minutes is allowed to elapse to benefit from the hemostatic effect of the 1:100,000 adrenaline that was mixed with the local. **D**, The incision is made along the tarsal-supratarsal fold using a razor-blade knife. **E**, A sagittal view of the upper eyelid to demonstrate the limited depth of the incision that extends just through the thin skin. This discourages extravasation of blood into the delicate tissue planes of the eyelid. This would obscure these structures and make the dissection more difficult. **F**, Hemostasis is maintained with microbipolar cautery.

reanimation surgery, this therapy should be continued so the effect of the reanimation procedure can be determined.

Results Reanimation was considered successful if either closure was achieved or preoperative symptoms of keratitis or eye irritation were improved. This was determined at 6 weeks because it takes that long for the levator papebral superioris muscle to adjust to the implanted weight. Overcorrection may be due to either fatigue or weakening of the muscle, while undercorrection may be due to an increase contraction strength or inadequate eye closure. Rather than consider the procedure a failure and contemplate revision surgery, it is best to wait an additional 6 weeks since the problem may correct itself or actually get worse. If the gold has not achieved its intended results at 12 weeks, then it is worthwhile to consider placing a lighter weight if the lid is overclosed or a heavier weight if it is underclosed.

There was a 90% success rate with the gold implant. Of the 482 gold implants, the gold weight was removed in 48 patients (10%) for the following reasons: (1) inadequate upper lid closure, (2) extrusion, (3) a cosmetic deformity was created, and (4) a chronic skin inflammation formed, thought to be secondary to the patient's sensitivity to gold (Tables 6–11 and 6–13).

Cosmetic deformities were created when the gold migrated over the lid margin in two patients; in one of these, there was eversion of the eyelashes. This interfered with vision and caused corneal irritation from lash contact.



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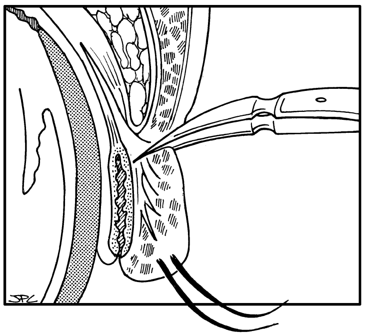

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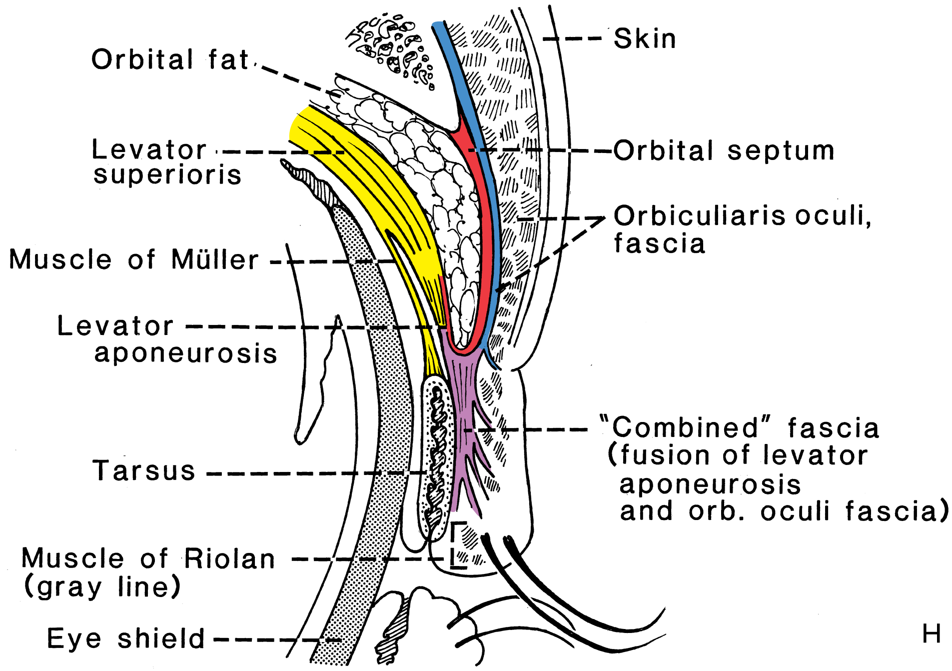

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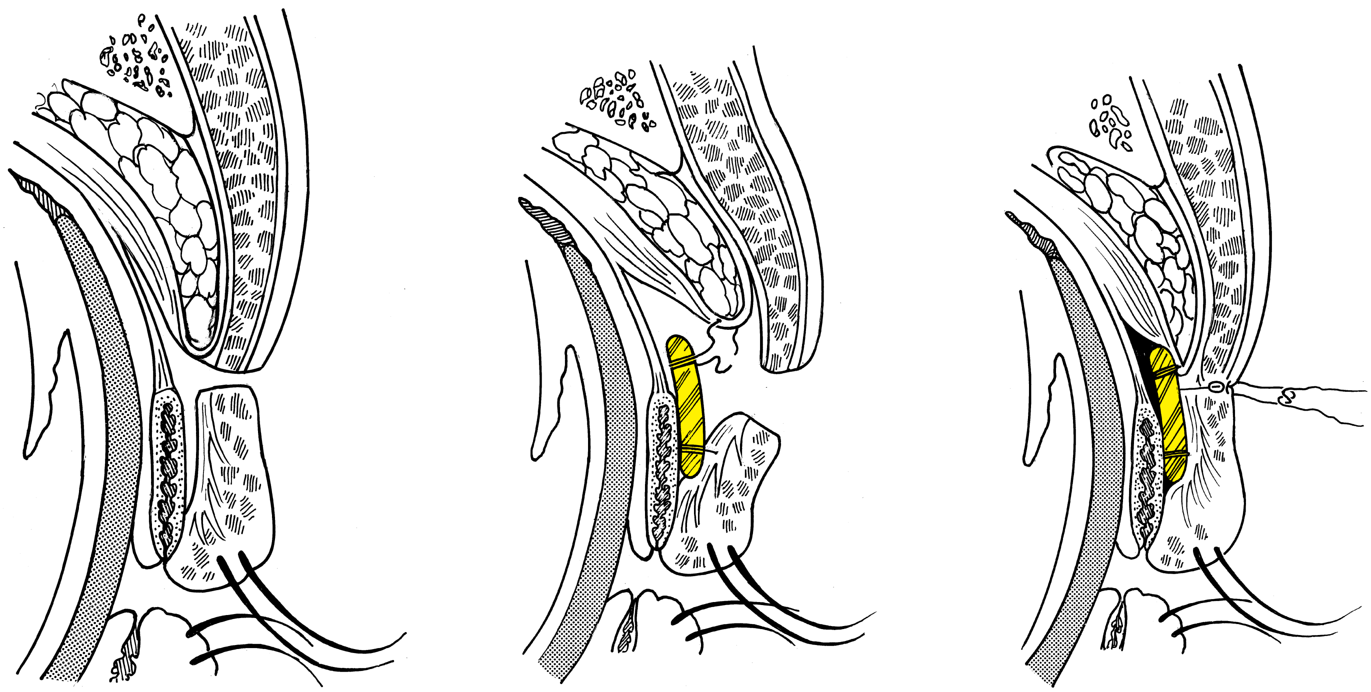
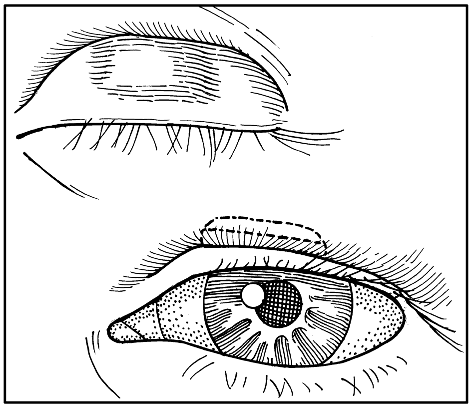


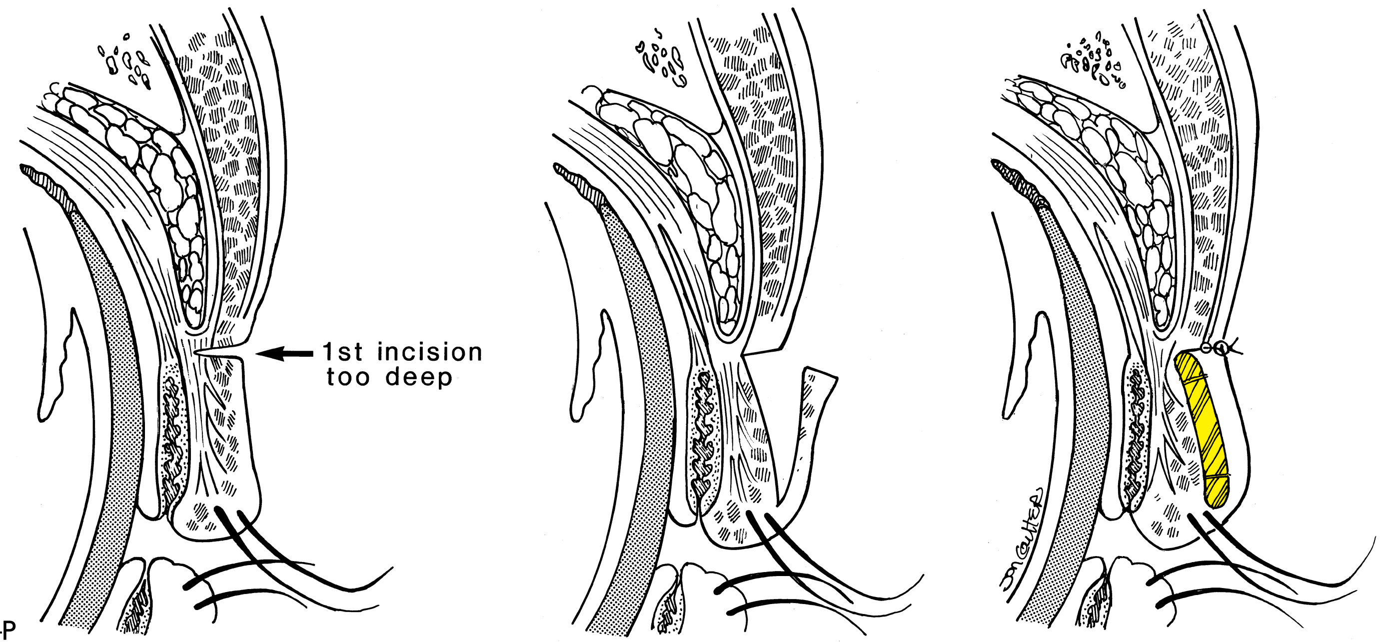
J–L

Figure 6–31. *(continued)* **G**, The double-action scissors is directed perpendicular to the lid plane while displacing the lower wound edge. The dissection extends to the tarsal plate. **H**, Details of the cross-sectional anatomy of the upper lid help understand the dissection from the skin to the tarsus. **I**, The scissors with the blades opened is pushed against the soft tissue in a perpendicular direction towards the tarsal plate. Then the blades are closed to divide the orbicularis oculi muscle and levator aponeurosis. The tarsal plate becomes palpable as a firm structure at the depth of the wound. The lid margin becomes deflected as the points of the scissors touch the tarsal plate. The tarsal plate becomes visible as a smooth colorless structure sitting in the bottom of a pocket made up of soft tissues. **J**, The dissection extends inferiorly over the surface of the tarsus to within 3 mm of the lash margin and superiorly between levator aponeurosis and orbital septum over the thin layer of conjunctiva-muscle of Müller. If the conjunctiva is perforated, the globe is protected with an eye shield. The defect can be repaired with 6-0 Vicryl with the knot towards the wound rather than on the side of the globe. **K**, The gold implant is then placed in the pocket created over the tarsus and under the orbital septum. The gold is fixed with 8-0 Ethilon sutures placed through each of the three holes in the gold weight. Two sutures fix the gold weight superiorly to the orbital septum and one inferiorly to the levator aponeurosis. The final position is 3 mm from the lid margin inferiorly, under the orbital septum superiorly, over the upper third of the tarsus, and horizontally parallel with the lid margin. The gold is centered at the juncture of the medial and central third of the lid to improve coverage of the medial third of the globe (see Fig. 6–30M). **L**, Then, the levator superioris and orbicularis oculi or subcutaneous tissue is closed with 6-0 Vicryl and the skin with 6-0 chromic. Important keys to closure to prevent gold migration, extrusion, or wound dehiscence: The 8-0 Ethilon must be tied with three throws otherwise the knot tends to unravel, and the wound requires a double-layered closure. *(Figure continued next page.)*



M

Figure 6–31. *(continued)* **M**, Final position of implanted gold as described in **K**. **N**,**O**,**P**, Common technical errors that lead to lid prominence, skin reaction, and extrusion. **N**, Initial incision too deep. **O**, The flap is under the lid skin rather than a pocket over the tarsus. Further, the dissection extends to the lid margin. **P**, This places the gold in a superficial position covered only by very thin and transparent eyelid skin.



N–P

Table 6–12 Gold Implant: Postoperative Care, Patient Instructions, and Evaluation of Results

1. Wound Care
   First week–keep dry.
   Second week–remove residual skin sutures; steroid cream for skin reaction.
2. Improve Lid Closure
   Sleep on two pillows.
   Look down to blink, "think blink."
   Overclosure with reading–hold material at eye level.
3. Eye Dryness and Irritation
   Continue to use preoperative eye medications–drops and ointment.
4. Re-evaluate Lid Closure at 6 Weeks
   Overclosure–may be due to levator fatigue. Often levator will compensate over next 6 weeks.
   Underclosure–may improve if levator develops fatigue; therefore, wait 6 more weeks.
5. Re-evaluation at 12 Weeks
   Overclosure–revise by placing lighter weight.
   Underclosure–revise by placing heavier weight.
   *Other procedures or combinations may be required (see Tables 6–10 and 6–14).

Table 6–13 Reasons for Failure of Gold Implant (48 Patients)

Underclosure	22 (5%)
Overclosure	14 (3%)
Extrusion	7 (1%)
Cosmetic (noticeable)*	6
Sensitivity to gold	1

One patient not included as a failure developed skin abscess from foreign body reaction to suture. Suture removed, abscess drained, and infection resolved. Gold remained in place.

*Gold migrated inferiorly (3) and formation of pseudocapsule (3).

In three patients, a thick fibrous pseudocapsule formed around the gold, causing a bulge over the gold implant that produced an unslightly deformity of the upper eyelid. In each of these cases, the problem was corrected by revision surgery; either the gold was refixed with permanent sutures to a correct position, and/or the capsule was resected. The success rate was improved from 90 to 98% with revision surgery. Useful results are noted in Figures 6–28, 6–29, and 6–32 through 6–34.

Failures The common causes and reasons for failure associated with the gold implant are outlined in Tables 6–13 and 6–14. They include lid over- or underclosure, lid deformities, and gold extrusion. The success rate can be improved by following the guidelines listed in Table 6–15. Basically they consist of careful patient selection, proper choice of gold implants, and meticulous adherence to the surgical technique.

Inadequate lid closure usually can be traced to one or a combination of factors. Either the levator palpebral superioris is overactive, not reflexly inhibited with efforts to close the eye, or the weight was too light. These problems usually can be predicted by careful preoperative evaluation or at the time of surgery.

Excessive lid closure is usually due to levator palpebral superioris fatigue or the weight being too heavy. Plication or shortening of the levator muscle and/or placing a lighter weight may correct this problem.

Lid deformities can usually be traced to improper patient selection, gold weight size, or surgical technique in placing the gold weight. A gold implant may migrate, rotate, or shift position causing a lid deformity, if it is not fixed in place with permanent sutures superiorly in two places to the orbital septum and inferiorly to the levator palpebra superioris aponeurosis.

Lid bulge is usually due to a gold weight that is too large or is placed in an incorrect pocket under the skin of the upper lid (Fig. 6–34). On rare occasions, the gold will create a reaction and form a pseudocapsule as a result of contamination with surgical glove powder, scratches created by the instrumentation, or an unclean weight. There was only one patient among the 482 who had evidence of a sensitivity to gold (Fig. 6–35).

Gold extrusion occurred in seven patients (1%). The cause of extrusion in most cases could be traced to poor patient compliance or an error in surgical technique (Fig. 6–36). In one patient, the gold extruded because the patient swam in the ocean 1 day following surgery. In another, the skin over the gold implant was irritated by the patient's constant rubbing. The gold extruded in four patients due to errors in surgical technique that included improper placement, failure to suture the gold in place, and unraveling of a poorly tied suture. The 8-0 monofilament suture used to secure the gold requires three throws, otherwise the suture may come apart. Extrusion in the last patient was due to marked atrophic senile tissue over the gold. In retrospect, this patient was not a good candidate to place a gold weight.

Advantages and Limitations of the Gold Weight Implant Of all the procedures to reanimate the upper lid (wire spring, magnets,[35] Silastic encircling,[32] temporalis muscle fascal sling, and tarsorrhaphy), the gold weight implant has been the most reliable, reproducible, and technically least complicated. The procedure can be performed under local anesthesia with a commercially available prosthesis, and unlike the other techniques, it has the lowest complication rate in terms of deforming the eyelid, and the lowest extrusion rate (1%) of all of the prostheses. The most important advantage of the gold weight is its preoperative predictability in terms of expected outcome and the ability to revise or even reverse the procedure without any sequeleae. Clearly this is the most popular approach to reanimate the upper lid for the reasons mentioned and is based on a large experience, perhaps the most ever accumulated by a single surgeon.

However, with all of its advantages, there are limitations. These shortcomings must be appreciated by the surgeon and shared with the patient. One cannot expect to recreate a normal blink since the involuntary reflex blink takes 0.13 to 0.2 seconds according to Smellie,[17] who cites work by Hall (1936). The normal rapid blink reflex does not give time for the weight to overcome the inertia of the upper eyelid. Therefore, reflex blinking is never restored, and the ability to wink with the involved eye is rarely restored. However, the voluntary blink that is essentially opening and closing the lid can be restored with the gold weight. The patient can enhance the action of the gold by remembering to look down when eye closure is desired and to "think blink."

The re-establishment of voluntary eyelid closure depends on the reciprocal activity of the levator superioris and the orbicularis oculi muscles, but in some patients, this is not present. Therefore, if patients have a strong active levator with lid retraction as the patient makes an effort to close the eye, one must suspect that this reciprocal activity is not present. On the other hand, if the involved upper lid descends to some extent with an effort to close the normal eye, the reciprocal activity is working, and the patient should be a good candidate for restoring the closing mechanism. The gold

Figure 6–32. Results of implanting gold weight in upper eyelid. **A**, Eyelids open. Note lateral tarsorrhaphy, placed by referring doctor. **B**, Attempted closure before gold implantation. Gold implanted but lateral tarsorrhaphy not disturbed until the effect of the gold could be evaluated. **C**,**D**,**E**,**F**, After gold implantation, the gold is visible but camouflaged with eye make-up. This patient reported that relief of eye symptoms following gold implantation was dramatic.

weight is less effective under these circumstances, and the spring implant may be ideal for such patients.

Patel and Anderson's Experience In practice, the gold weight mechanically lowers the upper eyelid to the primary position, provides better passive eyelid closure, and provides a limited degree of improved closure during a blink. The normally functioning levator palpebrae superioris muscle is still able to open the eyelid. May already pointed out the importance of lower eyelid tightening in combination with insertion of gold weights. This is an important observation; in patients with permanent facial palsy with loss of muscle tone, insertion of the gold weight alone is rarely sufficient. The majority of our patients

A B

Figure 6–33. Patient is not ideal candidate for gold implant because of **A**, deep supratarsal sulcus and no supratarsal fold. **B**, After gold implant, the eyelid closure is much improved, and patient is relieved of eye symptoms. In spite of the gold showing which was unavoidable in this situation, patient is pleased and covers the gold with eye makeup.

Table 6–14 Gold Implant: Common Causes of Failures

Problems	Causes	Solution
Lid closure inadequate	Lid retraction and/or weight too light	*LPS recession, and/or heavier weight, or combination procedures (see Table 6–10, Other)
Lid drooping	*LPS fatigue and/or weight too heavy	*LPS plication and shortening, or lighter weight
Lid deformities		
Lash eversion	Gold not sutured correctly	Revise
Gold shifted		
Lid bulge	Gold too large or pseudocapsule	Revise
Skin reaction	Gold sensitivity	Replace with tantalum
Gold shows through	Poor patient selection	Camouflage with eye shadow
Gold extrusion	Gold not sutured correctly Poor patient compliance	Remove and replace

*Levator palpebrae superioris

Table 6–15 Gold Implant: Keys to Improving Success Rate

1. Proper patient selection
2. Choice of gold weight
3. Surgical technique
   - Incision placement
   - Pocket creation
   - Gold fixation
   - Closure with two layers
4. Postoperative care

undergo a lower eyelid elevation and tightening procedure in addition to insertion of a gold weight with or without recession of the levator muscle.

The weight of gold required depends on the degree of proptosis, levator function, upper eyelid position (presence or absence of levator overreaction/fibrosis), and position of gold weight placement. Hertel measurements are an important prognosticator of improvement following gold weight insertion. Proptotic eyes will allow less effect by gravity on the gold weight, and more effort to close the eyelids may also be required. It is important to place the gold weight on the upper eyelid for at least 30 minutes to accurately assess the correct weight required. This identifies levator fatigue, which is not evident on brief testing. The ideal weight should allow the patient to open the upper eyelid (without producing ptosis) and also allow the upper eyelid to drop when the eyes are voluntarily closed.

Upper eyelid retraction seen immediately following the development of facial palsy sometimes worsens with time. This may be related to secondary contracture in the levator muscle. In view of this, we generally perform a levator recession in conjunction with the insertion of a gold weight. The combination of a graded recession of the levator muscle together with the insertion of a gold weight has allowed

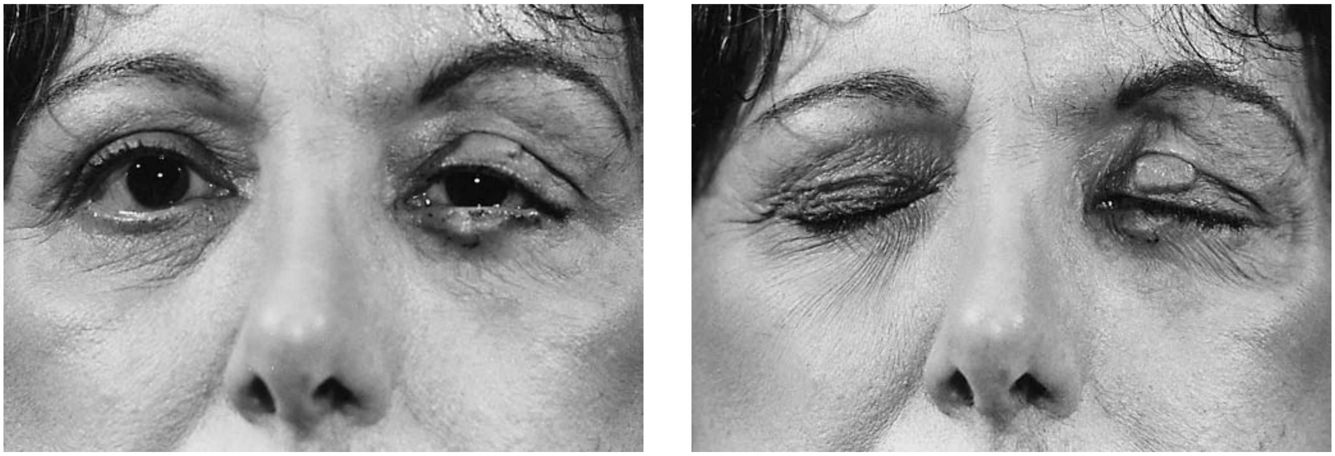

A B

Figure 6–34. Patient with unacceptable result. **A**, Six months post-gold weight to upper lid and cartilage to lower lid. Both implants are prominently visible through the thin skin and aesthetically unacceptable. **B**, This gold implant was placed in a superficial plane and fixed in an oblique position. Revision could improve this result by replacing the gold higher and deeper as described in Figure 6–31 (see Figs. 6–31N through P to explain this result).

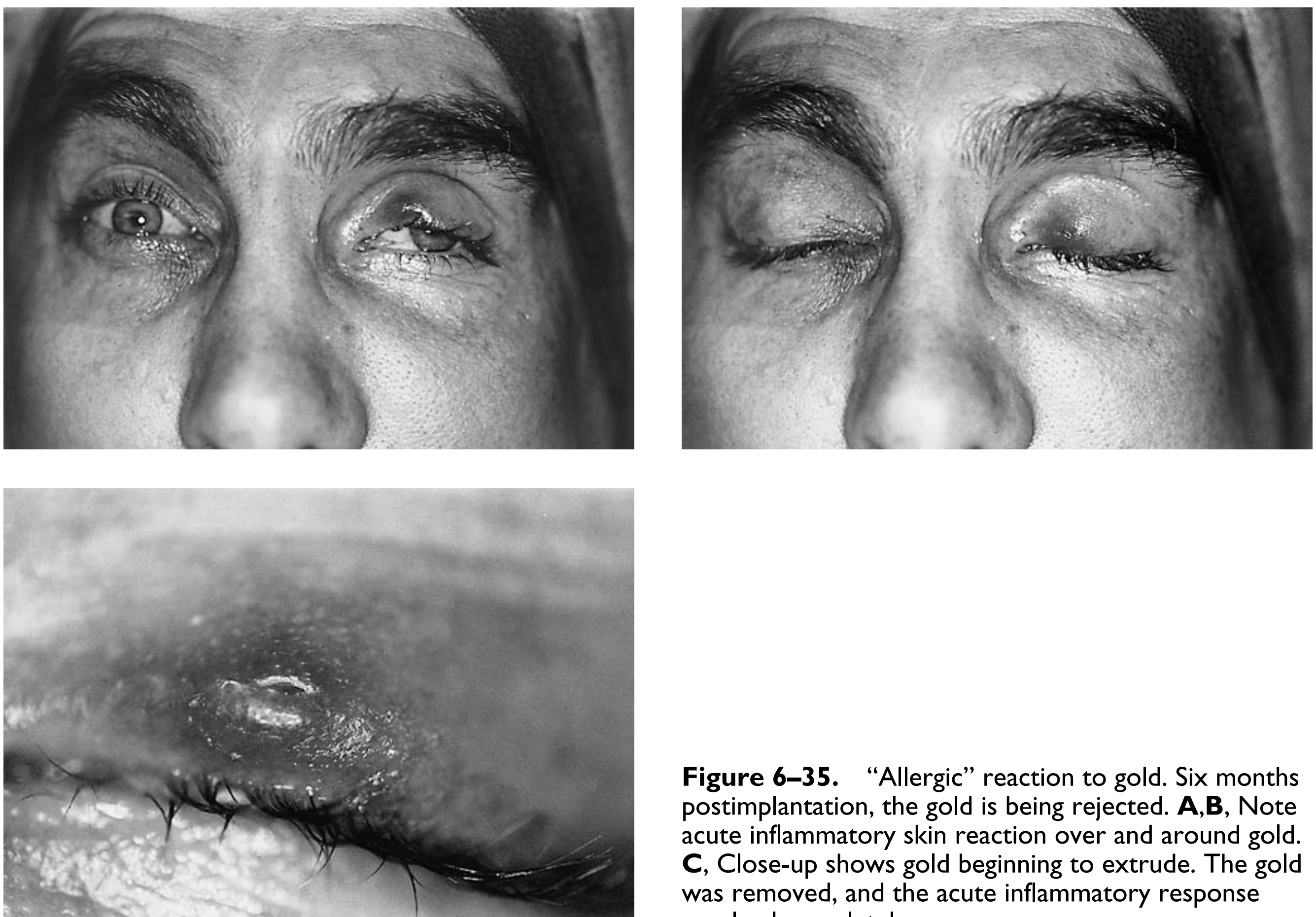
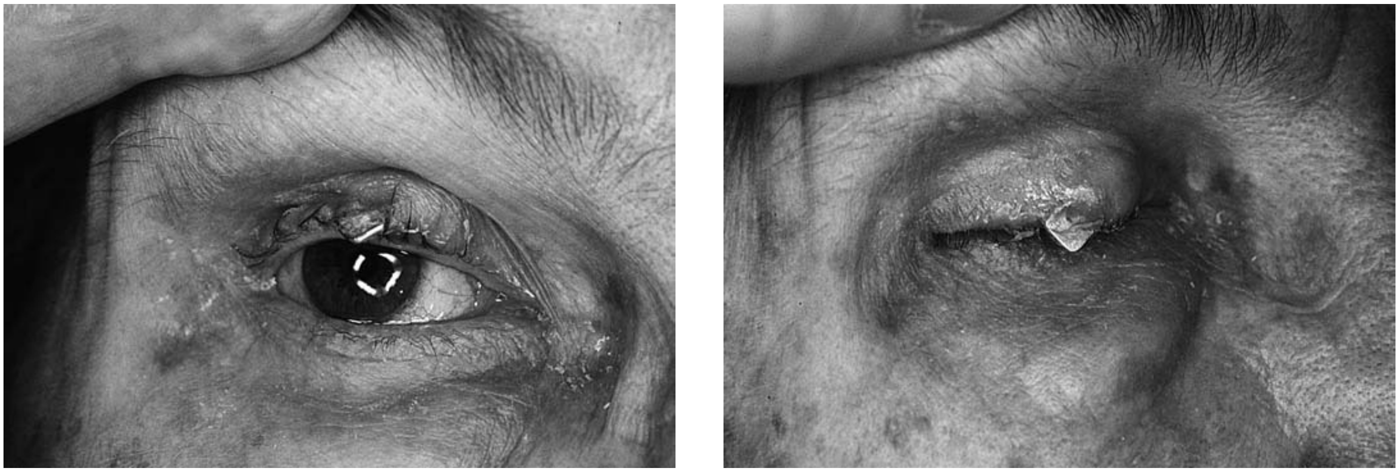

A B C

Figure 6–35. "Allergic" reaction to gold. Six months postimplantation, the gold is being rejected. **A**,**B**, Note acute inflammatory skin reaction over and around gold. **C**, Close-up shows gold beginning to extrude. The gold was removed, and the acute inflammatory response resolved completely.

us to use a 0.8 or 1.0 g weight in almost all our cases, with only a few 1.2 g weights being necessary.

The technique of Patel and Anderson is similar to that described in this chapter. Some helpful additions will be mentioned. The incision is made over the junction of the medial one third and middle one third of the upper eyelid where the levator function is at its maximum. When the skin crease is low, we make an incision approximately 8 to 10 mm above the eyelid margin. We feel it is important to avoid placing the incision over any part of the gold weight as this may result in thinning of the overlaying tissues or even extrusion.

Two 7-0 Prolene sutures are passed through the tarsus, taking care to avoid full thickness sutures. The tarsus should



A B

Figure 6–36. Another patient with gold extrusion. Two months following gold implant. **A**,**B**, Gold extruding through lid margin. This implant was placed too close to the lid margin. The recommendation of 3 mm from lid margin was not followed and extrusion resulted (see Fig. 6–31).

be everted to ensure that the suture is not to be visible through the tarsal conjunctiva. If a blue track is visible, it is better to replace the suture, as eventual erosion of the suture through the tarsus may occur. (May does not pass sutures through the tarsus but rather the fascial attachments to the tarsus.) After the gold is sutured in place, the patient sits up, and the closure of the eyelids assessed. In cases where there is considerable overaction of the levator muscle, we perform a segmental levator aponeurosis recession over the junction of the medial one third and central one third of the eyelid. (May routinely performs a levator aponeurosis recession.) The levator is disinserted from the tarsal attachments and separated from its attachment to Müller's muscle. This levator recession may not be graded until an adequate upper eyelid position and closure are obtained.

It is important to assess the relative prominence of the globe before a decision is made to insert the gold weight higher than the tarsal plate. When the gold weight is positioned above the tarsus in the presence of a prominent globe, the eyelid may remain open at night when the patient is recumbent. The patient may need to lie semirecumbent to allow adequate closure of the eyelids. Even in the absence of a prominent globe, better closure and protection can be obtained by pretarsal fixation of the gold weight as opposed to insertion above the tarsal plate. The lower position of the gold weight gives the weight a better mechanical advantage. Also, in general, the higher the gold weight is placed, the heavier it will need to be.

The thickness of the pretarsal tissues also needs to be considered in choosing the position of the weight. In older patients, in patients who have undergone prior eyelid surgery, or following trauma, there may be attenuation of the skin and orbicularis muscles, necessitating higher placement of the gold weight. Alternatively, the weight may be inserted and covered by advancing the levator aponeurosis over the weight.

Gold weight is not without complications, as already noted by May. We have observed some others. Increased and variable with-the-rule astigmatic refractive error may develop related to the gravitational effect of the gold weight on the corneal surface curvature. This is more common with heavier weights. It is rarely a problem with the smaller weights. A small hyperopic shift may also occur.

We had one patient, a long-distance truck driver, who found the gold to be unbearably cold when driving through sub-zero temperatures, and the weight needed to be removed. Fortunately, he had enough facial nerve recovery to allow adequate eyelid closure. In such patients, insertion under the levator aponeurosis may be beneficial.

Eyelash ptosis may also occur in the presence of a gold weight that has been placed low on the tarsal plate. Some patients may even develop frank entropion. Correction of the lash ptosis involves an upper eyelid skin crease incision, followed by closure with incorporation of the levator muscle in the closure so that the inferior flap is pulled upward when the lids are opened. The gold weight may also need to be repositioned.

Summary If one adheres to the recommendations presented, reproducible and rewarding results can be achieved. We strongly recommend that Jobe's original article[18] be carefully studied along with the material presented in this chapter. In spite of our enthusiasm for this procedure, there is rarely one solution for all patients. Therefore, it is necessary to be aware of the complete menu of procedures available in order to offer the patient what is best for their particular situation.

Wire Spring Implants The palpebral spring was first described by Morel-Fatio and Lalardrie[36] in 1965. Levine reported his initial experience in 1972.[1] Since 1968, Levine has implanted over 800 springs with favorable results.[37]

The open eyelid spring is most effective in patients with complete and/or permanent facial paralysis associated with significant lid retraction and/or a poor Bell's phenomenon. When properly designed and positioned, the spring affords the best degree of restoration of not only a voluntary blink, but is capable of mimicking to some extent the more rapid spontaneous blink. This is in contrast to what can be achieved with the gold weight. Whereas the gold depends on the force of gravity to close the lid, the spring, fashioned like an open safety pin, holds the upper lid in a closed position and is opened by the active contraction of the levator palpebral superioris. The potential problems with the spring include the need for technical mastery of the procedure; overclosure of the upper lid if the spring is opened too far; a bulge created by the Dacron cuff over the distal wire, particularly in thin-skinned individuals; increased difficulty associated with spring removal, if necessary, compared with removal of the gold weight; and the frequent need for adjustments. Despite these potential drawbacks, success has been achieved in 82% of carefully selected patients. Note that the success rate is not as great as with the gold implant procedure.

Palpebral Spring: May's Experience Between 1977 and 1996, 284 wire springs were implanted. Twenty-four percent required adjustments, and one third ultimately required removal. Twenty percent of those were removed because facial function recovered to some extent, and the spring was no longer needed. The remainder were removed because of inadequate closure, overclosure, or extrusion.

Our experience with the wire spring implants reported in 1987[34] has not changed significantly since that time. The technique that we use is illustrated in Figure 6–37 with results demonstrated in Figures 6–38 through 6–40. Implantation of the spring gives immediate results and often is combined with other procedures to address related problems involving the brow and lower lid (Fig. 6–41). The spring is useful for the patient who is not an ideal candidate for gold, as described previously (Fig. 6–30). The complications and failures with the spring are greater than with gold. Like gold, the spring can be revised or removed, thus the procedure is reversible (Figs. 6–42 through 6–44).

Palpebral Spring: Levine's Technique

Spring Fabrication The spring has the same general configuation as an open safety pin. It should be prepared prior to surgery, with adjustments made at the time of surgery. The spring is fashioned by making a loop in a piece of stainless steel orthodontic wire measuring 0.010 in in diameter. Because the forces involved are so small, fatigability of the wire is not a significant factor. It is helpful to use a round-nosed pliers to bend the wire and a second pair of pliers to fix the wire. It is important that the loop at the fulcrum of the spring measures about 5 mm in diameter and is as flat as possible. The fulcrum should be placed as far laterally as possible on the orbital rim. The posterior extension of the loop is the upper arm of the spring, which rests on the periosteum of the orbital rim. The anterior extension of the loop is the lower arm, which will be positioned in the lid overlying the tarsal plate.

Two curves are placed in each arm of the spring to make it conform properly to the contour of the lid. One curve is made in the frontal plane, to allow the upper arm of the spring to conform to the curvature of the orbital rim and to allow the lower arm to conform to the contour of the upper lid. A second curve is made anteroposteriorly to allow the spring to accommodate the orbital rim above the meridianal curvature of the globe below. The spring is customized by fitting it exactly to conform to the patient's anatomy, prior to surgery.

Operative Procedure (Fig. 6–45) The goal of surgery is to place the spring such that the upper arm and fulcrum are fixed to orbital rim periosteum, and the lower arm works against the levator palpebral superioris to push the lid shut. Then tension is set on the spring so that the levator can work against it to pull the lid open.

The patient is positioned on the operating table, and a scleral shell is put in place to protect the eye. An anesthetic mixture is prepared consisting of 2% lidocaine with epinephrine (45% of mixture), 0.75% dupivacaine (45% of mixture), and 8.4% sodium bicarbonate (10% of mixture). The addition of the bicarbonate causes less discomfort from the solution. Next, 1.0 cc of the mixture is injected along the tarsal-supratarsal fold of the upper eyelid. An additional 1.0 cc is injected over the lateral orbital rim. Excessive infiltration deforms the lid, and resulting akinesia interferes with the evaluation of lid function. Separation of the arms of the spring should measure 1.5 times the interpalpebral fissure when the lids are open. In cases of severe lagophthalmos, this factor should be increased to 2.0. Because it is easier to lessen the tension of the spring than to increase it, initially it is better to have the arms too far apart than too close together.

A lid fold incision is made, starting at a point above the medial limbus and extending across the lateral orbital rim. Dissection is carried downward at the medial aspect of the incision to expose tarsus. Laterally, the periosteum of the orbital rim is exposed. Hemostasis is achieved with bipolar cautery.

A blunted 22-gauge spinal needle with its stylet in place is passed from the medial incision, beginning at midtarsus, along the plane between the anterior surface of the tarsus and the orbicularis oculi in a slightly inferior direction. The needle is directed to pass about 2 mm superior to the lashes at the lateral extent of the upper lid and to emerge at the lateral incision. The undersurface of the lid should be checked to ensure that the tarsus has not been inadvertently perforated. The end of the previously prepared spring is passed into the needle after the obturator is removed. Then the needle is withdrawn, and the spring is brought into position. A 4-0 Mersilene suture is placed through the fulcrum of the spring to secure it to orbital rim periosteum, taking an extra bite of periosteum in the stitch.

The scleral shell is then removed and the spring contours checked with the eye open and closed. The spring should be positioned so that the lower arm moves somewhat posteriorly on opening the lid to accommodate the normal lid movement in that direction. The scleral shell is replaced, and two addtional 4-0 Mersilen sutures are placed to secure the fulcrum, taking an extra bite of periosteum with each stitch.

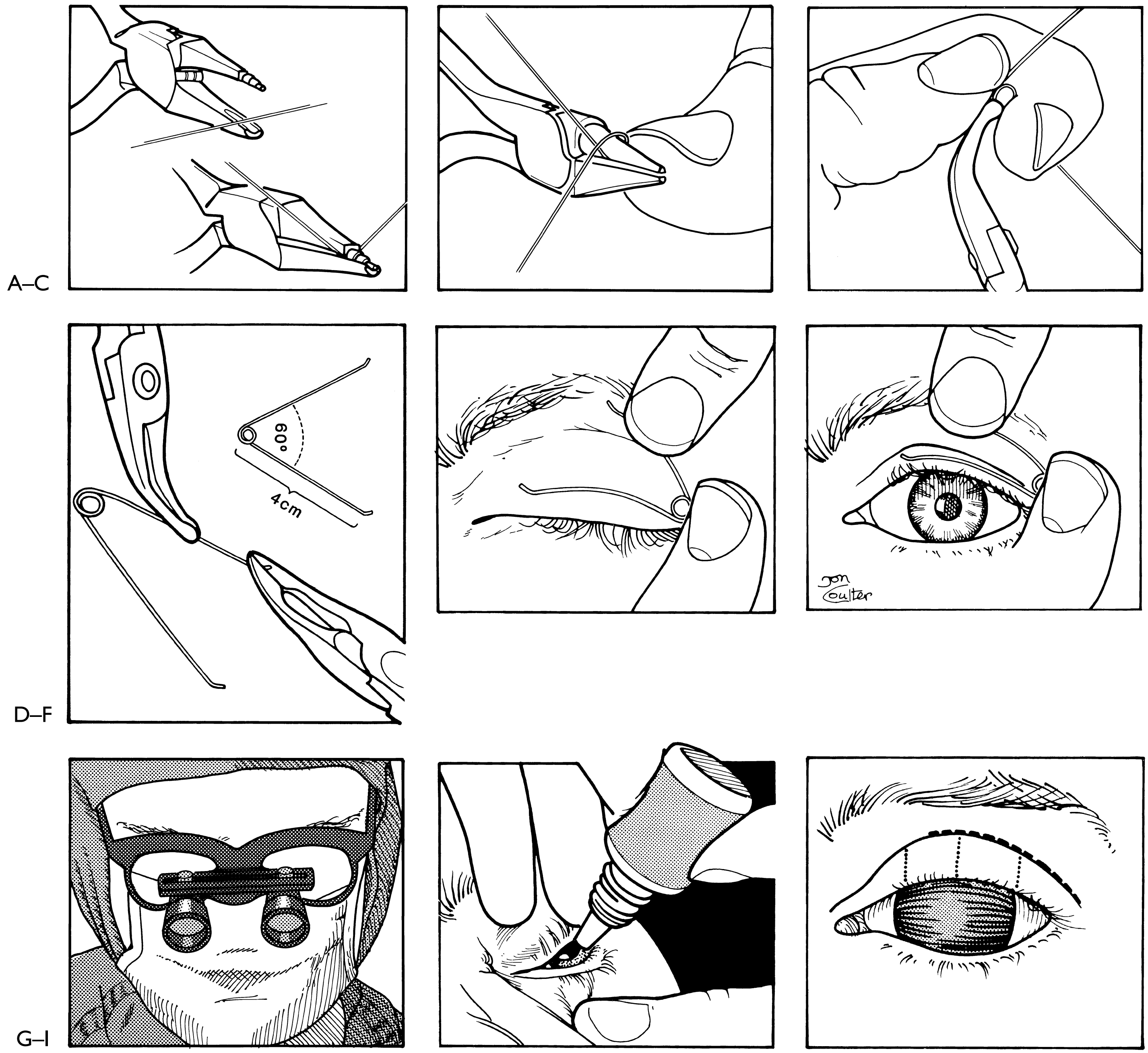


Figure 6–37. Palpebral spring–May technique (see Table 6–6 for instrumentation). **A**,**B**,**C**,**D**, The spring is fabricated from 0.01-in orthodontic round wire. Special dental instruments are required to fashion the spring (see Table 6–6). **E**,**F**, The spring is prepared and adjusted to conform to the patient's orbital rim and upper lid prior to surgery so that the spring can be tested for proper alignment to achieve desired blink. **E**, Eyelid closed by spring action. **F**, Levator palpebral superioris muscle innervated by third cranial nerve lifts upper eyelid against tension of spring. **G**, The procedure is performed under local anesthesia; using loops for magnification has been helpful. **H**, Topical conjunctival and corneal anesthesia is achieved with Proparacaine, 0.5%. **I**, The contact lens is in place to protect the cornea. Upper lid lash margin is divided as indicated by small dotted lines into four equal parts for later determination of the length of the lower limb of the spring. The incision in the supratarsal fold is marked as indicated with a heavy dotted line. *(Figure continued next page.)*

J–L

M, N

P

O

Q

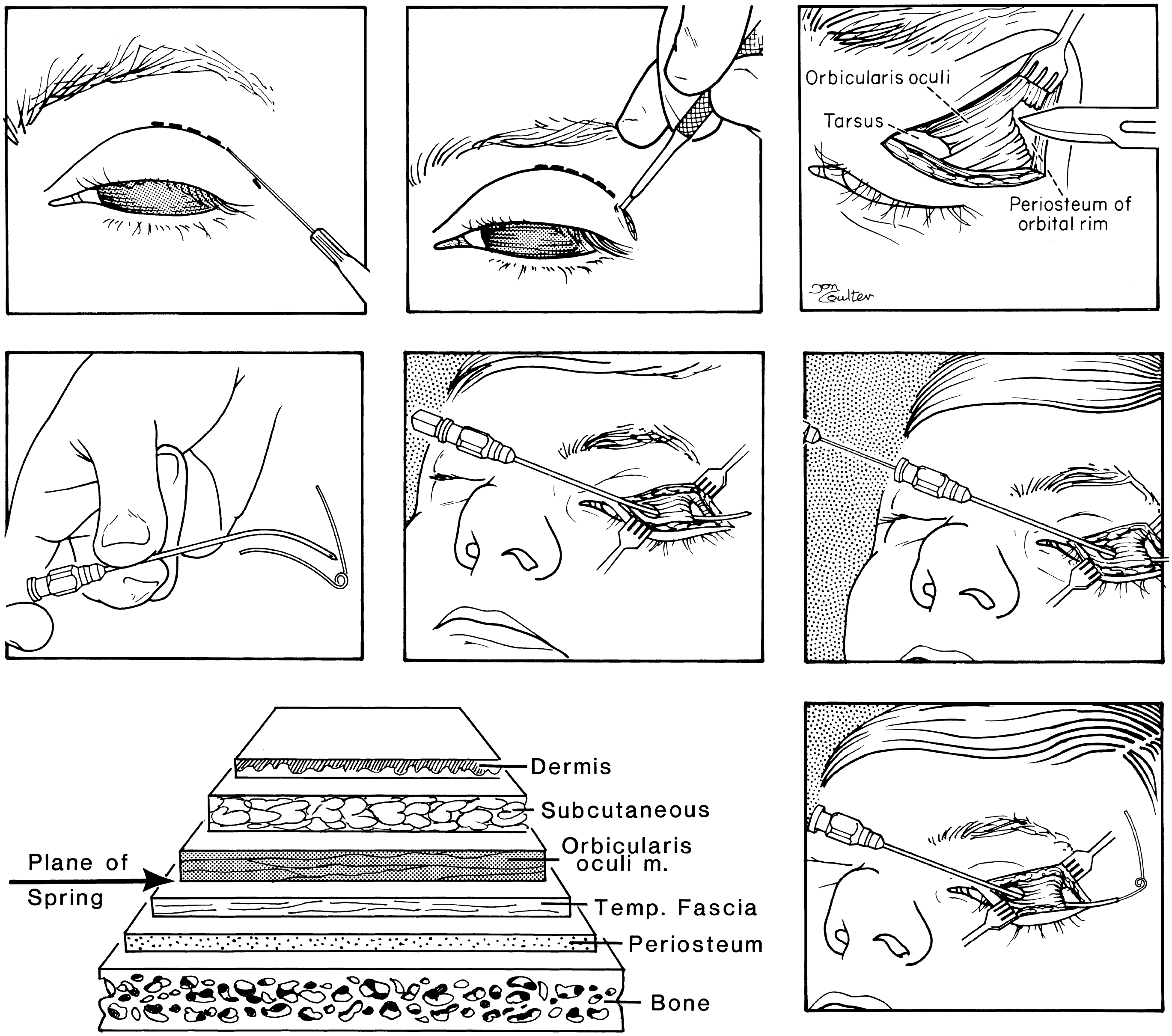
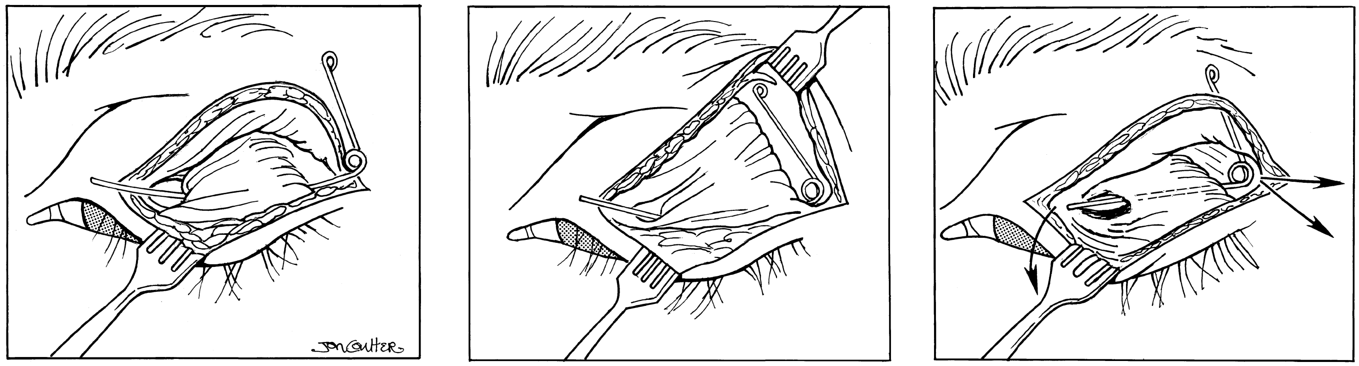
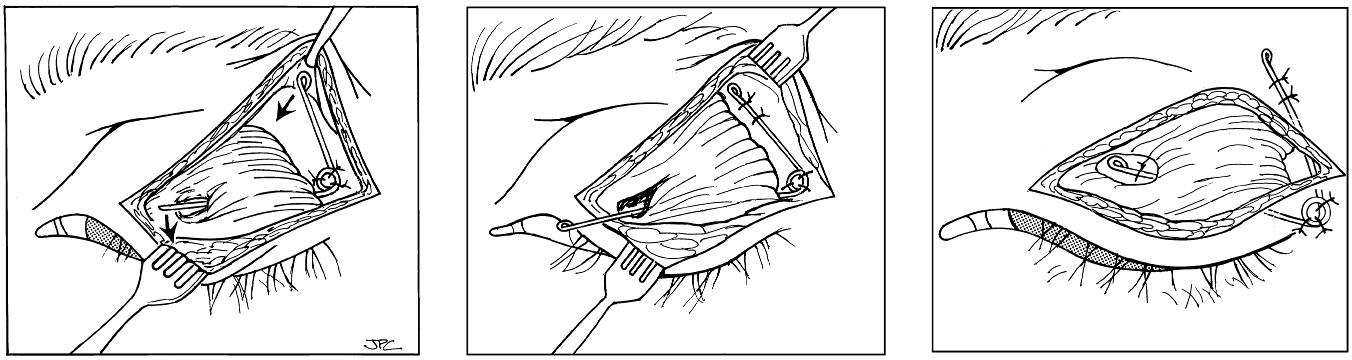


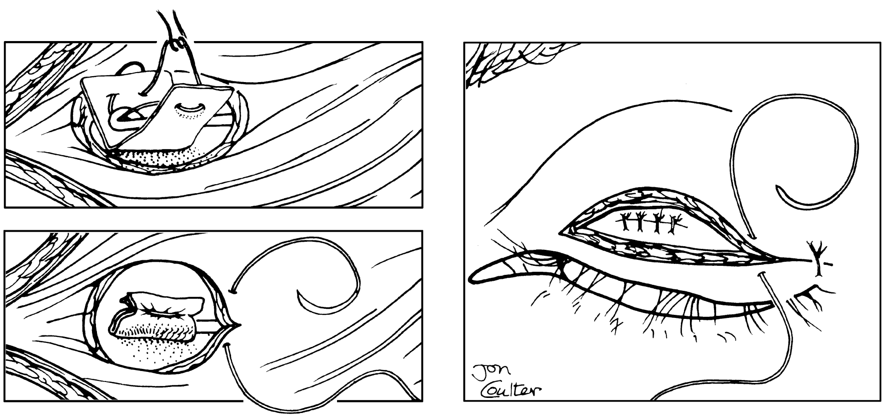
Figure 6–37. *(continued)* **J**, The incision area is infiltrated with 1% lidocaine and 1:100,000 adrenaline in order to achieve local anesthesia and hemostasis. **K**, An incision is made with the Sparta blade through the skin and subcutaneous tissue. **L**, The incision is extended through the periosteum of the lateral orbital rim with a No. 15 scalpel. The incision is extended through the levator palpebral superioris to the tarsal plate using a Westcott scissors. **M**, A No. 19 spinal needle is bent to match the curve made in the lower limb of the spring. **N**, The spinal needle is passed through soft tissue, over the tarsal plate, into the depths of the lateral incision made in the supratarsal fold at the level of the periosteum of the lateral orbital rim. **O**, The 19-gauge spinal needle passes between the orbicularis muscle and periosteum of the orbital rim as depicted in the cross-section demonstrating tissue layers in this region. **P**, The obturator is removed from the spinal needle. **Q**, The lower limb of the spring is passed through the lumen of the spinal needle.



R–T



U–W



X, Y

Figure 6–37. *(continued)* **R**, The spinal needle is removed, leaving the lower limb of the spring in place. **S**, The upper limb is placed in a pocket under the soft tissues and over the periosteum of the orbital rim. **T**,**U**, By moving the fulcrum laterally and down, the leverage-tension on the horizontal limb of the spring can be adjusted. (The more lateral and down the fulcrum is fixed, the greater the tension.) This helps determine where to fix the loop of the fulcrum. **T**, Once the location of the fulcrum is determined, it is fixed with 5-0 clear supramid. **U**, The ideal position to fix the upper limb to the orbital rim periosteum is determined by the amount of tension desired (the more forward, the greater tension). **V**, The wound is retracted superiorly, and the upper limb of the spring is placed flat against the periosteum and fixed with the same suture material. Now that the fulcrum and upper limb have been secured, the contact lens is removed before the lower limb is secured so that there is no distortion of the upper eyelid and the spring tension can be checked and adjusted. **W**, The lower limb is secured with 8-0 Ethilon suture to the tarsus in the desired horizontal position. This suture prevents the spring from migrating inferiorly or superiorly, and yet allows the spring to move in a horizontal plane as the lid opens and closes. **X**, The lower limb is secured over the tarsus by enveloping it in a fold of Dacron patch fabric. The fabric is fixed to the wire loop with 8-0 Ethilon. The Dacron patch becomes incorporated into the soft tissue within 3 weeks and fixes the spring to the lid tarsus. **Y**, The lower limb is further secured by overseeing the levator superioris and orbicularis oculi muscles in the margins of the lid incision. In the event that these muscle fibers are not present, a subcutaneous layer is oversewed, placing the lower limb in a tunnel. This maneuver holds the spring in place and discourages upward migration.

A, B

C, D

Figure 6–38. Excellent result with eye spring. Patient is 4 years post-skull base schwannoma resection with multiple postoperative cranial nerve deficits (VII,IX,X,XI, and XII). Facial nerve was anatomically spared, and recovered with tone and slight movement (House-Brackmann V/VI). **A**, Repose. Note on involved left side, the interpalpebral fissure is wider than on the right. It is interesting to note a deep supratarsal sulcus on the involved side. Usually there is drooping of the supratarsal fold following denervation of the periorbicularis oculi muscles. In addition, note the heavy eyelid "liner" (make-up) used by the patient to effectively camouflage the eye asymmetry (see Chapter 9 for more on camouflage with cosmetics). **B**, Effort to close eyes. A spring was used because a gold weight did not overcome the lid retraction. **C**, In the operating room, immediately following spring implantation. Eyes open. **D**, Eyes closed.

Loops are then fashioned at the upper and lower ends of the wire with special orthodontic pliers designed for that purpose. The superior loop should be made at the upper end of the lateral incision and the inferior loop at the center of the upper lid superior to the lower arm of the spring. (If the loop is formed inferiorly, the lower arm loses its smooth contour on its palpebral aspect.) The wire is then cut, and each loop is closed carefully so that there is no sharp end that may perforate adjacent tissues.

It is imperative that the spring be placed precisely so that pressure exerted on adjacent tissues is minimal. Any point pressure on the tissues could potentially lead to migration or extrusion of the spring. Therefore, the lower loop should be flat against the tarsus and parallel to it; similarly, the upper loop should be flat against periosteum. The lower loop position should be checked after the scleral shell is removed with the eyes open and closed.

Opening the eyelids causes the upper lid to move posteriorly as well as superiorly. The lower loop of the spring must therefore be oriented slightly posteriorly so as to remain nearly parallel to the tarsus when the lid is opened as well as when it is closed.

The lower loop of the spring is not sutured. Rather, it is secured in position by encasing it in a folded piece of 0.2-mm-thick Dacron patch material. The crease in the Dacron is best obtained by folding the material in a gelfoam press that is subsequently put through a normal steam autoclave cycle. A piece of the folded Dacron approxi-

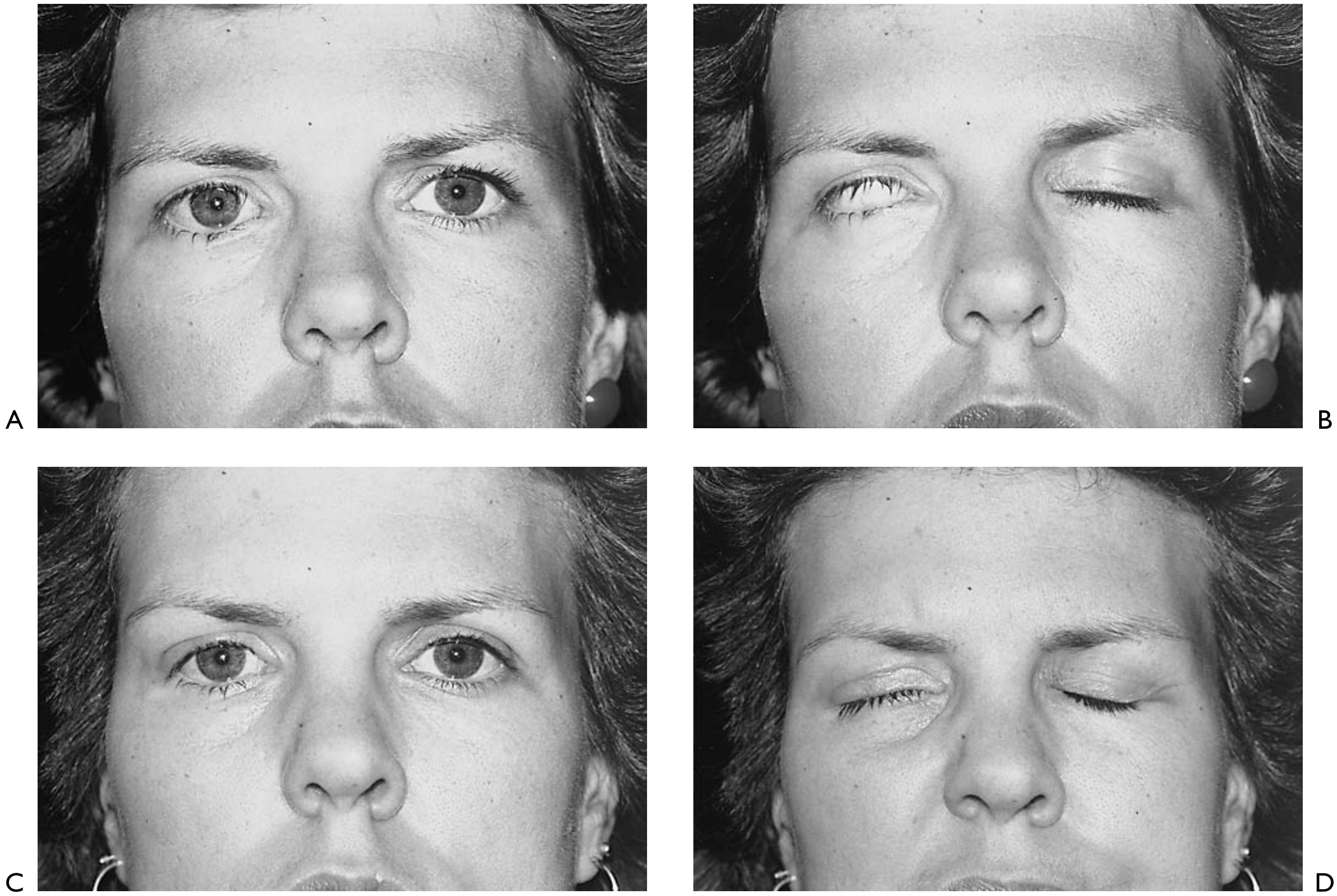


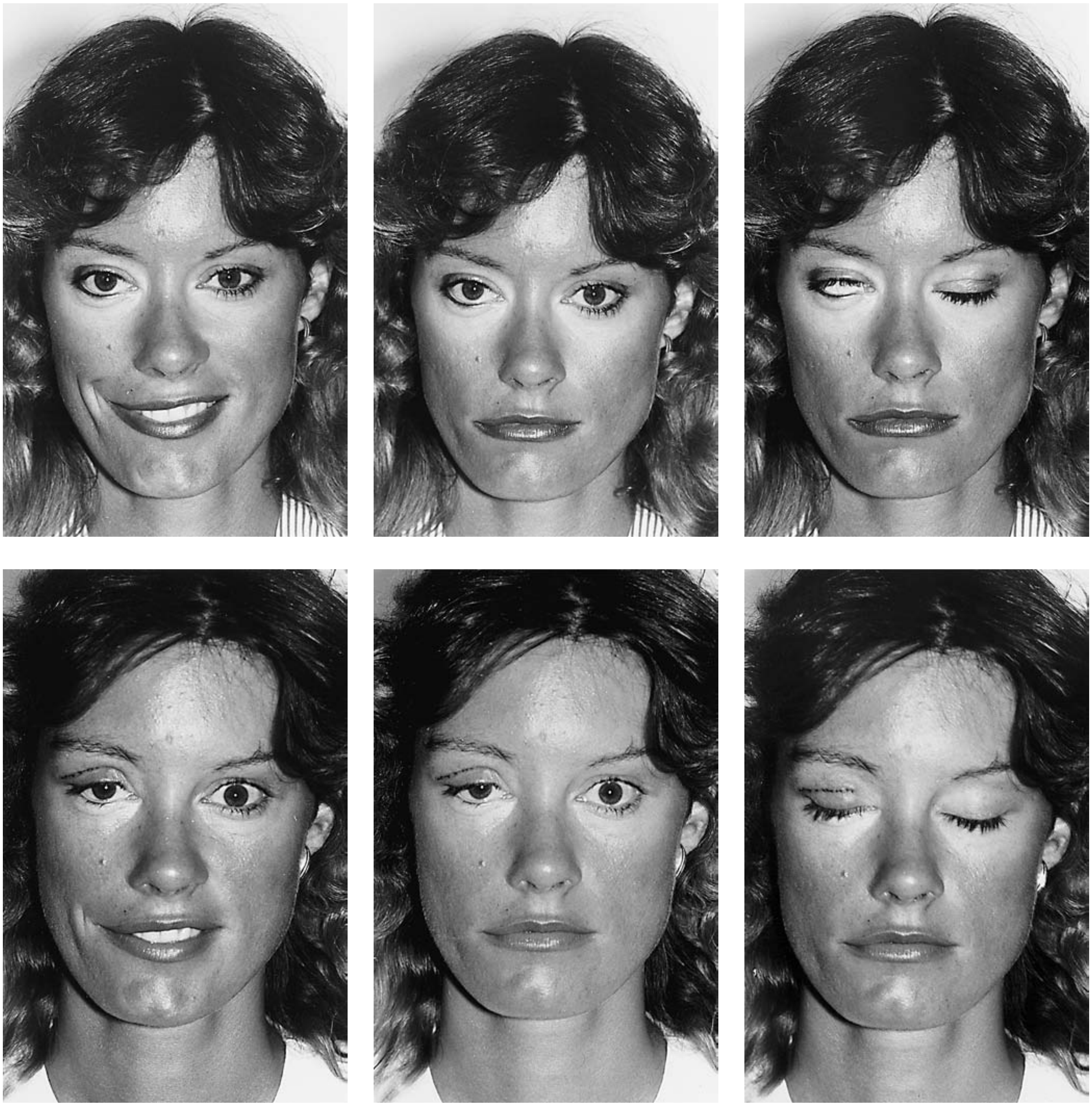
Figure 6–39. Excellent results with eye spring. Patient recovered tone but no movement around the eye region on the right following resection of facial nerve schwannoma and graft repair 8 years ago. She complains of symptoms related to exposure keratitis in spite of aggressive medical treatment. **A**, In repose. **B**, Effort to close eyes. Bell's phenomenon present. Look at the eyelashes on the involved right side. Note the loss of the normal upward curvature, and the disorder and matting appearance of the lashes on the right compared to the normal left side. This is a sign of severe denervation (see Fig. 6–7). **C**, One year after spring implantation. Eyes open. **D**, Eyes closed.

mately 5 mm wide and 10 mm long is cut and placed around the wire. The crease is directed toward the lid margin. A suture of 8-0 nylon is passed through both surfaces of the Dacron as well as through the wire loop to prevent the wire from slipping out of the Dacron envelope. The Dacron is held in position in the upper lid by closing overlying tissues meticulously with vertical mattress sutures and interrupted skin sutures of 6-0 Polydek.

Final tension then can be placed on the spring either by varying the position of the upper arm or by bending the wire with two instruments. The upper arm is secured to periosteum with three 4-0 Mersilene sutures, taking an extra bite of periosteum with each stitch. A final inspection of the spring is made and the tension adjusted if necessary. Slight overcorrection is desirable. The deep aspect of the lateral wound is closed with 5-0 plain sutures. The skin is closed with interrupted or running 6-0 plain gut. The eye is dressed with antimicrobial ointment, and an ice pack is applied. Moderate lid swelling resolves over the following week.

Spring adjustments can be made easily in the office if necessary, for example, to compensate for partial return of facial function. After injection of a small amount of local anesthetic, an incision is made just above the lower arm of the spring adjacent to the fulcrum, and 0.5 cm of wire is exposed. Tension on the wire is adjusted with two pairs of pliers, and the wound is closed with one or two sutures.

Refinements in Technique In the earliest spring implants, the loop in the lower arm of the spring was sutured to the orbicularis with 4-0 Mersilene sutures. This elicited too much foreign body reaction, so 7-0 silk sutures were used. Care had to be taken to get an adequate bite of tarsus without at the same time putting the suture so deep that it punctured the inner conjuntiva. Morel-Fatio and Lalardrie[36] suggested using Dacron felt to envelop the lower loop, and allowing it to fibrose to tarsus without sutures. This technique worked quite well, exept that fine strands of felt tended to perforate the overlying tissues. For this reason, Dacron velour, which



A–C

D–F

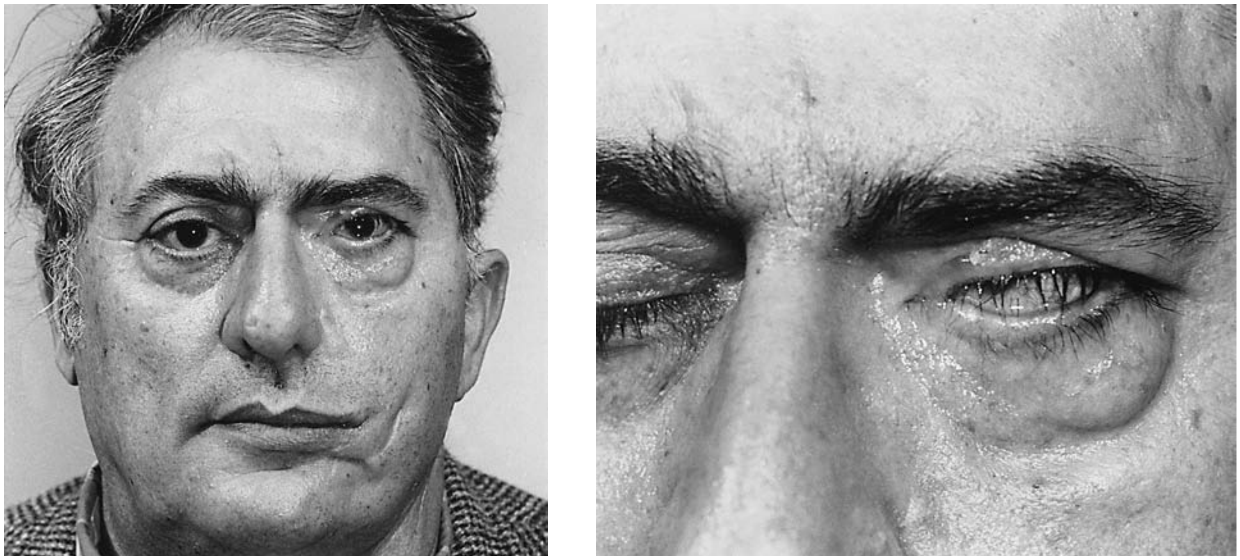
Figure 6–40. Result of combining spring for eye and temporalis muscle for mouth to reanimate patient following facial nerve sacrifice in acoustic tumor surgery. **A**, Post-temporalis muscle transposition and before eyelid spring implantation. Note use of eyelid "liner" on involved right eyelids to make the interpalpebral distance look symmetrical with the normal left side (see Chapter 9 for more on camouflage with cosmetics). **B**, Eyes open. **C**, Eyes closed. **D**, Immediately post-spring implantation. Note overcorrection. This is desirable because there will be some natural correction over 6 weeks due to loss of tissue edema and accommodation by the levator palpebral superioris muscle. This overcorrection can be adjusted if it persists beyond 6 weeks (see Fig. 6–42). Also note the lid retraction on the left, indicating the patient's effort to overcome the spring action of the right. This is an example of Hering's law to preserve vision in the dominant eye. (See on Gold Weight for Patients with Other Procedures.) **E**, Eyes open. **F**, Eyes closed.

Figure 6–41. Example of combined procedures: lysis of tarsorrhaphy bands, lower eyelid wedge resection to repair defect created by tarsorrhaphy and to tighten lower eyelid, brow lift, and eyelid spring implant. This patient is 1 year post-acoustic surgery. The nerve was severed in posterior fossa and repaired. There has been no evidence of recovery. Note the problems with a medial and lateral tarsorrhaphy. The medial tarsorrhaphy formed a wide band and obstructs vision in forward gaze. **A**, Eyes open. Note brow droop and sagging supratarsal fold. **B**, Eyes closed. **C**,**D**, Close-up of eyelids on right side. Note how the tarsorrhaphy disrupts the lid margin and lashes. **C**, Eye open. **D**, Eye closed. **E**, Following brow lift, eyelid spring, and lower lid repair. Eyes open. **F**, Eyes closed. **G**, Close-up. Right eye open. **H**, Closed.

A B C D

E

Figure 6–42. Eyelid spring adjustment. **A**, Inability to close the eye and lack of Bell's phenomenon on the paralyzed side. **B**, Eyelid spring implanted but in poor position. **C**, Topical anesthetic was instilled and the spring adjusted with a small hemostat. **D**, Eyelid spring in proper position. **E**, Eye closure with the aid of the eye spring.



A B

Figure 6–43. Eyelid spring extrusion. **A**, Patient post-acoustic surgery, temporalis muscle transposition and eyelid spring implantation. **B**, The Dacron patch envelope has extruded. Note the wire has extended out of the envelope and this is most common cause for extrusion. This usually follows departure from surgical technique (see Fig. 6–37X). Sometimes the spring can be reimplanted in cases where it is functioning to close the eyelid.

Figure 6–44. Eyelid spring extrusion and removal. Here the wire remains enclosed in the Dacron envelope and still there is an extrusion. Note the tissue reaction. The extent of the extrusion is exaggerated by pulling the eyelid skin laterally. To remove the spring, the exposed wire is clipped at the junction of the wire and Dacron. Then an incision is made in the lateral rim over the fulcrum. The fulcrum is exposed, the sutures holding it in place are divided, and by grasping the fulcrum with a hemostat, the entire spring is removed.

is smooth on the outside, was tried and found to be more suitable except for a bump resulting from the thickness of the velour. A Dacron patch material, which is only 0.2 mm thick and, like velour, has no fibers on the outside surface, was then tried. This material did not elicit enough granulomatous reaction to fix the wire loop firmly to surrounding tissues forming between the inside surfaces of the envelope so the spring tended to slip out of its envelope. Placing a single 8-0 nylon suture through the envelope and spring loop alleviated this problem.

Because there is tension on the spring with the lid open, the palpebral aperture on the involved side is liable to be narrower than that on the uninvolved side. If the spring tension is decreased to allow for wider opening in the primary position, residual lagophthalmos may result on attempted lid closure. Four technique modifications are helpful in ameliorating this problem. First, whereas formerly the fulcrum of the spring was anchored right at the orbital rim, it is now anchored as far lateral as possible before falling into the temporal fossa. This positioning has improved the amount of opening possible while still retaining full closing tension. Second, the spring tension in the open position has been reduced by the use of thinner wire, 0.010-in wire is used routinely instead of the 0.011-in wire used previously. Third, complete closure is no longer the goal in all cases. Patients with poor or absent Bell's phenomenon or associated corneal anesthesia require full lid closure. However, many patients with good Bell's phenomenon and normally innervated corneas can tolerate several millimeters of residual lagophthalmos without any difficulty. The spring tension is therefore set as a compromise between adequate closure and adequate opening. Fourth, this solution has turned out to be the most useful, and it involves enhancing the spring implant. It is called "enhanced" because the spring implant is combined with a procedure to tighten the levator at the same time.

Enhanced Palpebral Spring: Levine's Technique The enhancement of the palpebral spring operation consists of tightening of the levator during the same procedure (Fig. 6–46).[38] The spring is prepared as described above, except that 0.10-in or heavier wire is used.

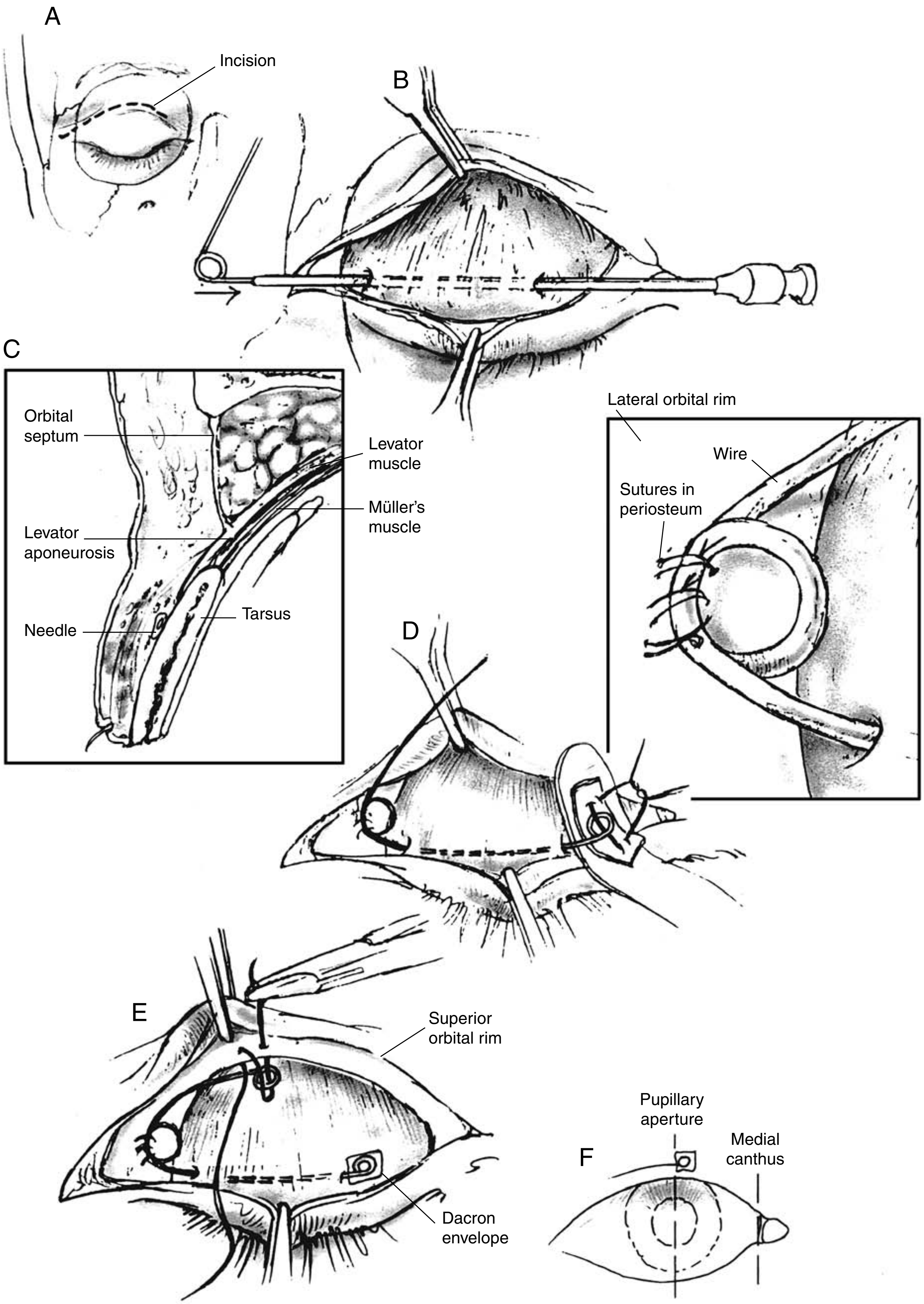


Figure 6–45. Palpebral Spring–Levine technique. The implantation of the eyelid spring is described in detail in the text under Operative Procedure. Levine's technique differs from May's in a number of ways. **A**, The exposure is through a blepharoplasty incision that extends from the tarsal-supratarsal fold to the natural lateral crease. The wire lies on the surface of the tarsus. **B**, The spring is guided through a 25-gauge spinal needle. **C**, The fulcrum is fixed to the lateral orbital rim. **D**, A spatula is used as a working platform to suture the Dacron to the wire. **E**, The upper limb is fixed through holes made in the orbital rim. **F**, The end of the lower limb of the spring extends just past the middle of the pupil aperture. (From Levine RE.[38] With permission.)

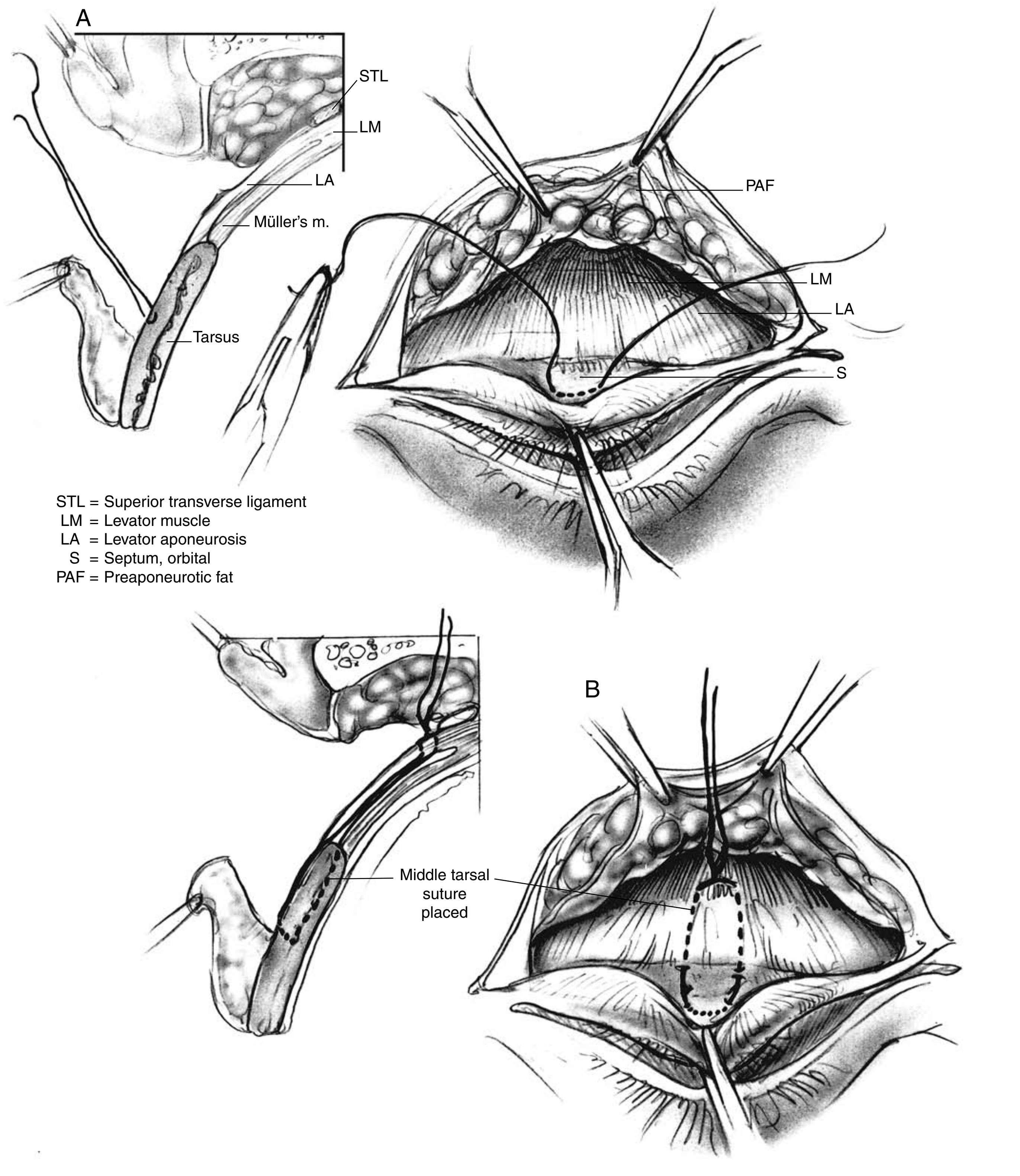


Figure 6–46. Enhanced palpebral spring implantation. Levine's modification of Figure 6–45. The surgical details are described in detail in the text under the same subject. **A**, The levator aponeurosis and the inferior aspect of the muscular portion of the levator are exposed. Centrally, the superior portion of the tarsus is also exposed. A double-armed 5-0 Mersilene suture is then placed through the midtarsus. **B**, Each arm of the suture is brought superiorly through the levator to emerge just above the point at which the aponeurosis meets the levator muscle. Temporary knots are tied. If necessary, an additional lateral suture and possibly an additional medial suture are placed in a similar manner. Inset: The course of the suture is illustrated in cross-section. The surgeon should check to be sure that the suture has not perforated either the tarsus or the conjunctiva. (From Levine RE.[38] With permission.)

Surgical Technique A scleral shell is placed. The initial skin fold incision is the same as that described earlier. Dissection is carried upward until preaponeurotic fat can be visualized through the orbital septum. The septum is then opened, and dissection is carried down to expose the levator. Dissection is then carried inferiorly to expose the tarsus centrally. A 5.0 Mersilene suture is then placed through the midtarsus.

The undersurface of the lid is inspected to ensure that the suture has not perforated the tarsus. Both arms of the suture are then brought superiorly through the levator to emerge just above the point at which aponeurosis ends and levator muscle is visualized. A temporary knot is placed, and the patient is asked to open the eye.

The scleral shell is removed and the extent of levator tightening evaluated. If necessary, an additional lateral suture and possibly an additional medial suture are placed in a similar manner to achieve desired lid strengthening and maintenance of proper upper lid curvature. If the surgeon is not sure whether additional sutures are necessary, their placement can be deferred until after the spring has been placed, and the overall effect of the spring and the initial suture can be evaluated.

Regardless of how many sutures are used, they are adjusted after the spring is in place, at the same time that the spring itself would otherwise be adjusted. The levator is tightened to a point at which maximum strengthening is achieved without inducing cicatricial lagaphthalmos from an overly shortened levator.

The stronger the levator can be made, the greater the tension possible on the spring and, therefore, the more rapid the blink. The nuances of adjustment of both the levator and the spring can be appreicated only with experience. Nevertheless, once the general principles are understood, excellent results can be obtained (Fig. 6–47).

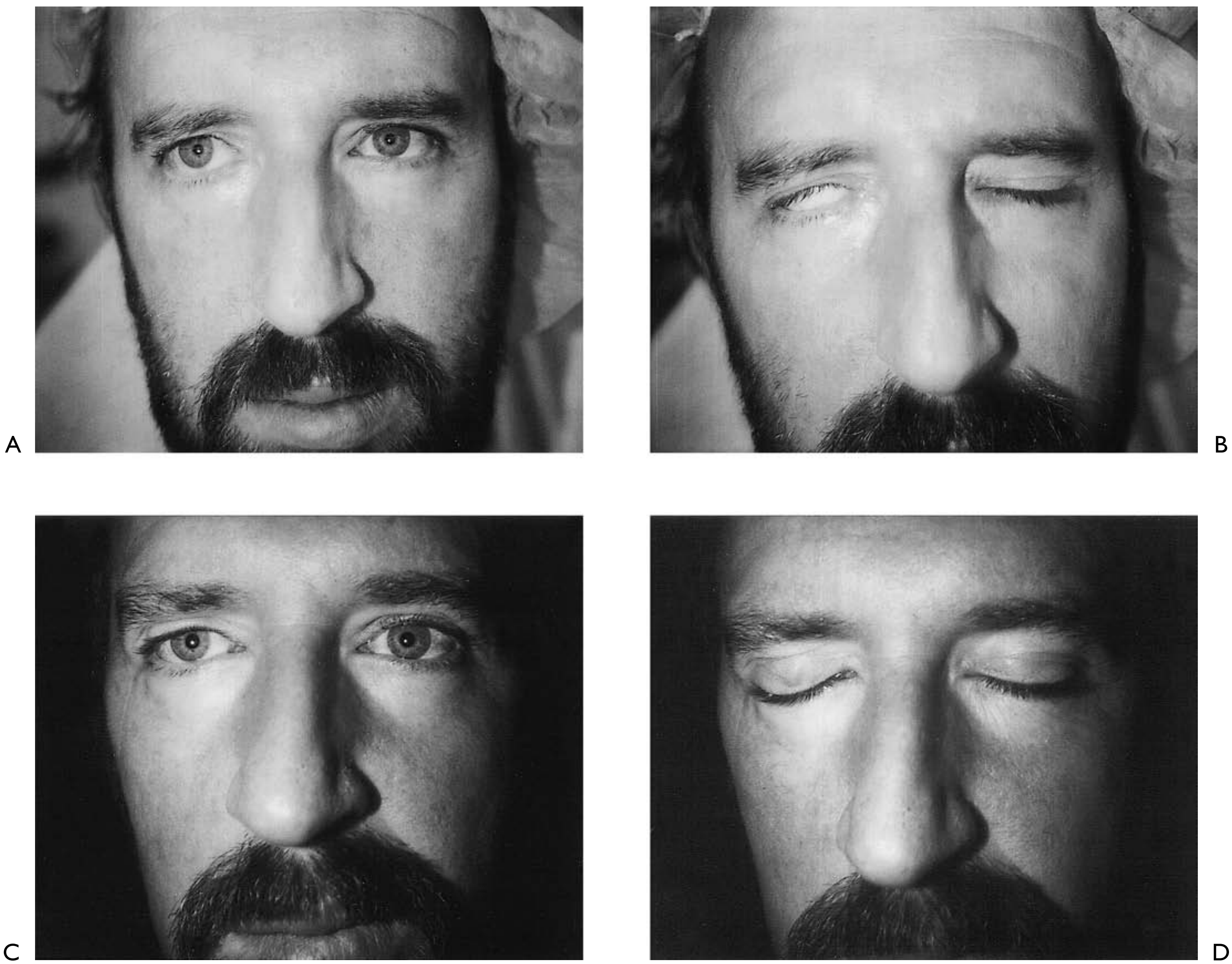


Figure 6–47. Results of enhanced palpebral spring. The patient has a total facial paralysis following transection of his facial nerve required to remove a ninth nerve schwannoma. **A**, Note brow droop and scleral show secondary to lower lid weakness. **B**, Note that there is no closure of the upper lid. **C**, The brow has been surgically elevated and the lower lid tightened with medial and lateral canthoplasties. A slight pseudoptosis has been created by the enhanced palpebral spring procedure. **D**, The enhanced palpebral spring procedure results in excellent lid closure.

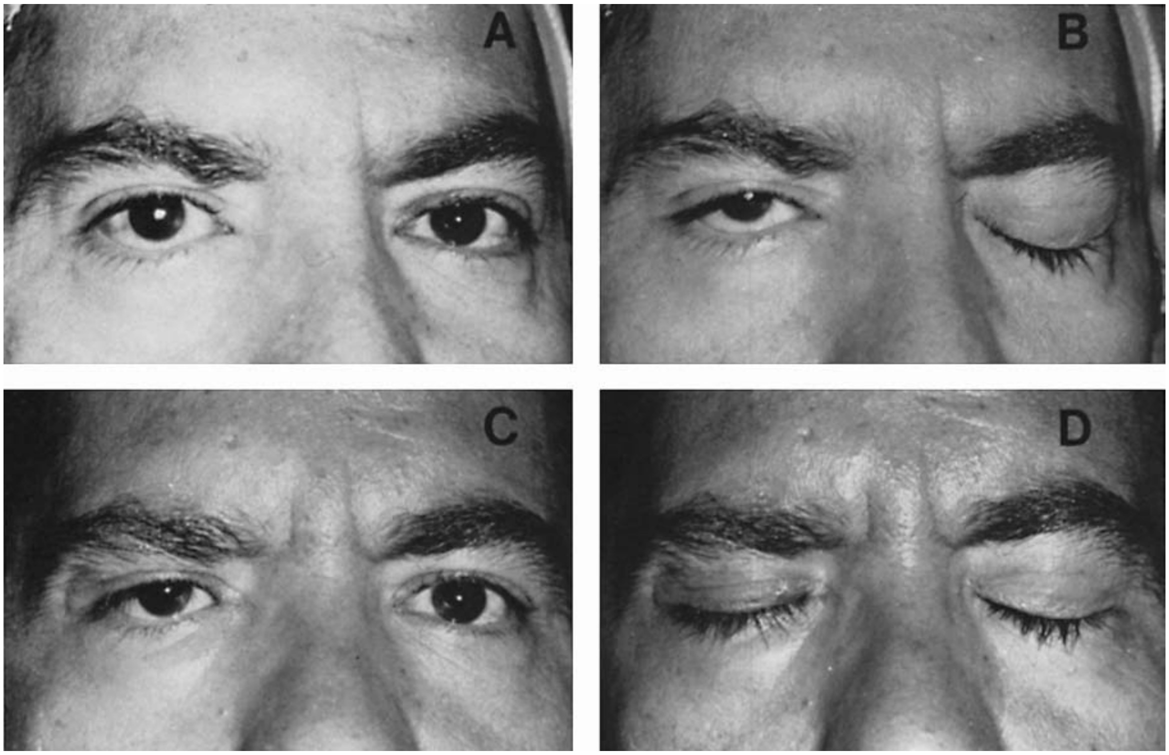


Figure 6–48. A 40-year-old patient suffered marked facial weakness, decreased corneal sensation, and poor Bell's phenomenon following removal of an acoustic tumor with facial nerve transection. The facial nerve was repaired with an end-to-end anastomosis. **A**,**B**, Eyes opened and closed. **C**,**D**, Lower lid position has been improved with medial canthoplasty, and upper lid closure has been achieved with palpebral spring implantation. Note that palpebral aperture on involved side is slightly decreased in the primary position.

A recent improvement in the technique described is to not complete the medial levator suture until the spring is implanted. The medial suture is then brought through the Dacron patch and tied, anchoring the spring before completing the passage of each of the sutures through the levator.

In Levine's opinion, despite all of the limitations discussed, implantation of a palpebral spring, frequently combined with a medial canthoplasty (Fig. 6–48), is the procedure of choice in patients with severe lagophthalmos and/or other factors predisposing to corneal problems (e.g., poor Bell's phenomenon or corneal anesthesia). The spring does not weaken with time, provides dependable lid closure, and can easily be adjusted in the office.

Closed-Eyelid Spring The technique was first reported in 1988[39] and is illustrated in Figure 6–49. Implantation of gold weights and open wire springs to close the eyelid has provided good corneal protection in selected patients with eyelid paralysis. These techniques, however, do not overcome lower eyelid drooping. The closed-eyelid spring technique was developed to address this problem, and to date, the senior author has implanted 41 closed-eyelid springs. This technique re-established a voluntary blink, provided corneal protection, and effectively held the lower lid in a relatively normal position. The procedure was considered successful in 88% of the 41 patients (Figs. 6–50 and 6–51). Failures were related to overclosure (1), underclosure (2), discomfort (1), and extrusion (1). In four cases, the wire broke.

Upper Lid Entropion Correction Technique Entropion of the upper lid results in eyelash dropping. This not only interferes with vision but may contribute to corneal irritation and breakdown. An effective surgical technique to correct this problem is illustrated in Figure 6–52.

Lower Eyelid

Goals *for lower lid reanimation* are to improve lower eyelid margin approximation to the globe to maximize the efficiency of the tear drainage and distribution system, and to correct ectropion in its acute phase. This prevents scarring and retraction that results from chronic exposure of the delicate conjunctival mucous membrane and occurs when the lower lid falls away from the globe.

The procedures to reanimate the lower lid are for the most part static and therefore more predictable and reliable than the procedures described for the upper lid, which are dynamic. Unlike upper lid techniques, lower lid reanimation procedures are usually performed in combination with other procedures to restore lid function (Table 6–16). Just as there are special reciprocal relationship between the muscles that open and close the upper lid, there is a similar mechanism with lower lid. The depressor inferioris muscle retracts the lower lid upon looking down and relaxes when

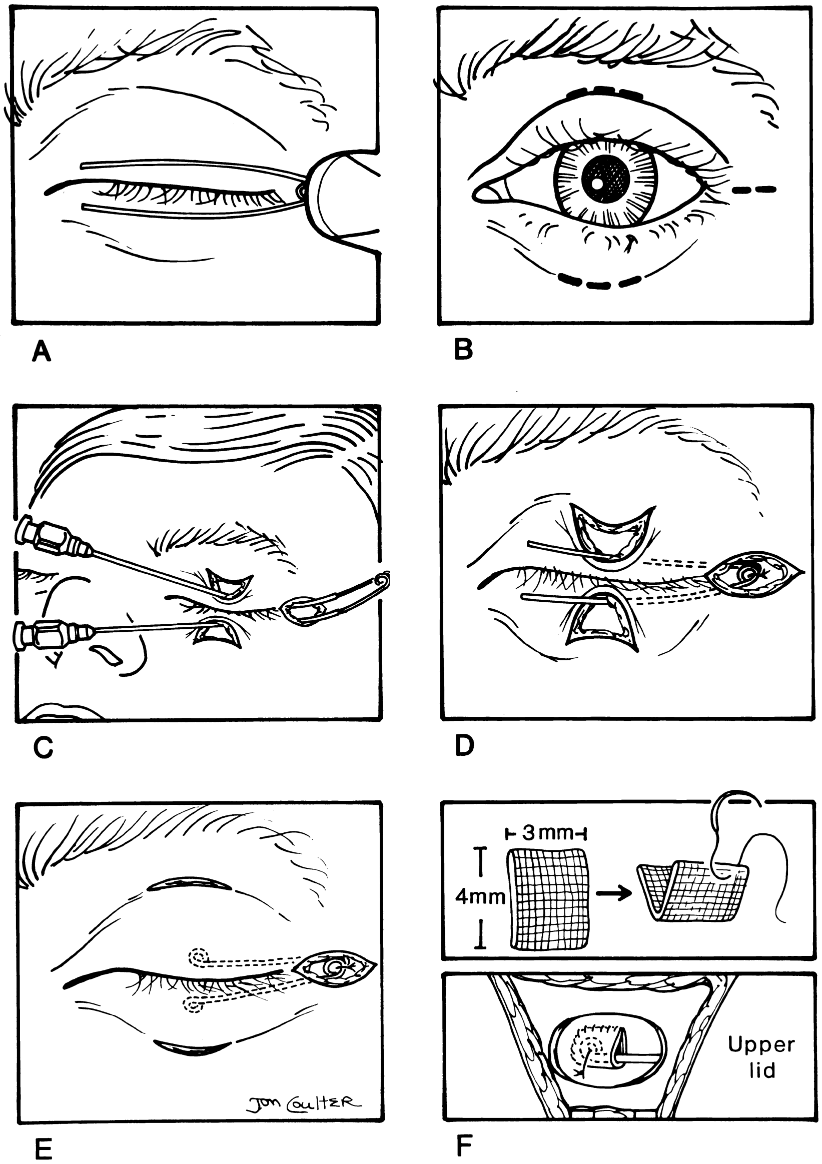


Figure 6–49. Closed-eyelid spring implant—May's technique. Material used for the closed-eyelid spring technique are listed in Table 6–6. Before surgery, the wire spring is fashioned from 0.01-in orthodontic round wire with the special pliers listed in Table 6–6. **A**, The orthodontic wire must be shaped to conform to the curvature of the upper and lower lid margins, but the wire is brittle and breaks easily, so it must be shaped carefully. However, the wire will retain its shape once it is formed. Once the spring is ready, a topical anesthetic is applied over the patient's cornea, and 1% Zylocaine with 1:100,000 adrenaline solution is instilled just below the skin of the lid in the incision areas indicated in **B** (dotted lines). Through these incisions, the tarsal plates of the upper and lower lids and the periosteum in the lateral orbital rim area are exposed. **C**, Spinal needles are then inserted from the tarsal incisions to the lateral orbital rim area. **D**, The spring is inserted through the lumens of the spinal needles, and the spinal needles are then withdrawn. The fulcrum of the wire is sutured to the periosteum of the lateral rim at about the level of the lateral canthus, with two or three 5-0 clear supramid sutures. **E**, Next the ends of the wire limbs are cut with the wire cutter so that they will be the correct length to form a loop to reach to approximately the pupillary line. The loop is formed with the smooth side towards the palpebral aperture, using the looping pliers. **F**, A Dacron sleeve is then fashioned from a 3 × 4-mm patch that is pleated by folding it on itself and placing it in a Gelfoam press, which is then placed in an autoclave and flashed for 3 minutes. Following this, a permanent pleat is made in the Dacron, and the sleeve is completed by closing it on two sides using 8-0 Ethilon suture material. This Dacron sleeve is placed over the wire loop and fixed to the loop with an 8-0 Ethilon suture to prevent extrusion of the loop; tissue grows through the mesh and fixes the loop to the surrounding soft tissue. However, some movement is required for the spring to work effectively, which is why the suture is not placed through the tarsus. Finally, the wounds are closed, and the procedure is terminated. (From May M.[39] With permission.)

the eyelids approximate as with blinking or closing the eyes. Recessing or resecting the depressor inferioris muscle and implanting a strut between the lower edge of the inferior tarsal plate combined with a lower lid shorting procedure will raise the level of the lower lid and hold it in position. This combination of procedures counter the effects of gravity on the denervated orbicularis oculi muscle.

The senior author finds greatest success with lower lid shortening and cartilage strut implant. The Bick lower lid shortening procedure was learned from Dr. George Beurger, a Pittsburgh ophthalmoplastic colleague, and the cartilage strut implant placed into the lower lid was learned from Dr. David Soll, a Philadelphia ophthalmoplastic surgeon.

Procedures that shorten or change the position of the eyelid must not disturb the special relationship between the lacrimal puncta, particularly the inferior one where it must lie closely approximated to the globe for it to effectively drain the tear pool that forms between the interface of the lower lid and globe. Care must be taken not to pull the inferior puncta laterally or evert it upon tightening the lid. As a general rule with lid shortening procedures, one must monitor this relationship as one decides how much of the lid is to be resected for shortening purposes. Usually up to one eighth of the length of the lower lid can be resected without disturbing the relationship of the inferior puncta to the globe.

Another problem that can be created by overshortening the lower lid is to pull the lid margin too tightly and create a hammock effect, with the lower lid actually bowing down under the globe. Ideally, the lower lid margin should form a straight line between medial and lateral canthus to

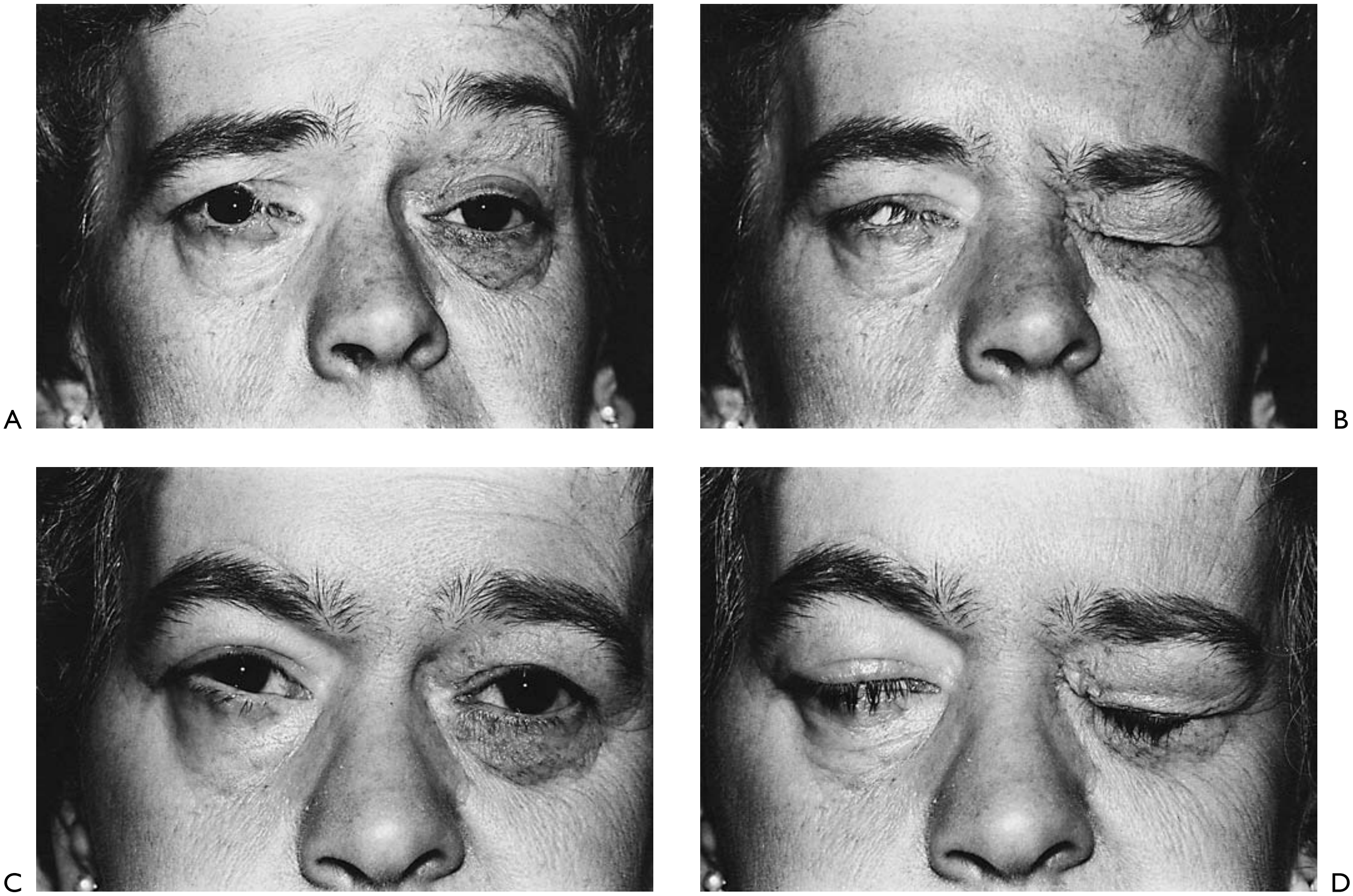


Figure 6–50. Results of closed spring. **A**, One year after total facial paralysis following acoustic tumor surgery on the right side, medial and lateral tarsorrhaphy was performed. **B**, Incomplete eyelid closure, even with tarsorrhaphies in place. **C**, Four months later. Tarsorrhaphies are removed and closed-eyelid spring implanted. The lower lid droop is corrected. **D**, Eyelid closure almost complete. (From May M.[39] With permission.)

maximize upper and lower lid approximation. This hammock effect was more common with sling techinques using the temporalis tendon-fascia transposition and was not uncommon with the Arion Silastic encircling procedure.

Laxity or stretching of the medial and/or lateral canthal tendons noted in long-standing facial paralysis may need surgical correction in order to maintain or improve the results achieved by the other procedures already mentioned. One should suspect a problem with the medial canthal tendon if the inferior lacrimal puncta is easily displaced with minimal lower lid shortening. In such cases, tightening the medial canthal tendon with a medial canthoplasty (Fig. 6–53) is quite effective.

When determining the best procedure for loss of lower lid support, Patel and Anderson determine if there is true medial canthal lengthening. When the lower eyelid is pulled laterally, the lower punctum normally only moves 1 to 2 mm. In the presence of true medial canthal tendon lengthening, the punctum may move by several millimeters.

It is important to understand medial canthal anatomy in order to perform the appropriate corrective procedure. The major positional support for the medial eyelid is provided by the deep attachments of the orbicularis oculi muscle. The deep head of the pretarsal orbicularis muscle (Horner's muscle) provides posterior, nasal, and medial support to the position of the eyelid and holds the punctum firmly against the globe. The anterior portion of the medial canthal tendon that inserts into the anterior lacrimal crest is important in providing strong anatomical support anteriorly and medially, but is not important in maintaining the eyelid's position against the globe (Fig. 6–54). Therefore, when true medial canthal tendon lengthening is present, simply tightening the anterior limb of the tendon will result in a medial but also anteropositioning of the inferior lacrimal punctum. The posterior limb needs to be tightened to obtain appropriate anatomical correction of the problem.

Success of reanimating the paralyzed eyelids is determined by the functional and cosmetic results. When the cornea is covered during blinking and sleeping, function has been restored; if the eyes appear symmetrical when the lids are opened, a pleasing cosmetic result has been achieved. This goal is often elusive although remarkable achievements have been accomplished by applying a combination of procedures. Table 6–16 lists all the major procedures that have been used to reanimate the eyelids and particularly the lower lid. The procedures are placed in groups depending

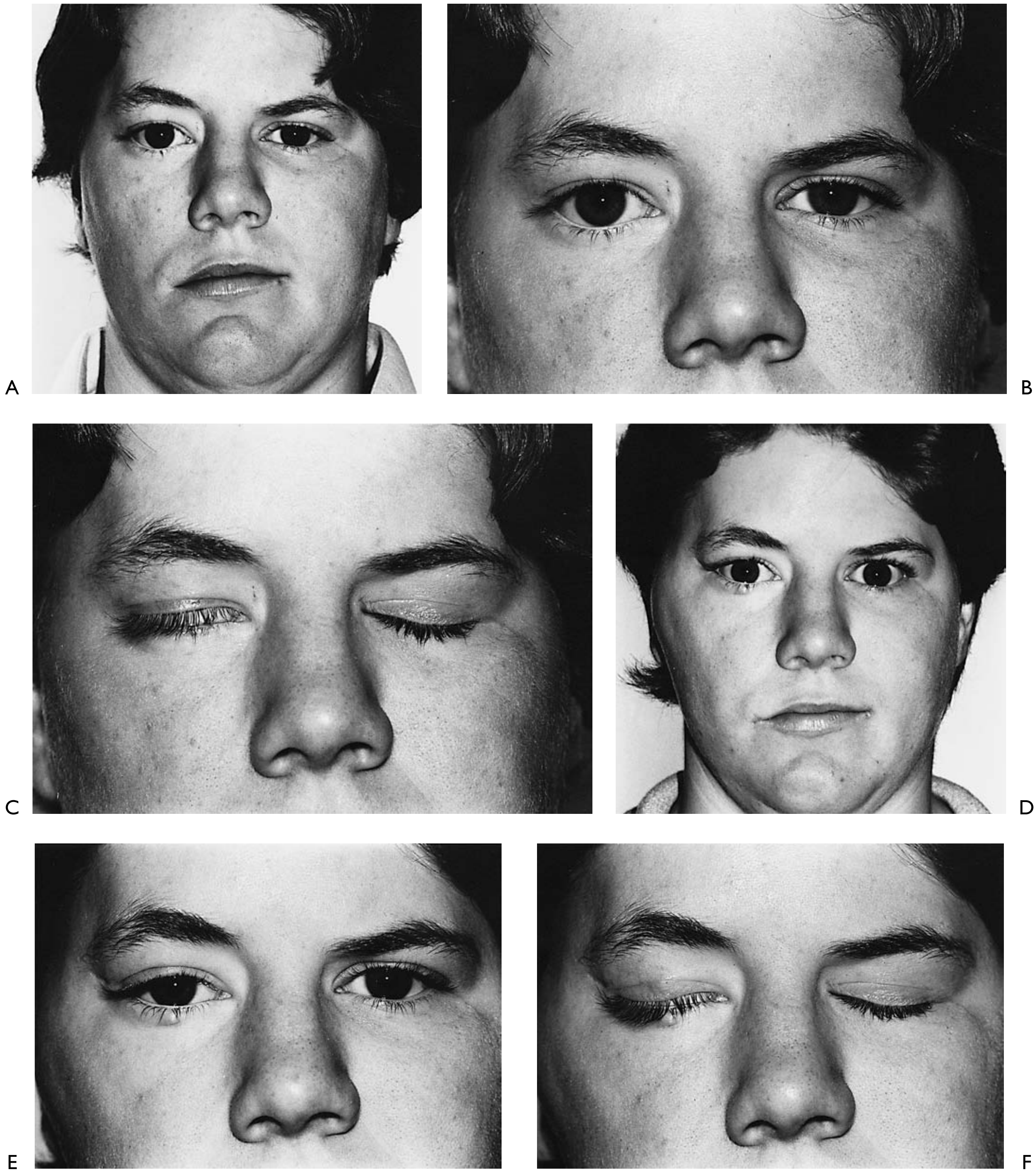


Figure 6–51. Results of closed spring. **A**, 21-year-old woman born with right facial paresis. Note widening of the interpalpebral fissure on the right, due mostly to drooping of the lower lid. **B**, Closer view of eyes open. **C**, Eyes closed. **D**, Patient 6 months after insertion of a closed-eyelid spring on the right. **E**, Closer view of eyes open. **F**, Eyes closed. Note how closed-eyelid spring corrects lower lid droop. In addition, facial symmetry and eyelid closure are improved. (From May M.[39] With permission.)

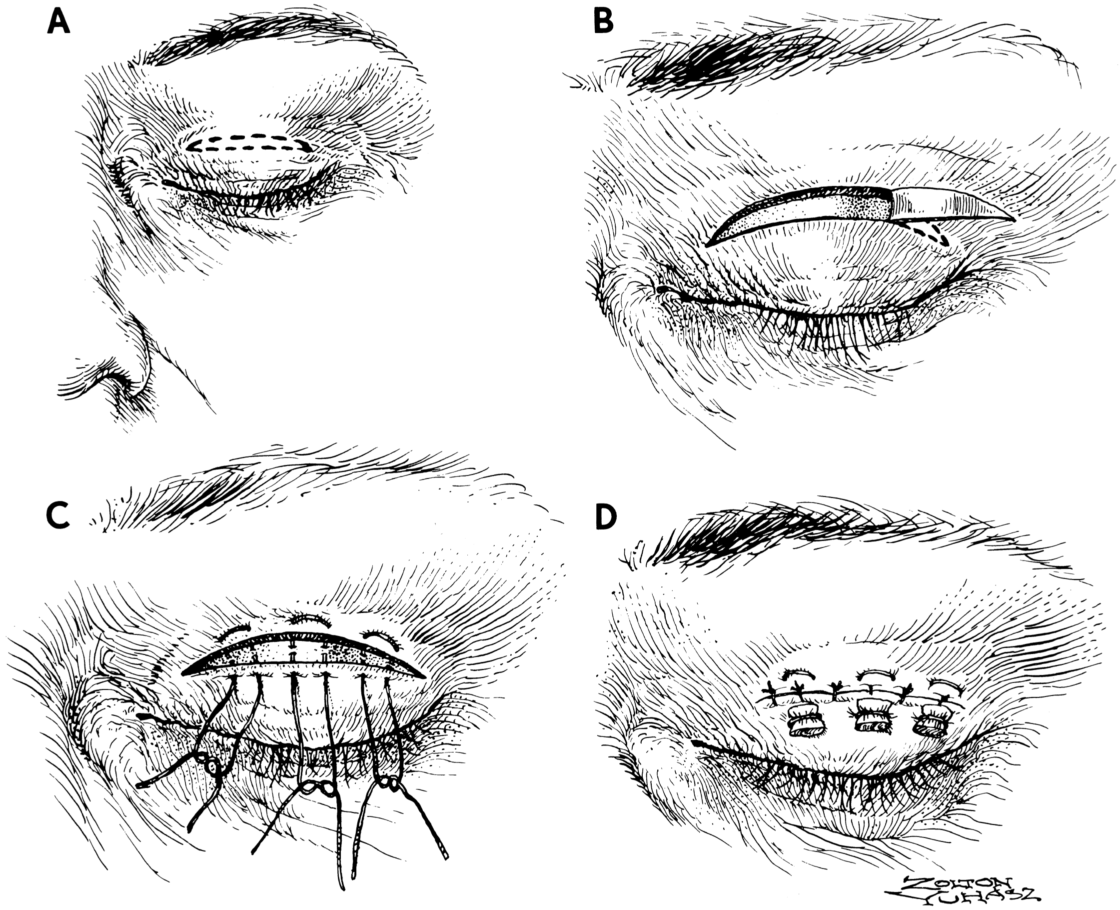


Figure 6–52. Technique for correction of upper lid entropion. **A**, Amount of skin-muscle excision required to correct entropion is determined and incision sites marked. **B**, Skin-muscle ellipse is removed. **C**, Mattress sutures anchored in upper tarsus elevate lower edge of skin-muscle lamina. **D**, Wound closure. (From Levine RE.[1] With permission.)

on whether they are intended to *approximate the lids, tighten, or elevate the lower lid.* An effort has been made to compare the various lower lid procedures in terms of their advantages and disadvantages.

Procedures To Correct Lax Medial Canthal Tendon (Patel and Anderson's Experience)

Collin Medial Canthoplasty In the presence of a *marked degree of medial canthal* laxity, the tendon as well as the redundant lower canaliculus need to be addressed in any surgical procedure. The Collin medial canthoplasty involves resection of the inferior canaliculus and redundant medial canthal tendon which works well (Fig. 6–55).[41] With the lower eyelid on stretch laterally, a full thickness incision (which includes the lower canaliculus) is made in the lower eyelid at the point where the lower punctum should be. The conjunctival incision is then carried posterior to the plica semilunaris. Using blunt dissection with scissors and Sewall retractors, the medial orbital wall is exposed behind the lacrimal sac. A 4-0 Vicryl suture on a half-circle needle is passed through the periosteum of the medial orbital wall behind the posterior lacrimal crest. The lateral portion of the cut lower eyelid is pulled in posteriorly, and any excess lower eyelid is excised. The suture is then passed through the cut tarsus and tied, pulling the eyelid medially and posteriorly. The lower canaliculus is mobilized, slit open, marsupialized, and sutured to the surrounding tissues. The eyelid margin and skin edges are sutured. Patel and Anderson only use this approach when there is severe lengthening of the medial canthal tendon. With careful marsupialization of the medial stump of the lower canaliculus, additional epiphora can be prevented in the majority of patients. Advantages of this procedure are that it anatomically corrects the medial canthal laxity. A major disadvantage is that if the surgeon is unfamiliar with canalicular anatomy and its repair, the patient can be left with a scarred lower canaliculus.

Another approach is to tighten the medial canthal tendon by exposing the posterior lacrimal crest via a dacryocystorhinostomy (DCR) approach or an S-shaped incision as shown in Figure 6–56. The medial part of the tarsal plate is sutured to the posterior lacrimal crest area using a 4-0 Vicryl suture. When this procedure is performed at the same time as a DCR, the exposure makes the placement of the suture relatively straightforward. However, in the absence of a DCR, the placement of the suture can be technically demanding. Also, in the presence of true medial canthal tendon lengthening, there may be lengthening of

Table 6–16 Comparative Scheme of Lower Lid Reanimation Procedures

Purpose of Procedure	Figure	Procedure	Advantage	Disadvantage
Plication or approximation of eyelids		Tarsorrhaphy[37,40,41]	Technically uncomplicated	Static result
	6-52	Medial		Limits gaze
	6-59	Lateral		Unsightly
		Combination (Kuhnt-Szymanosky[53,54] McLaughlin)[55]		Lid notching, lid margin deformity
		Magnets[35], (Muhlbauer)	Dynamic reanimation	Extrusion lid deformity, commercially unavailable
Lower lid tightening combined procedures to elevate lower lid	6-53	Bick[42]	Technically easiest of procedures in this group	Lateral canthal blunting, burry lashes
	6-55	Tarsal strip[43]	Allows adjusting tension on lid	Tedious
	6-58	Dermal flap[44]	None	
		Midlid wedge	Ideal for taking down tarsorrhaphy to tighten and correct lid deformity	Tedious, lid notching, short lasting
Struts or implants to elevate the lower eyelid combined with lid tightening procedures	6-57	Cartilage[43–48], (Soll)	Donor available with minimal morbidity	Cartilage–stiff, thick, brittle. May cause lid deformity.
		Palatal mucosa[50,51] (Siegel)	Mucosal cover can be used to interface with conjunctiva	Donor site pain with eating until heals
		Tarsoconjunctival[52] (Shaw-Khan)	Appropriate contour	May not be able to harvest large enough graft
	6-48	Closed-spring[40] (May)	Dynamic reanimation	Technically difficult May cause lid deformity
Suspension	1-1C	Temporalis muscle–facial (fascia lata) slings[52]	Technically easiest of this group	Ectropion, eye opened at night
		Silastic encircling[32] (Arion)	Dynamic reanimation	Short-term results

the lower canaliculus, and this redundant tissue may form a kink in the canaliculus when such a posterior tightening is performed. However, in patients with severe medial canthal laxity, this is a very rewarding procedure.

Lee Medial Canthoplasty Patel and Anderson's preferred technique for *mild to moderate medial canthal laxity* is the Lee medial canthoplasty,[42] which has been modified (Fig. 6–57). They usually perform this in addition to the lateral tarsal strip with or without a lower eyelid spacer. The tarsal strip allows correction of the lower eyelid laxity and retraction, while the medial canthoplasty corrects the medial retraction and exposure.

The upper and lower canaliculi are protected with Bowmann probes. A No. 11 Bard-Parker blade is used to split each eyelid into an anterior lamella of skin and some orbicularis muscle, and a posterior lamella containing the canaliculus and surrounding orbicularis. These incisions commence just medial to the puncta. The incisions are extended medially to expose the anterior limb of the medial canthal tendon. In order to provide horizontal support, Patel and Anderson insert a horizontal mattress suture into

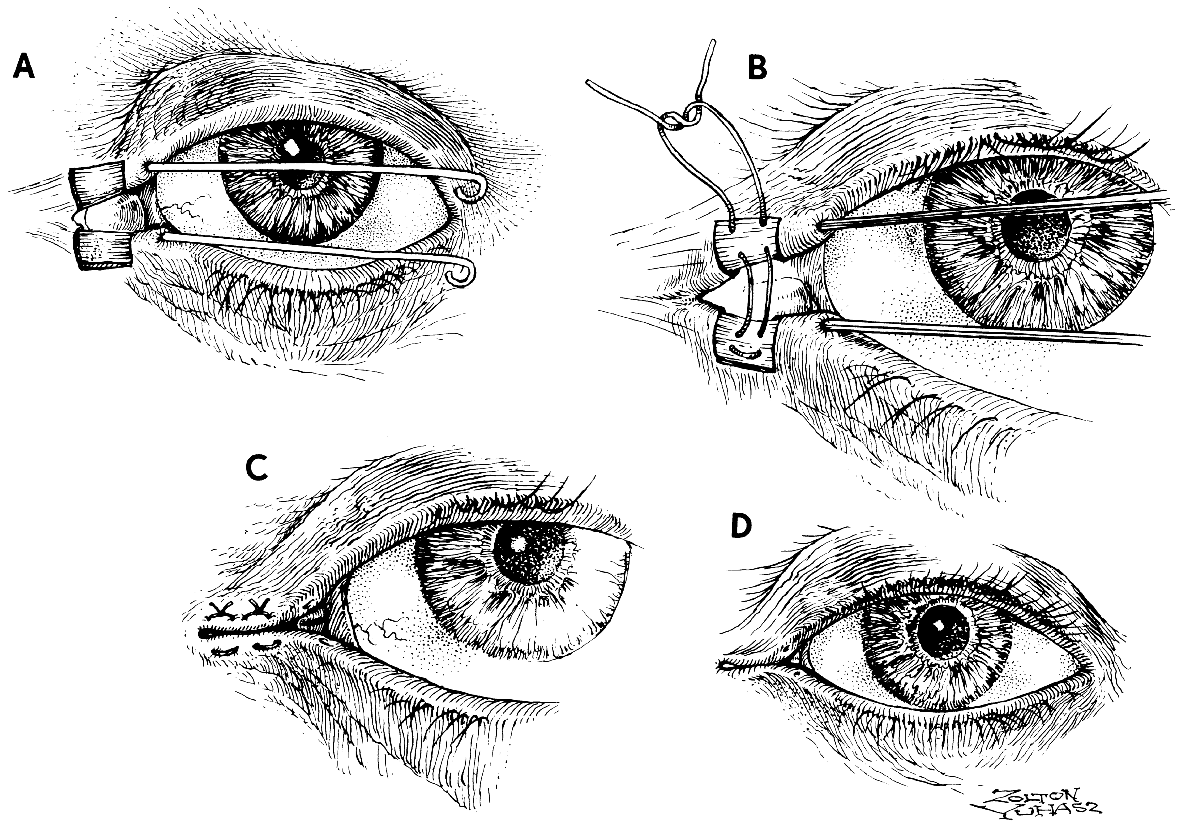


Figure 6–53. Technique of medial canthoplasty. **A**, Canthal tendon is exposed above and below while protecting canaliculi with probes. **B**, Arms of tendon are joined by double-arm suture directed superonasally. **C**, Skin sutures are placed. **D**, Completed canthoplasty after suture removed. (From Levine RE.[1] With permission.)

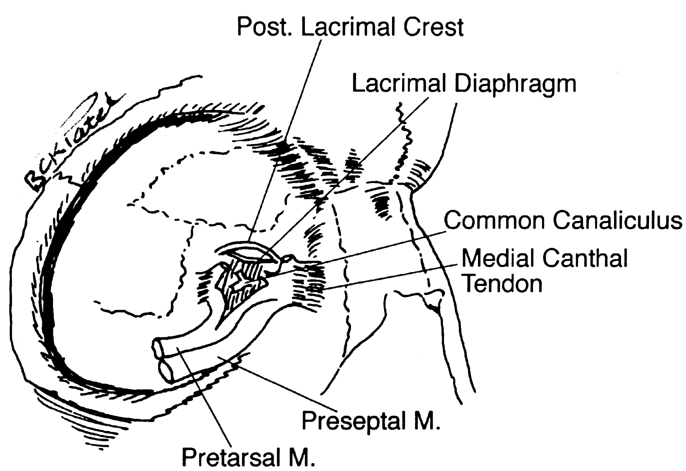


Figure 6–54. Anatomy of the medial canthal tendon.

the medial end of the lower eyelid tarsus and the tissues behind and superior to the medial canthal tendon (Fig. 6–58). It should be noted that the medial canthoplasty should be performed after the lateral canthoplasty to avoid dehiscence of this suture. The tissue below the lower canaliculus and above the upper canaliculus is then sutured together with a 6-0 Vicryl suture. This provides vertical support to the medial lower eyelid. The skin is trimmed as required and sutured. This procedure allows adequate correction of the retraction medially, repositions the puncta, and corrects a mild to moderate degree of medial canthal laxity without injury to the canaliculi (Fig. 6–59). One of the problems with the modified (or original) Lee procedure is that it changes the appearance of the medial canthal area, which may be cosmetically unacceptable to some patients. In a review of 31 of our modified Lee medial canthoplasties, only two patients expressed concern about the cosmesis. All patients noticed an improvement in their tearing and comfort.

Lower Lid Lateral Repairs and Tightening Techniques

Modified Bick Procedure as Performed by May The Bick procedure[42] or a modification known as a lateral tarsal strip[43] involves resecting a lateral wedge of the lower lid. A tongue of tarsus is developed, resutured, and anchored to the lateral orbital rim, thus shortening and tightening the lower lid. Both the modified Bick and tarsal strip procedures allow for fine adjustment of the tension on the lower lid determined by the precise amount tarsal strip resected. However, technically the tarsal strip procedure is more difficult because it requires a meticulous de-epithelialzation of the skin and conjunctival mucosa in the lateral canthal region. Both procedures run the risk of overcorrection, and therefore conservatism is recommended. Finally both techniques require placing the suture through the tarsus and fixing it to the deep surface of the lateral orbital rim at a

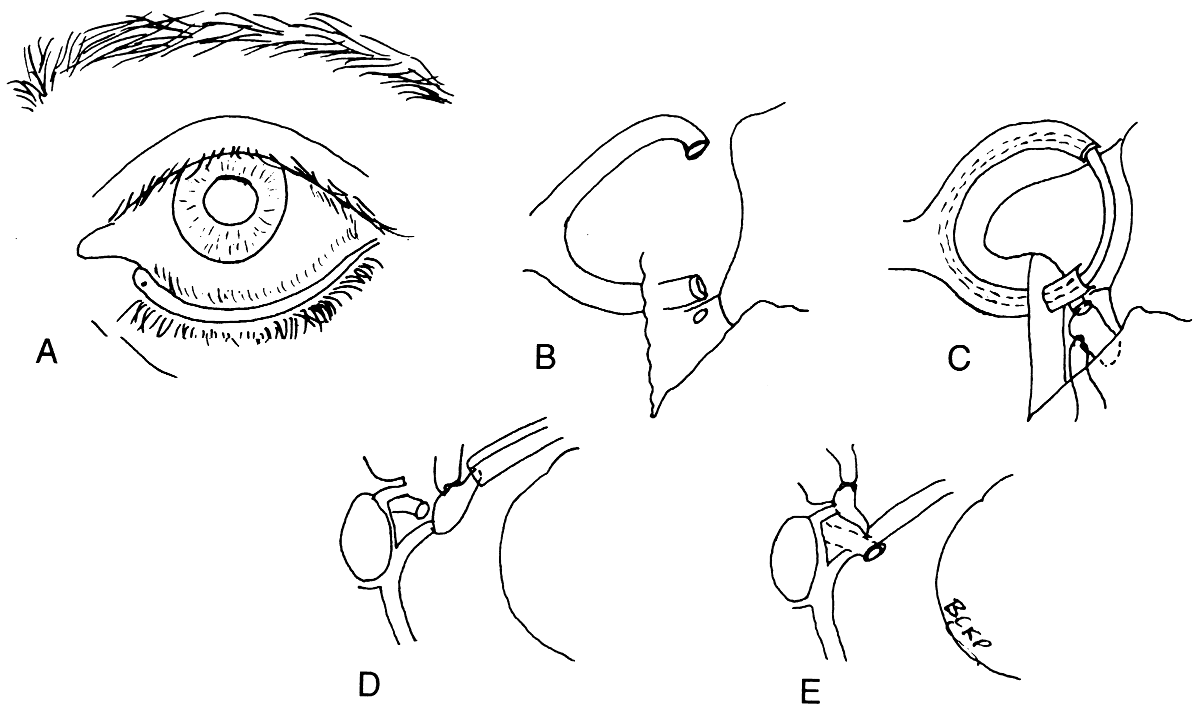


Figure 6–55. **A**, The Collin medial canthoplasty for true laxity of the anterior and posterior limbs of the medial canthal tendon. **B**, A full-thickness incision (which includes the lower canaliculus) is made in the lower eyelid at the point where the lower punctum should be. The medial orbital wall is exposed behind the lacrimal sac. **C**, A 4-0 Vicryl suture on a half-circle needle is passed through the periosteum of the medial orbital wall behind the posterior lacrimal crest. The lateral portion of the cut lower eyelid is pulled in and posteriorly, and any excess lower eyelid is excised. **D**, The suture is then passed through the cut tarsus and tied, pulling the eyelid medially and posteriorly. **E**, The lower canaliculus is mobilized, slit open, marsupialized, and sutured to the surrounding tissues. The eyelid margin and skin edges are sutured.

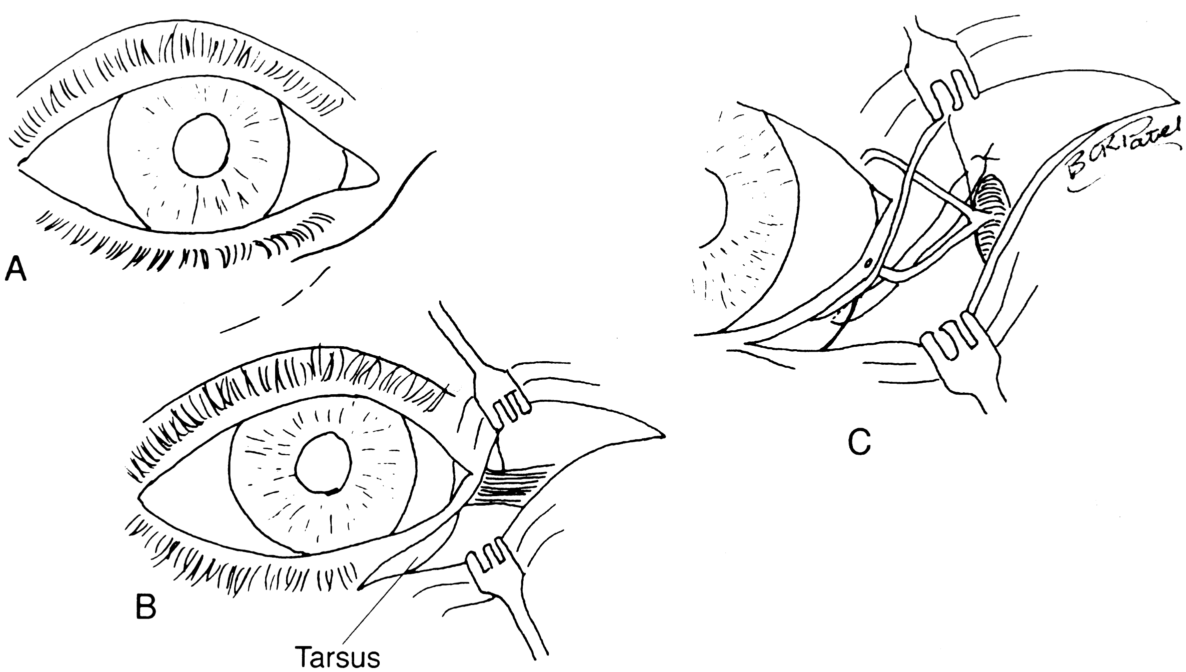


Figure 6–56. Medial canthoplasty to correct laxity of posterior and anterior limbs of the medial canthal tendons. **A**, An S-shaped incision is made. **B**, The medial tarsal plate and the medial orbital wall posterior to the lacrimal sac are exposed. **C**, The medial part of the tarsal plate is sutured to the posterior lacrimal crest area using a 4-0 Vicryl suture.

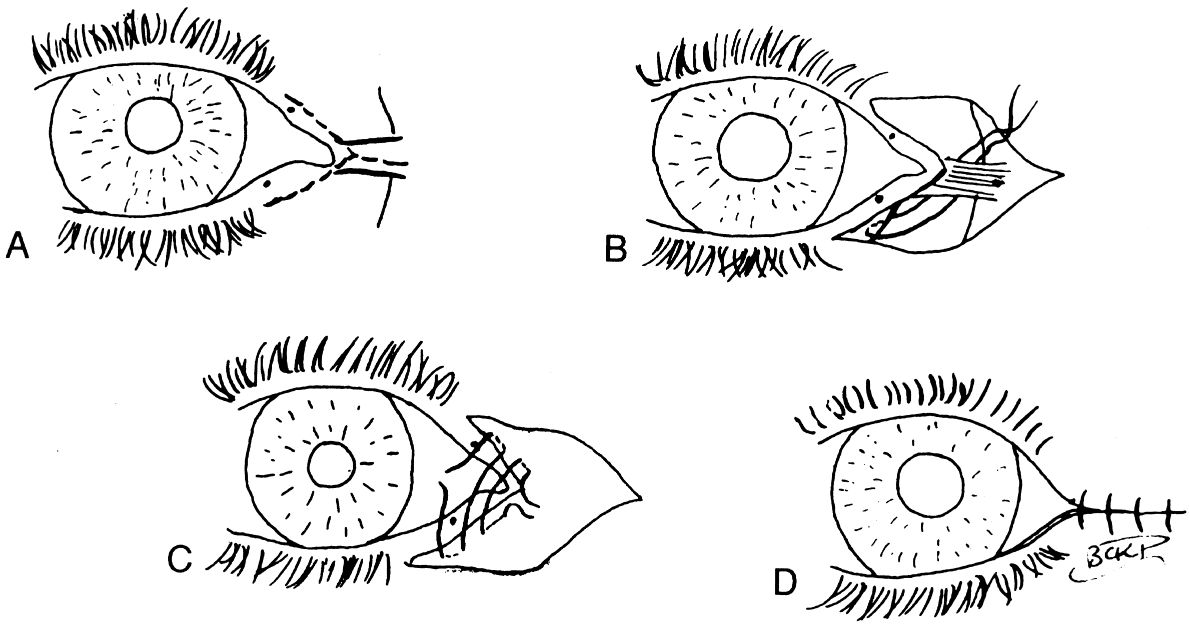


Figure 6–57. The modified Lee medial canthoplasty for mild to moderate medial canthal laxity without true posterior limb laxity. **A**, The upper and lower eyelids are split into an anterior lamella of skin and some orbicularis muscle and a posterior lamella containing the canaliculus and surrounding orbicularis. **B**, The incisions are extended medially to expose the anterior limb of the medial canthal tendon. A horizontal mattress suture between the medial tarsus and the tissues behind and superior to the anterior limb of the tendon provide horizontal support. **C**, The tissue below the lower canaliculus and above the upper canaliculus is then sutured together with a 6-0 Vicryl suture. This provides vertical support to the medial lower eyelid. **D**, The skin is trimmed as required and sutured.

Figure 6–58. Suture being passed from the medial tarsal plate to the tissues posterior and superior to the anterior limb of the medial canthal tendon.

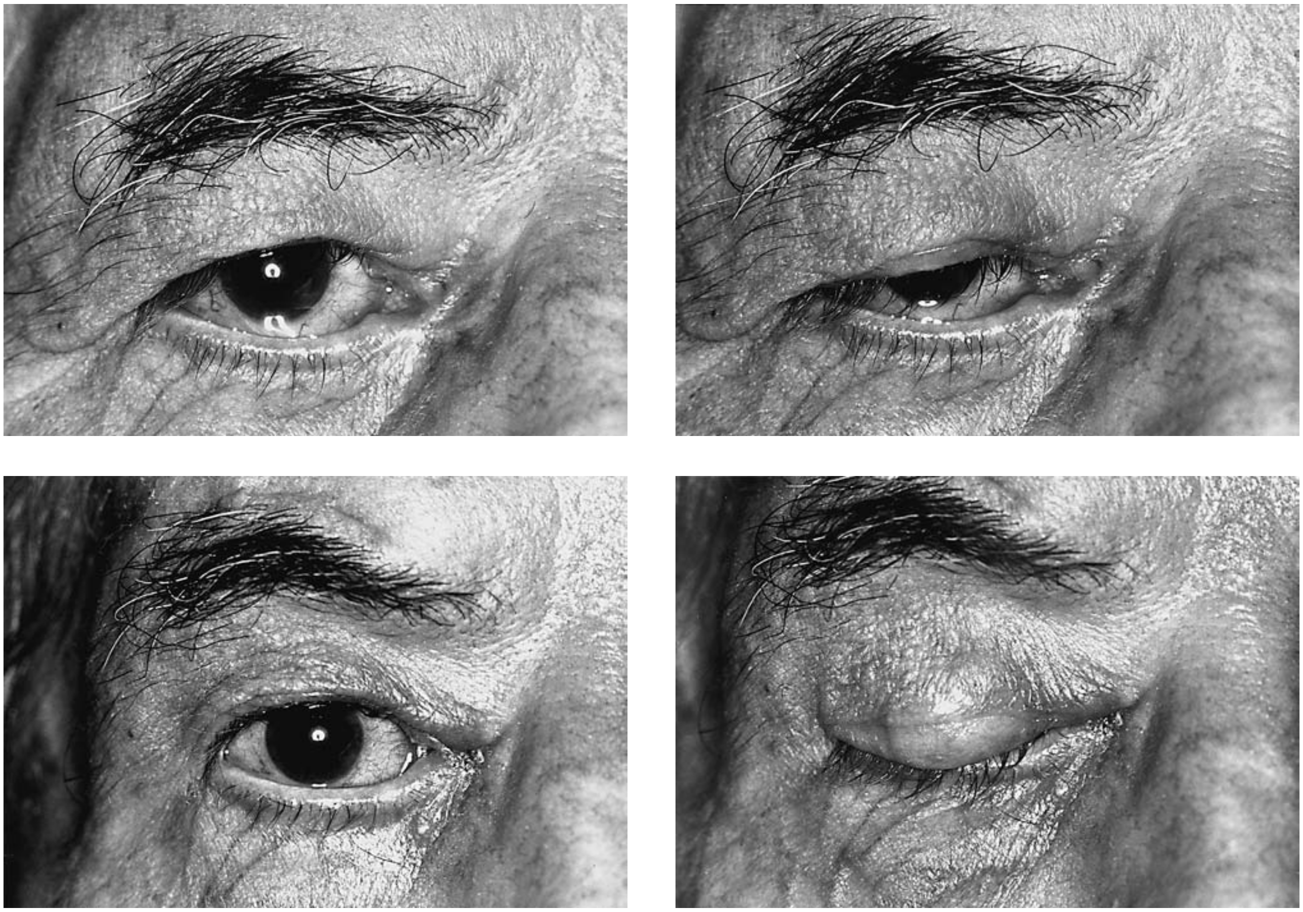
point that corresponds to the midpupillary line in order to restore the lateral canthus in its natural position. Wound infection is a rare occurrence and usually responds to incision and drainage and appropriate antibiotics. The major complication associated with these procedures is a dehiscence or separation of the suture fixation between the tarsus and the lateral orbital rim periosteum. This last complication is almost always attributed to surgical technique. The materials required for these procedures are noted in Table 6–7. The modified Bick procedure as performed by May is illustrated in Figure 6–60 and results demonstrated in Figure 6–61.

Tarsal Strip Procedure as Performed by Anderson The key to this operation is making a lateral strip of tarsal plate that is firmly sutured to periosteum inside the lateral orbital rim. Some authors use permanent sutures, whereas Anderson prefers 4-0 polygalactin 910 because it lasts long enough to provide a good scar and results in fewer infections and granulomas at the lateral canthal region.

Variations of the lateral tarsal strip are utilized in conjunction with a transconjunctival blepharoplasty procedure. A "mini" lateral tarsal strip is combined with transconjunctival fat removal. This results in a pleasing elevation to the lateral canthus and lower eyelid, and eliminates many of the wrinkles in the lower eyelids. This variation of the lateral tarsal strip also helps avoid lower lid retraction postoperatively.

As noted in Figure 6–62, the lateral tarsal strips are much longer than presently utilized in most patients. Simply forming a lateral tarsal strip and suturing the edge of the lateral tarsal strip to the lateral orbital rim effectively tightens the eyelid approximately 6 mm. If the tarsal strip is moved more superiorly, it provides even further tightening.

One must be especially careful not to shorten the tarsus in cases of proptosis or relative proptosis when attempting to correct lower lid retraction. With prominent globes,



A B C D

Figure 6–59. **A**, Facial palsy with medial lower eyelid retraction and ectropion. Patient has already had a gold weight inserted and a lateral tarsal strip performed previously. **B**, Marked lagophthalmos which is the worst medially with marked scleral and caruncular exposure. Note the pooling of tears along the lower eyelid. **C**, Following the modified Lee canthoplasty, there is elevation of the medial lower eyelid with coverage of the caruncle. Note the improved position of the lower eyelid centrally (raising of the hammock) and also the improvement in the tear film. **D**, Good closure.

overtightening results in further inferior displacement of the eyelid in some cases. In these cases, it may be necessary to suture the lateral tarsal strip to the superior portion of the lateral canthal tendon rather than attaching it to periosteum.

The lateral tarsal strip has many advantages over other lid shortening procedures: (1) it corrects the lateral canthal tendon laxity, whereas simply shortening the eyelid further stretches the lateral canthal tendon; (2) it avoids removal of tear-producing structures; (3) it avoids a central scar that can lead to retraction in the lower eyelid; (4) it lengthens the eyelid rather than creating phimosis, and canthal malpositions can be simultaneously corrected; and (5) it provides a pleasant "mini" face-lift effect to the lower eyelid and helps remove wrinkles.

Anderson finds the lateral tarsal strip to be the most versatile operation in his ophthalmoplastic surgical practice and recommends its use to those performing surgery on and around the eyelids. Results of this procedure are noted in Figures 6–62 and 6–63.

Elevation of the Lower Lid The closed-spring technique already described (Fig. 6–49)[39] elevates the lower lid and provides a dynamic effect, allowing the lids to open and close with volition. However, the closed spring involves implanting an alloplast with problems related to deformation, fracture, or extrusion. Using autologous material either taken from the patient's ear,[44–47] nasal septum,[48,49] hard palate,[50,51] or eyelid[52] avoids these problems.

The *palatal mucosal graft*[50,51,53] is soft and pliable with a mucosal surface that can be used to interface with the conjunctiva acting as a wedge support not only for the tarsus but also adding tissue to the conjunctival surface. *Cartilage*, in contrast, taken from the ear or nasal septum is stiff, thick, and brittle and may cause a lid deformity as the thin lower lid skin drapes over the cartilage implant (Fig. 6–33).

Recently Shaw and Khan[52] described harvesting a *tarsal conjunctival composite graft* from the contralateral upper eyelid. Although their experience is limited to 14 patients with a follow-up of 2 years, their technique seems to have distinct advantages. Unlike the other autologous donors, the patient's own tarsal plate from the contralateral upper lid matches the curvature of the recipient lower lid without any need to contour the graft. Like the palatal graft, the posterior surface of the tarsal composite graft conjunctiva allows it to be placed in the deepest possible layer, thus minimizing any

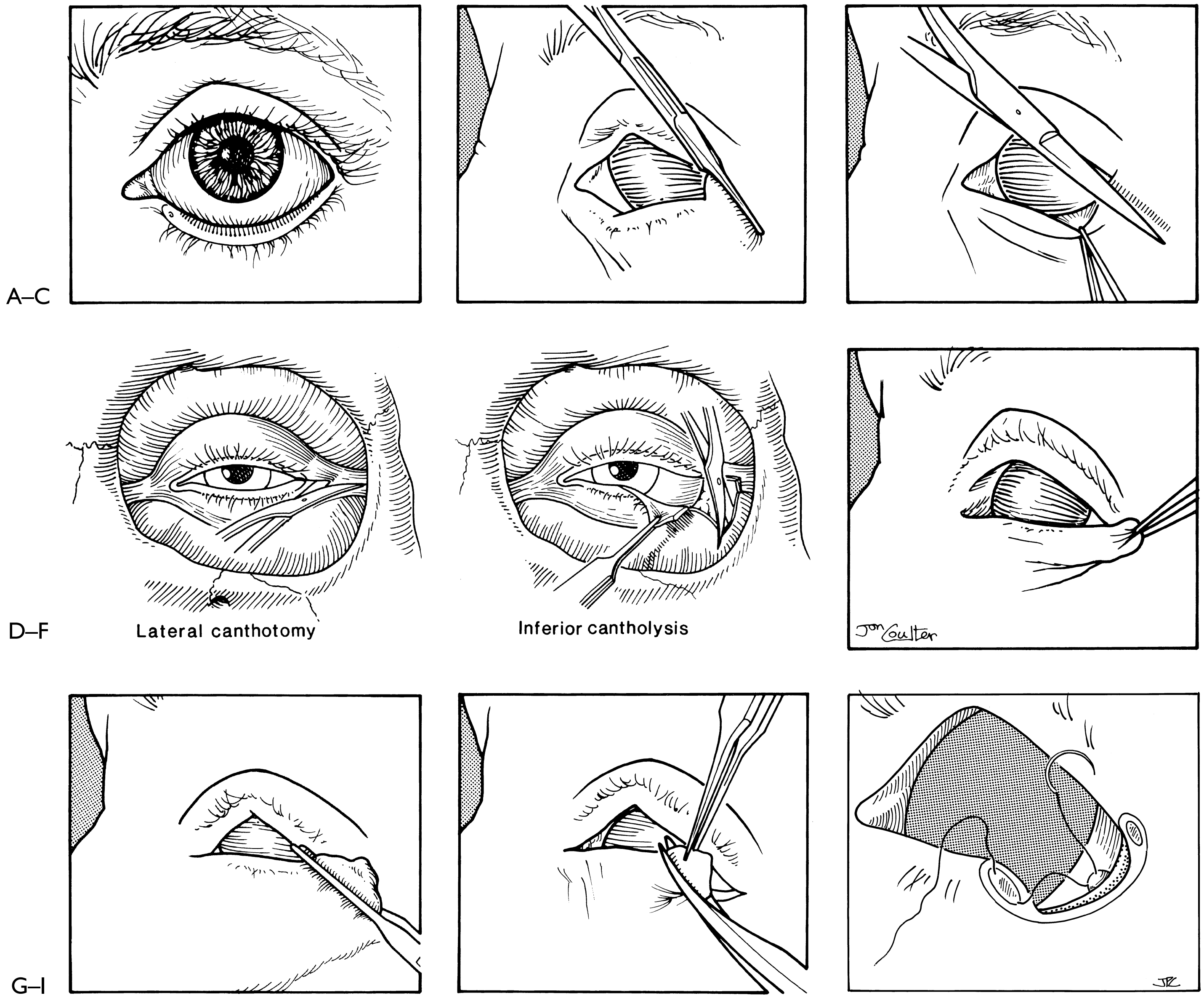
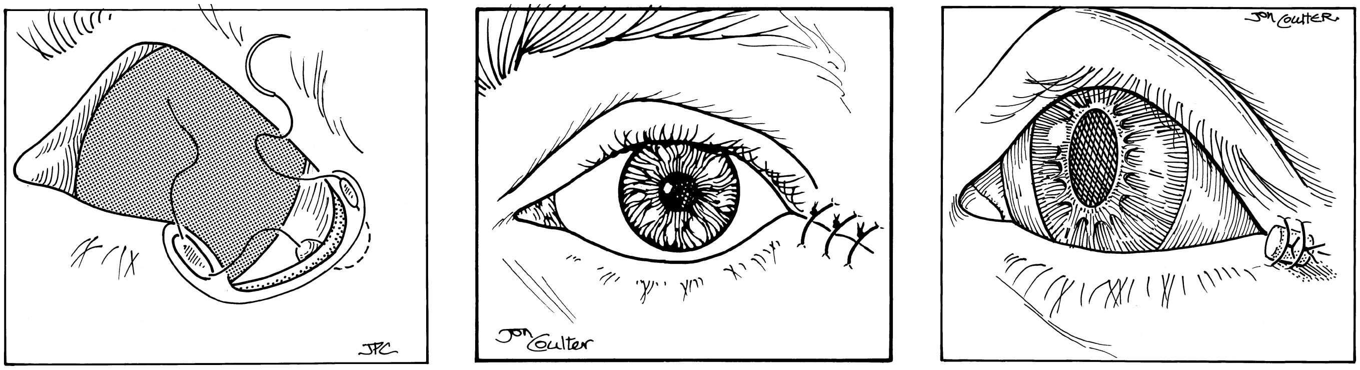


Figure 6–60. Lower lid tightening—modified Bick procedure (see Table 6–7 for instrumentation). The procedure is performed with local and topical anesthesia and insertion of a contact lens as illustrated in Figures 6–37H and I. **A**, Ectropion, drooping of lower eyelid. **B**, Resection clamp placed and directed parallel to lid margin close to the orbitial rim. The tissues are crushed between conjunctiva and skin in the lateral canthal region. **C**, The area of crushing is sectioned with an iris scissors. **D**,**E**, show the details of lateral canthotomy and inferior cantholysis (see Figs. 6–62C and D). **F**, The lateral most portion of the lid is pulled laterally to achieve maximum shortening. Up to one-third of the lid margin can be resected. Care must be taken not to pull the inferior lacrimal puncta away from the globe because this might lead to faulty tear drainage and epiphora. **G**, The resection clamp is placed through the lid margin, marking the portion that is to be resected. **H**, The area of crushing is sectioned with an iris scissors. **I**, The new lateral margin of the tarsus is now fixed to the lateral canthal tendon and then to the lateral margin of the tarsus of the upper lid with 4-0 Dexon. *(Figure continued next page.)*

noticeable bulging. The technique described by Shaw and Khan[52] is clearly illustrated in their report.

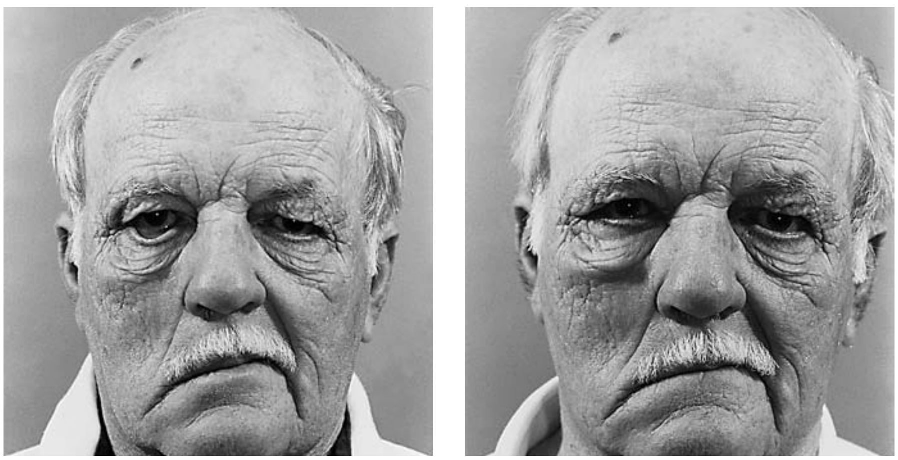
Mucosal Graft For the last 6 years, our spacer of choice has been the palate mucosal graft as performed by Patel and Anderson. Since Seigel[50] first described the use of palate mucosal grafts for eyelid reconstruction in 1985, they have found widespread application.[54] Palate mucosal grafts have the following advantages: (1) they do not undergo shrinkage or folding, (2) the final eyelid position is predictable, (3) there is no erythema or bulkiness of the eyelid, (4) the grafts have a mucosal surface so a conjunctival lining is not necessary, (5) the material is firm enough to provide vertical support, (6) the consistency of the material is very similar to tarsus, (7) rejection and extrusion are not seen, and (8) donor site problems are uncommon.

Complications include a discharge or mattering in a few patients, corneal abrasion if a bandage contact lens is not



J–L

Figure 6–60. *(continued)* **J**, The new lateral margin of the tarsus is now fixed to the lateral canthal tendon and then to the lateral margin of the tarsus of the upper lid with 4-0 Dexon. **K**, The soft tissues are closed with 6-0 chromic. **L**, The incision line is reinforced with a bolster and left in place for 14 days.



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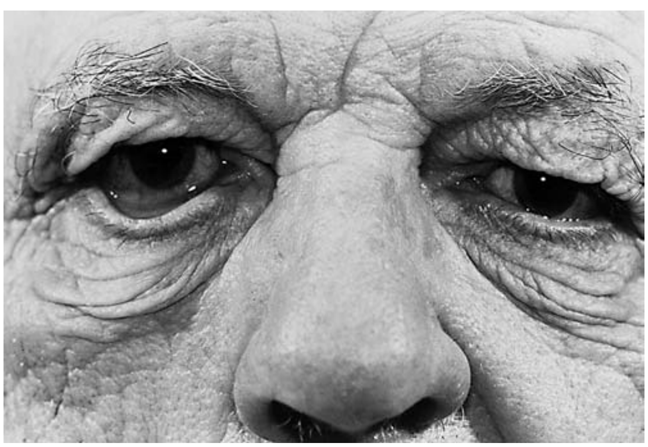


C

D

Figure 6–61. Modified Bick for severe paralytic ectropion and gold weight for lagophthalmos in patient with acute onset of Bell's palsy. **A**, Marked paralytic ectropion with signs and symptoms related to exposure, and epiphora unresponsive to medical treatment. **B**, Following modified Bick (Fig. 6–60) and gold weight implantation (Fig. 6–32). Note lower face still sags from persistent complete facial paralysis yet eyelids are symmetrical. The paralytic ectropion is completely corrected. **C**, Close-up to compare involved right side with normal side before surgery. **D**, After surgical correction.

E F

G, H

Figure 6–61. *(continued)* **E**, Closing eyes before surgery. **F**, After surgery. **G**, Lateral view of marked paralytic ectropion before surgery. **H**, After surgery.

used in the postoperative period (see below), and donor-site hemorrhage and infection (uncommon).[54] We perform a lateral tarsal strip in conjunction with lower eyelid retractor release and support with a palate mucosal graft in patients with a marked degree of lower eyelid laxity, ectropion, and retraction.

The surgery may be performed under general or local anesthesia. A side-mouth gag or a wooden spatula may be used. The graft is harvested between the gingiva and the midline where there is a well-defined submucosa allowing easy separation of the mucosa from the periosteum (Fig. 6–64). The graft site is limited to the hard palate. An outline of the desired graft is made on the dried mucosa with a skin marker. The hard palate is injected with 1 to 2 ml of 2% lidocaine with 1:100,000 epinephrine. A No. 11 Bard-Parker blade is used to incise the mucosa, with care being taken not to penetrate the mucoperiosteum. The usual size of graft required per eyelid is 5 mm wide and 20 to 25 mm long. The graft is dissected in the submucosal plane using a sharp Freer elevator, scalpel, or an angled Beaver blade. Suction cautery or bipolar cautery is used for hemostasis. Care must be taken not to overcauterize the bed of the graft as this delays healing. The dissection should stop 3 to 4 mm short of the junction of the hard and soft palate to avoid damage to the greater palatine vessels that pass through the greater palatine foramen located medially to the third molar and to avoid creating a fistula in the soft palate (Fig. 6–65). Care is taken to keep the palate periosteum intact. The fatty submucosa is removed from the graft and the graft placed in a saline-soaked gauze.

The lateral canthal region and the lower eyelid are injected with 2% lidocaine with 1:100,000 epinephrine. A 4-0 silk suture is passed through the eyelid margin to provide vertical traction on the lower eyelid while dissecting, and may be used as a vertical traction suture after surgery. A lateral canthotomy is performed with Stevens scissors, and the lower limb of the lateral canthal tendon is cut. The conjunctiva and the lower eyelid retractors are disinserted from the inferior border of the tarsus. This release extends medially to below the inferior lacrimal punctum. Once adequate hemostasis has been achieved, the graft is transferred to the bed and placed between the inferior border of the

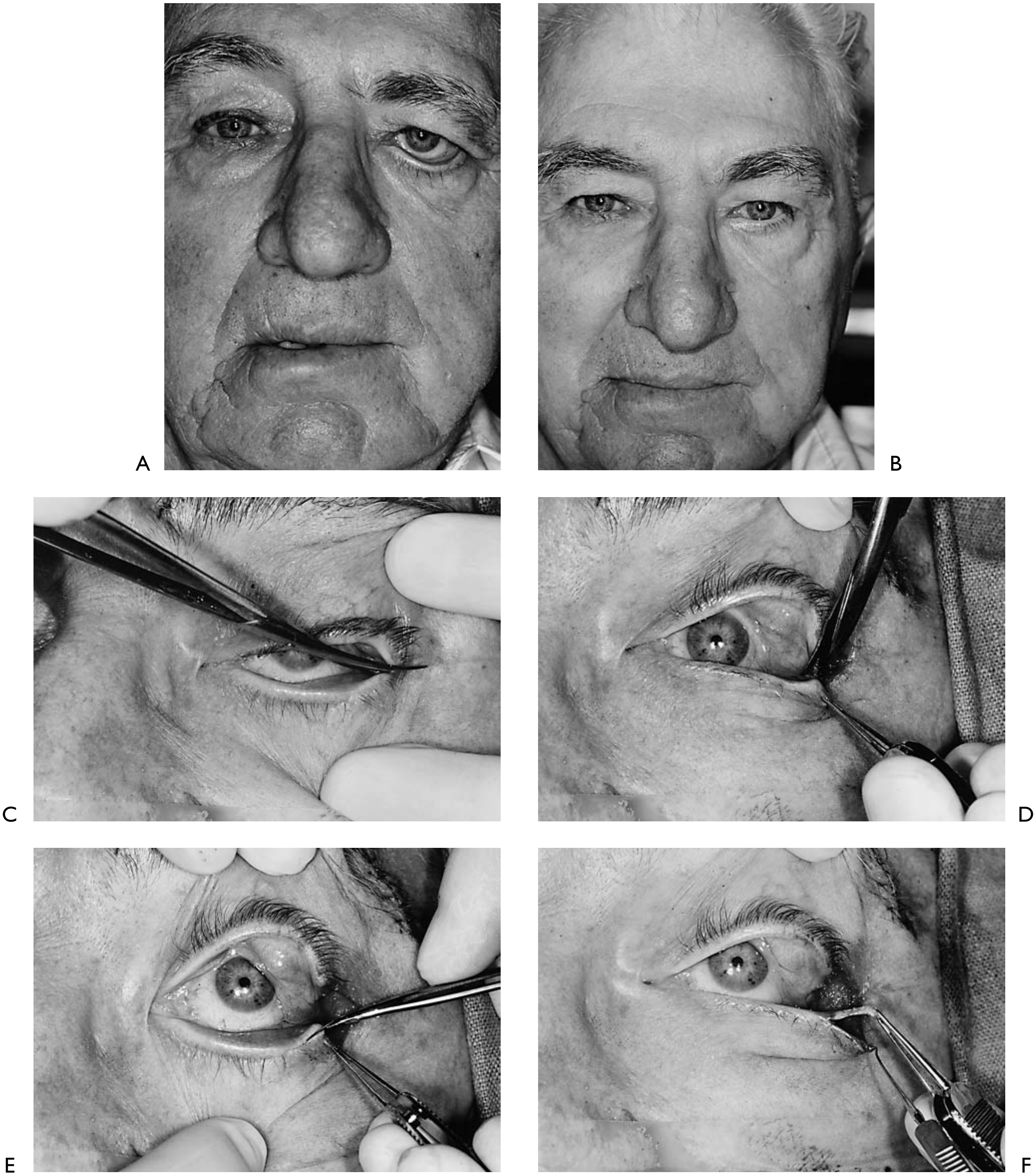
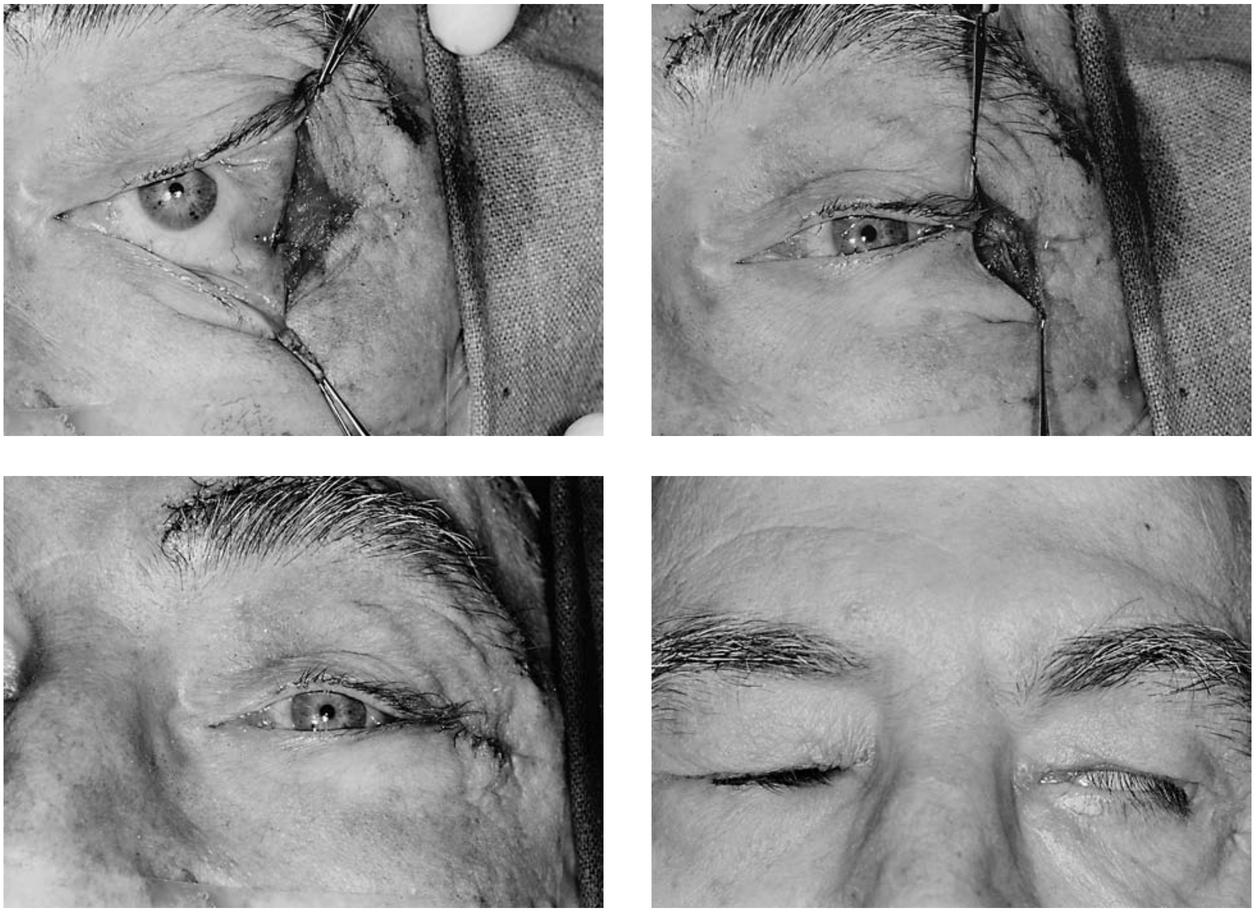
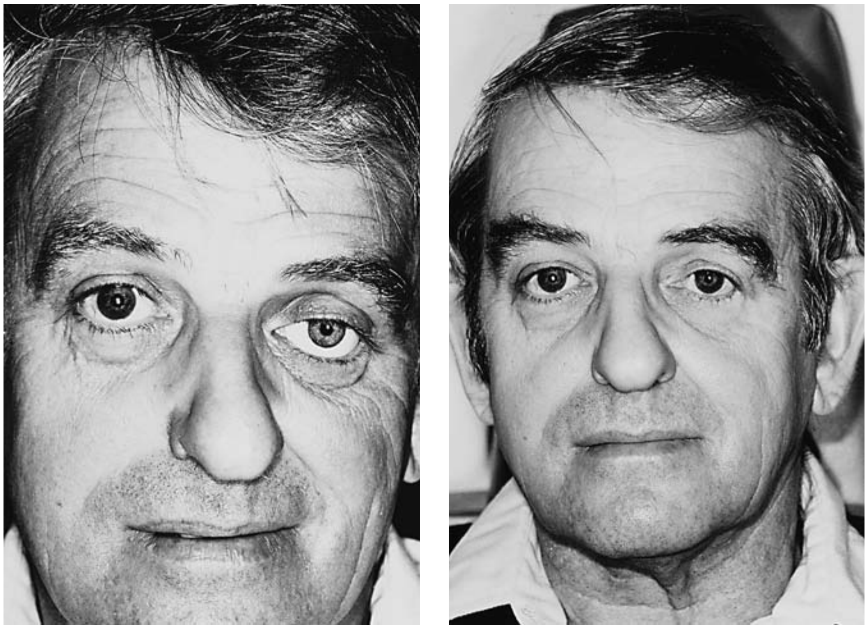


Figure 6–62. Tarsal strip procedure—Anderson technique. **A**, Patient with left-sided long-standing facial palsy and secondary lagophthalmos, laxity of the eyelids, and brow ptosis. **B**, Three months following upper and lower lateral tarsal strip procedure and direct brow elevation. The patient has greatly improved eyelid position and function, with improved corneal protection. Tarsal strip procedure performed by Dr. Richard L. Anderson in a step-by-step demonstration: **C**, Lateral canthotomy extended to lateral orbital rim. **D**, Inferior cantholysis and release of lateral retinaculum, which frees the lower eyelid to be mobilized superiorly. **E**, The eyelid is split at the grey line to form an anterior lamella and a posterior lamella. The entire height of the lower lid tarsus is fashioned into the lateral tarsal strip. **F**, The lateral tarsal strip is in a forceps, and the anterior lamella is retracted with a skin hook. The eyelid margin mucocutaneous junction has been stripped away from the tarsal strip, and the posterior lamella has been gently scraped with a scalpel to provide roughened edges. This tarsal strip is much longer than most tarsal strips, as this patient had marked lid laxity. Simply forming a tarsal strip without shortening it at all results in 6 mm of eyelid shortening, as the lateral canthal tendon is approximately 6 mm long. Most tarsal strips do not require shortening.



G H I J

Figure 6–62. *(continued)* **G**, An upper lid lateral tarsal strip has been formed in a similar manner. The upper eyelid tarsus is centrally 10 to 12 mm in height and temporally is much less. A 2- to 3-mm wide tarsal strip is created in the upper eyelid to avoid the palpebral lobe of the lacrimal gland temporally. If one transects the palpebral lobe of the lacrimal gland or its ductules, a dry eye may result. While lower tarsal strips are a very common operation for tightening lax eyelids of all types and are used in combination with many other procedures, upper and lower tarsal strips are reserved for cases of facial palsy with lax eyelids or cases where a lateral canthus is to be raised or lowered. **H**, The tarsal strips are sutured inside the lateral orbital rim. It is very important to suture the tarsal strips to the periosteum just inside the lateral orbital rim to direct the eyelids posteriorly and maintain contact with the globe. The sutures are usually placed just above *Whitnall's tubercle*, which is the normal site of insertion of the lateral canthal tendon. The lateral canthal tendon sutures are placed in a manner to elevate and tighten the eyelid, as it tends to stretch and sag somewhat with time. This stretching occurs especially in cases of facial palsy. In facial palsy, we now also usually disinsert the lower lid retractors and conjunctiva from the lower edge of tarsus and place a *palate mucosa* graft immediately below the tarsus to help support the lower eyelid (see Figs. 6–54 through 6–71). In some cases, we may combine this procedure with a *midface lift*, which helps relieve the inferior tension on the lower eyelid and helps maintain eyelid and facial position. Anderson prefers suturing tarsal strips to the periosteum with a 4-0 polygalactin 910 suture on a small, strong, half-circle P2 needle. This needle is the key to performing this procedure. A Castroviejo needle holder is used to hold the P2 needle, and this needle is rolled through the periosteum at the lateral orbital rim just above Whitnall's tubercle. A firm bite of periosteum is essential in suturing the tarsal strips. The suture is tied on the anterior surface of the tarsal strip to drive the eyelid as far posteriorly as possible and make a sharp lateral canthus. **I**, Although it may appear that excess skin is present at the lateral canthus, one must be careful not to remove too much skin. Skin from the lower eyelid is seldomly removed as the lower eyelid is raised, and excess skin is required to avoid inferior traction laterally. Skin sutures are placed from skin to deep periosteum and back to skin at the lateral canthus to form a sharp pateral canthal angle and avoid hooding of skin in this area. This usually utilizes what appears to be excess skin in this area. **J**, Postoperatively there is marked improvement of lid closure and much less lagophthalmos. The tarsal strip procedure is usally combined with a *gold weight* in the upper eyelid to improve closure and decrease lagophthalmos.



A, B

Figure 6–63. Results of tarsal strip procedure. **A**, Patient with an ocular prosthesis on the left. Years of stretching of the lower eyelid in the lateral canthus from wearing a prosthesis has created a marked facial asymmetry with inferior displacement of the lateral canthus and an orbital dystopia appearance. **B**, The same patient following an upper and lower lateral tarsal strip to elevate the lateral canthus and lower eyelid as well as a ptosis repair. Note the marked improvement in the facial asymmetry and orbital dystopia appearance simply from performing the lateral tarsal strip procedure associated with ptosis repair. This operation is extremely versatile, as demonstrated in this patient. The lower lateral tarsal strip procedure has become one of the most common procedures in our practice of oculoplastic surgery. The upper tarsal strip is reserved for marked lid laxity associated with facial palsy or marked canthal malpositions.

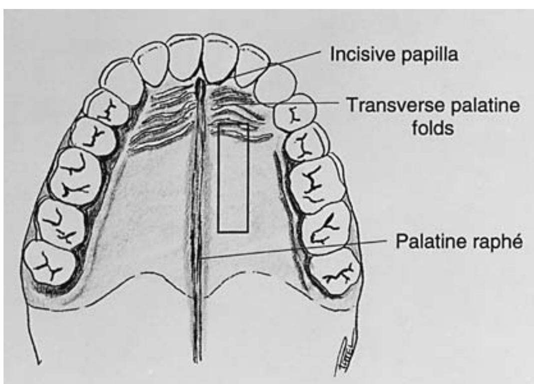


Figure 6–64. Anatomy of the hard palate. The graft is harvested between the gingiva and the midline where there is a well-defined submucosa allowing easy separation of the mucosa from the periosteum.

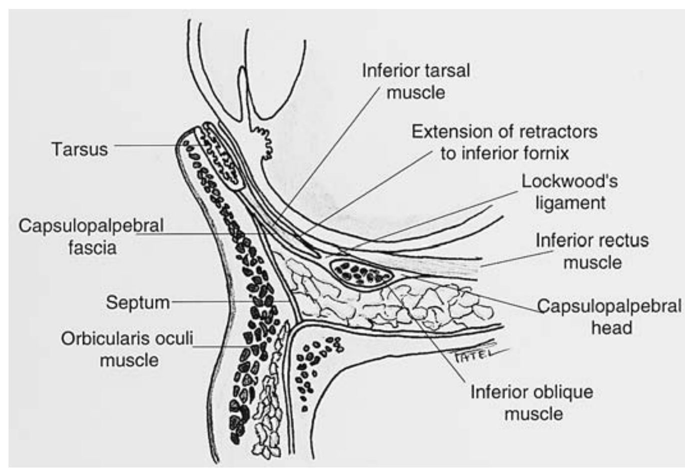


Figure 6–66. Cross-sectional anatomy of the lower eyelid.

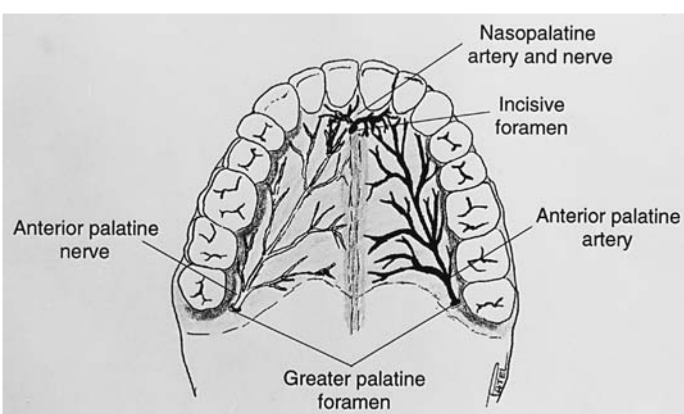


Figure 6–65. Vascular anatomy of the palate.

tarsus, and the recessed conjunctiva and lower eyelid retractors with the mucosal side against the cornea (Figs. 6–66 through 6–68). The palate mucosal graft is wider medially in order to provide more vertical support medially, thereby correcting the medial lower eyelid retraction and caruncle exposure. The graft is sutured into place using a running 6-0 chromic catgut suture tied on the skin or in the inferior fornix. A lateral tarsal strip is fashioned and sutured as high as possible to the inner aspect of the lateral orbital rim to supraplace the lateral canthus using a 4-0 polyglactin 910 suture on a P-2 needle. This corrects horizontal eyelid laxity and lateral canthal rounding and provides vertical support to the eyelid. In almost all cases, actual shortening of the tarsus is not performed. Simply making a lateral tarsal strip tightens the eyelid by about 6 mm (the length of the

Figure 6–67. Palate mucosal graft sutured with buried sutures between the recessed conjunctiva and eyelid retractors, and the inferior border of the tarsal palate. The forceps are holding the lateral tarsal strip.

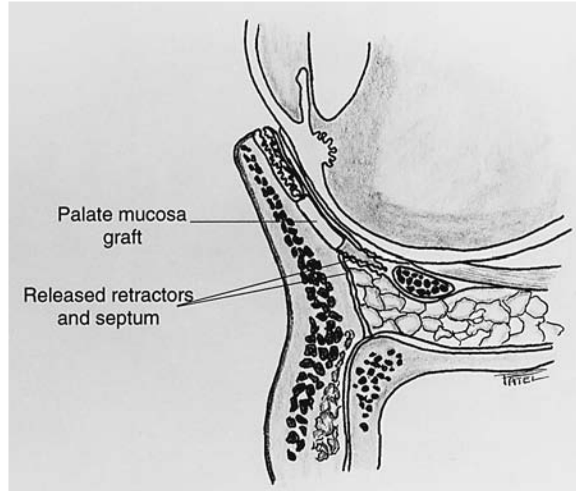


Figure 6–68. Cross-section of the lower eyelid to show the position of the palate mucosal graft.

lateral canthal tendon). Supraplacing the canthus as much as possible further tightens and supports the eyelid. This restores the position of the lateral canthus relative to the medial canthus. The overcorrection and Mongoloid slant induced in the early postoperative period resolves with time. We strive for early overcorrection. A bandage dissolvable collagen contact lens is placed on the cornea to protect the cornea from being abraded by the palate graft or the sutures.

A soft diet is prescribed for 7 days. Patients wearing dentures are allowed to resume their use immediately. An obturator for the roof of the mouth made prior to the surgery allows the patient to resume a normal diet more quickly (Fig. 6–69). However, we have found that with careful harvesting of the palate mucosa and avoidance of excessive cautery, most patients can resume a soft diet immediately and a normal diet within 2 to 3 days. The donor site usually heals within a week (Fig. 6–70). We frequently perform this procedure in patients who are referred to us with persistent symptoms after the insertion of a gold weight (Fig. 6–71).

Cartilage Strut Implant The technique as performed by May is illustrated in Figure 6–72. Over a period of 10 years, 176 cartilage struts have been implanted in 176 patients.

Complications occurred in 12 patients (7%): infection (3), periorbital edema (2), hematoma (1), ecchymosis (1), conjunctivitis (1), exposure keratitis (1), failure to correct the

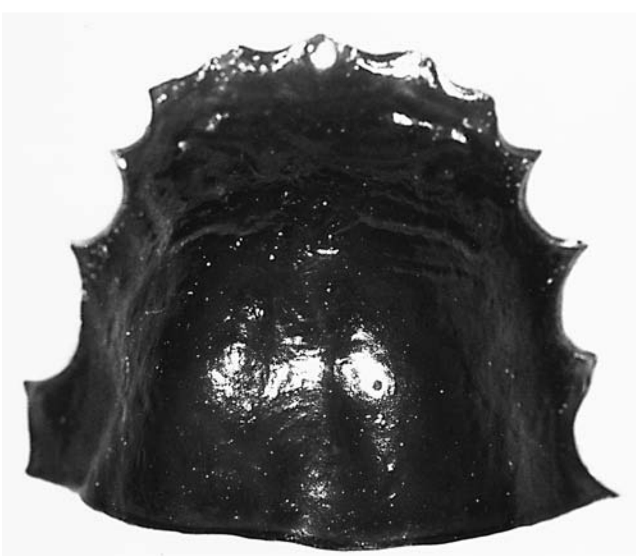


Figure 6–69. A self-retaining obturator protects the donor site and considerably improves the patient's comfort.

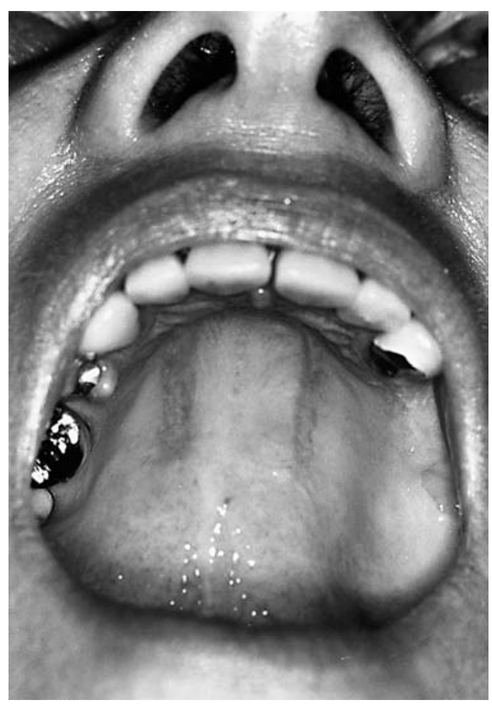
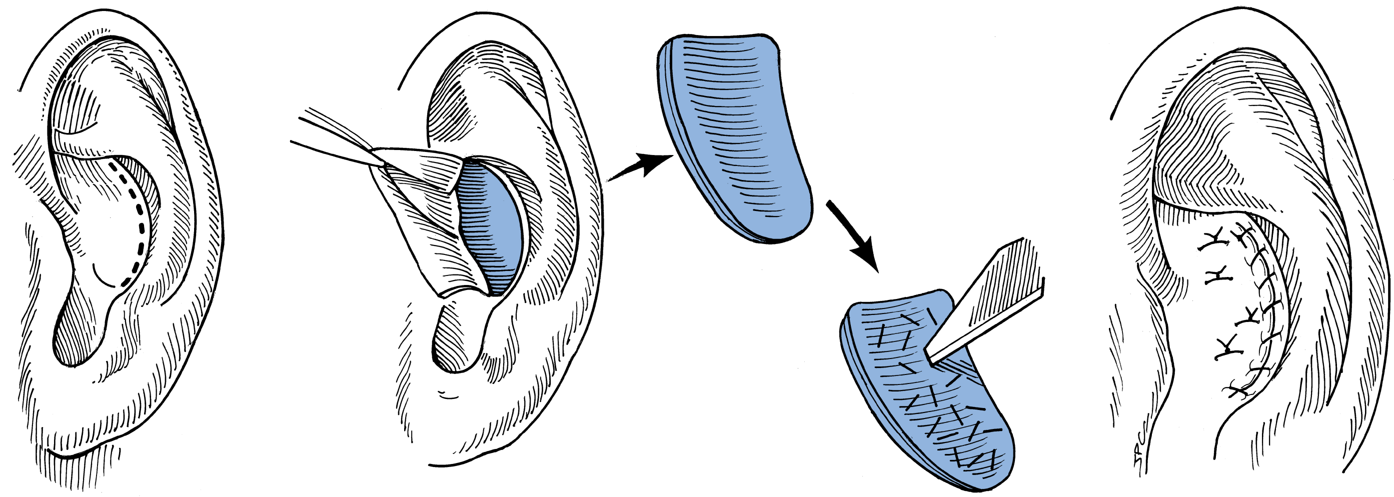


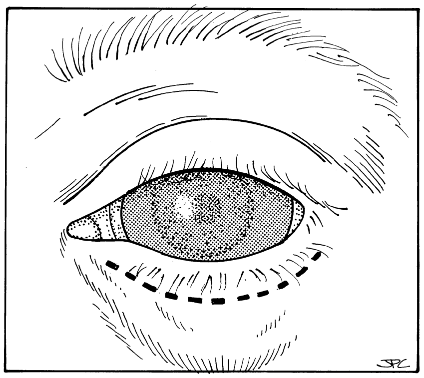
Figure 6–70. Appearance of the donor site at three weeks.

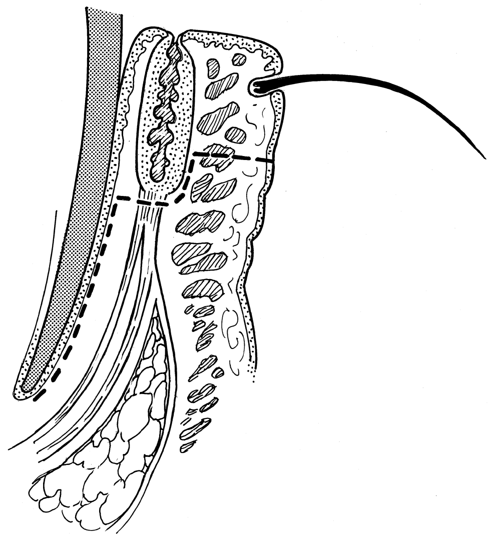
A B C D E F

Figure 6–71. **A**, Left-sided facial palsy following resection of an acoustic neuroma. Note the mild brow ptosis, upper eyelid retraction with a temporal flare, lower eyelid retraction, and ectropion with increased scleral show medially as well as laterally. **B**, Marked lagophtahlmos of greater than 1 cm with a poor Bell's phenomenon. **C**, Following insertion of a gold weight, there is improvement in the upper eyelid retraction. The lower eyelid retraction and ectropion persists. **D**, Persistent lagophthalmos of 4 mm with medial, central, and lateral scleral show. The patient was considerably improved but still needed ointment several times a day and at night. **E**, Following recession of the lower eyelid retractors, insertion of a palate mucosal graft and a lateral tarsal strip, there is improvement in the scleral show and better apposition of the lower eyelid to the globe. Note the improvement in the medial scleral show achieved by extending the palate graft medially to below the punctal area. **F**, Complete closure. Patient requires intermittent use of drops during the day.

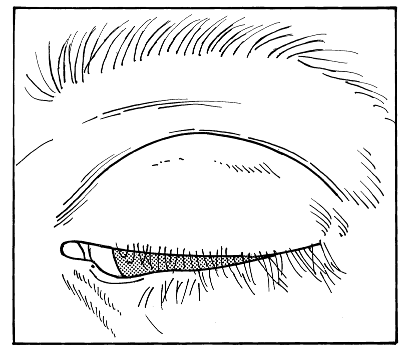


A–C

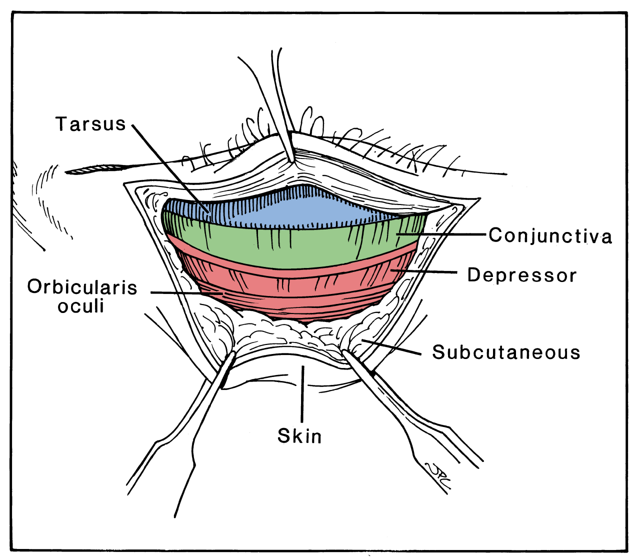




D, E



G



F

Figure 6–72. Auricular cartilage strut implantation—May's modification. Lower eyelid reanimation with cartilage is performed under local anesthesia. One percent lidocaine (Xylocaine) with 1:100,000 epinephrine is injected into the area of the concha symba on the lateral portion of the pinna, the corresponding medial portion of the pinna to block cervical cutaneous innervation, and the lower eyelid in the area where a subciliary incision is made. Topical anesthetic is applied to the patient's cornea, and a protective scleral shield is placed. **A**, The auricular cartilage is harvested from the concha symba of the ipsilateral ear. **B**, A U-shaped flap, anteriorly based, is elevated and the cartilage is harvested in such a way that perichondrium is left attached to both surfaces. The cartilage is then trimmed and stippled with a No. 15 blade through the perichondrium and cartilage on the lateral concave side, but not through the perichondrium on the deep side. This maneuver reduces the stiffness and curvature of the cartilage implant. The cartilage implant is trimmed and placed in such a way that it not only conforms to the general curvature of the globe, but also to the inferior border of the lower tarsus. **C**, The flap of skin on the pinna is sutured closed with a running 6-0 chromic suture, and the dead space is obliterated with 4-0 chromic mattress sutures. **D**, The subciliary incision is placed 3 mm below the lash line. **E**, The cross-sectional anatomy of the eyelid incision and dissection. The first incision extends to the surface of the tarsus. Then, in a step fashion, down the inferior face of the tarsus through the inferior depressors to reach the conjunctiva identified by the green contact lens showing through the transparent conjunctiva. **F**, The lower border of the lower tarsus is identified, and the inferior depressor muscles are separated from the tarsus so that a plane is developed immediately superficial to the conjunctiva. Then, the dissection is extended inferiorly to the level of the conjunctival cul-de-sac, about the level of the orbital rim. **G**, Medial "gaposis" frequently persists in spite of eyelid reanimation procedures because the eyelids close from lateral to medial. *(Figure continued next page.)*

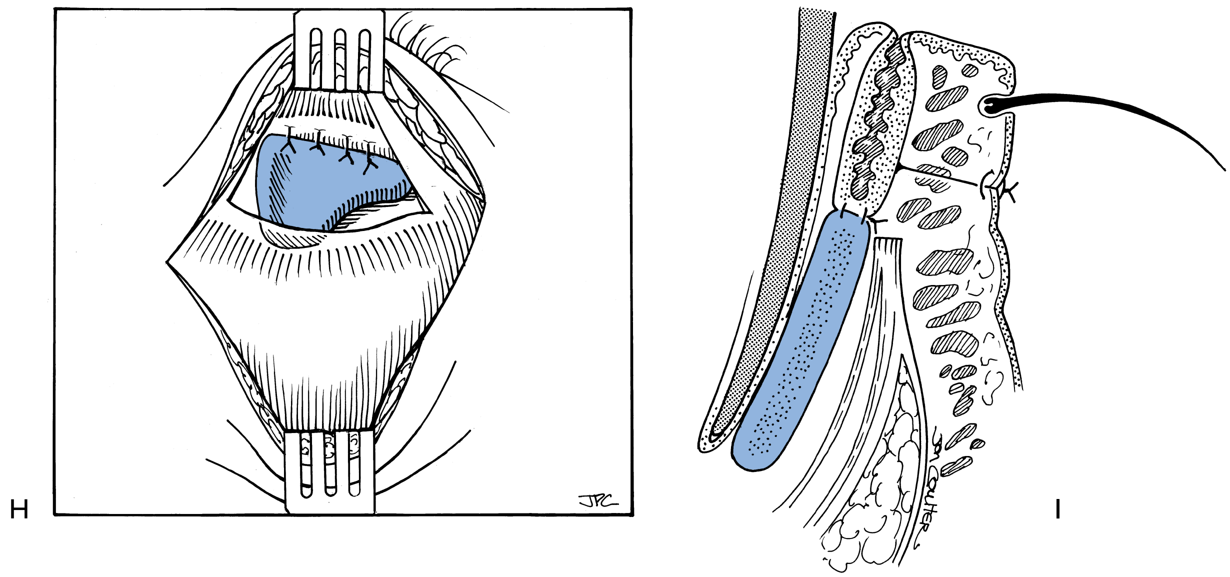


Figure 6–72. *(continued)* **H**, In an effort to correct this problem, the cartilage implant is shaped to have a greater height on the side placed under the medial aspect of the tarsus. The cartilage is inserted into this pocket and sutured with interrupted 8-0 nylon sutures to the lower border of the inferior tarsus. **I**, The skin is closed with a running interrupted 6-0 chromic suture. When a lower lid tightening procedure (modified Bick procedure, Fig. 6–60) is needed, it is performed after insertion of the cartilage implant to prevent tension on the lateral canthal repair, as the pocket for the cartilage implant is developed.

ectropion (1), lower lashes exfoliated (1), and skin breakdown over the donor sight (1). *Postoperative hematoma ecchymosis swelling* and even *infection* occurred in 7% of cases in spite of meticulous adherence to perioperative care and surgical technique. *Exposure keratitis* occurred in a patient with corneal anesthesia due to a fifth nerve deficit following a posterior fossa procedure and probably was not related to the cartilage strut implant. Failure to correct the *ectropion* relates more to expecting the cartilage strut to take the place of a lid shortening procedure. *Loss of lower lid* lashes occurred in one patient because the dissection extended to the lid margin and compromised the lash follicles. The *skin breakdown* over the ear donor site in one patient was probably due to compromise of the blood supply. *Perichondritis* following conchal harvest was reported in a patient with prior frostbite.[46] Although this problem has not been encountered in our series, since there is a reported case of this occurrence, it would be prudent to question patients regarding prior frostbite before scheduling a conchal cartilage implant.

Revisions were required in four patients. The cartilage was too large and placed lateral to the orbital septum in one. In another, a small area of the edge of the cartilage implant was prominent under the skin. In both cases, the deformity was corrected by trimming. In two patients, the cartilage separated from the lower border of the tarsus and was corrected by refixation with permanent suture. The *cartilage was removed* in five patients because it produced a prominent show under the skin in two, became infected in one, and facial function recovered enough so that cartilage could be removed in two patients.

The major reasons for revision and the need to remove the cartilage related to inadequate trimming of the implant, placing it in the wrong plane, and failure to fix the cartilage with interrupted 8-0 permanent sutures to the lower margin of the tarsus. These details of the cartilage strut procedure are stressed in Figure 6–72.

This procedure improved the position of the lower lid as well as restored function and appearance in over 90% of cases. Patients followed for up to 10 years demonstrated that the cartilage was not resorbed and remained stable. Close adherence to proper patient selection and surgical technique ensures the success of the cartilage strut technique.

Lower Lid Suspension There are a number of procedures designed to suspend the lower lid, however, there are three that seem appealing.

Temporalis Muscle-Fascia Sling The temporalis muscle-fascia sling (Fig. 1–10) or fascia lata sling[55] is technically the easiest of the group, but ectropion and the eye remaining open at night are two of its shortcomings. The temporalis muscle-fascia sling, in addition, creates a mass movement effect. When the patient voluntarily attempts to close the eye, the mouth moves, or with mouth movement and particularly when chewing, the eye closes rhythmically with chewing efforts. Separating eye closure from mouth movement requires using a separate system for each region.

Silastic Encircling Procedure[32] This technique dynamically reanimates the upper and lower eyelids. It is an ideal approach but a temporary measure with short-term results. By the third to the sixth month, the Silastic begins to stretch and on occasion even breaks. Based on this experience, the procedure has lost popularity.

Fascia and Nasal Cartilage Implant Procedures Flowers and Caputy[48] described a technique that combined a nasal cartilige strut with a fascial sling for suspension. The authors are from Hawaii and named their procedure the "diamond head" graft for paralytic ectropion of the lower lid. The configuration of the graft resembles Diamond Head, an extinct volcanic crater visible from the shores of Waikiki. The authors recognized the need to provide medial support to the lower lid, especially in the area of the punctum and the juxtaposed lower lid. They noted, as have we, that frequently following eyelid reanimation procedures there was a gaping defect and excessive exposure of the medial coruncle. The medial canthoplasty described in Figure 6–53 corrects this problem, but frequently it is not lasting because the adhesion created between the upper and lower lid in this region begins to stretch over time. Flowers and Caputy corrected the sagging punctum by directly elevating it with a cartilage graft taken from the nasal septum and supported it with a fascial sling suspended between the lateral wall of the nasal bone and the lateral orbital rim. The procedure required drilling holes in the nasal bone and orbital rim as well as taking donors from the nasal septum and fascia lata.

The authors pointed out that nasal septal cartilage is thinner and more delicate than the conchal cartilage graft and therefore is more suitable as a lower eyelid implant.

In spite of their enthusiasm, the procedure is technically demanding, and more importantly, the results achieved with this unique approach can be matched by the cartilage[45] or palatal[51] implant techniques. However, the point made by Flowers and Caputy regarding the shape of the cartilage implant and its placement to address the position of the medial aspect of the lower lid is an important observation. This concept has been incorporated in the *cartilage strut procedure* as illustrated in Figure 6–72.

Other Lower Lid Procedures

Midlid Wedge Resection Most of our patients are referred with tarsorrhaphies in place. If the tarsorrhaphy is in the vicinity of the midlid and particularly if lid shortening is required, a *midlid wedge* resection is useful for this situation (see Fig. 6–41 for patient example, and Fig. 6–73 for description of technique).

Lateral Tarsorrhaphy There are cases where combining a lateral tarsorrhaphy helps support the lower lid, if a *lateral tarsorrhaphy* is not in place (Fig. 6–74).

Midface Lift There are some patients with dense facial palsies in whom a lateral tarsal strip, palate mucosal graft and medial canthoplasty will be insufficient for adequate lower eyelid support and lid-globe apposition. These patients generally have marked midfacial ptosis with further exacerbation of the lower eyelid position due to the gravitational pull on these structures. Repositioning these ptotic midfacial tissues will provide additional support to the lower eyelid and lateral canthal region.

Normal changes of aging such as descent of the malar fat and orbicularis, production of a groove at the inferior orbital rim, malar laxity and folding, and formation of jowls are greatly exacerbated in the presence of facial palsy. The principle of midfacial elevation is to form a composite cheek flap and elevate it *en mass* superiorly and superolaterally.[56]

An extended lower eyelid transcutaneous blepharoplasty incision may be used for access to the midface. The other approach is to extend the lateral canthotomy incision laterally for 2 cm. The dissection is carried down to the

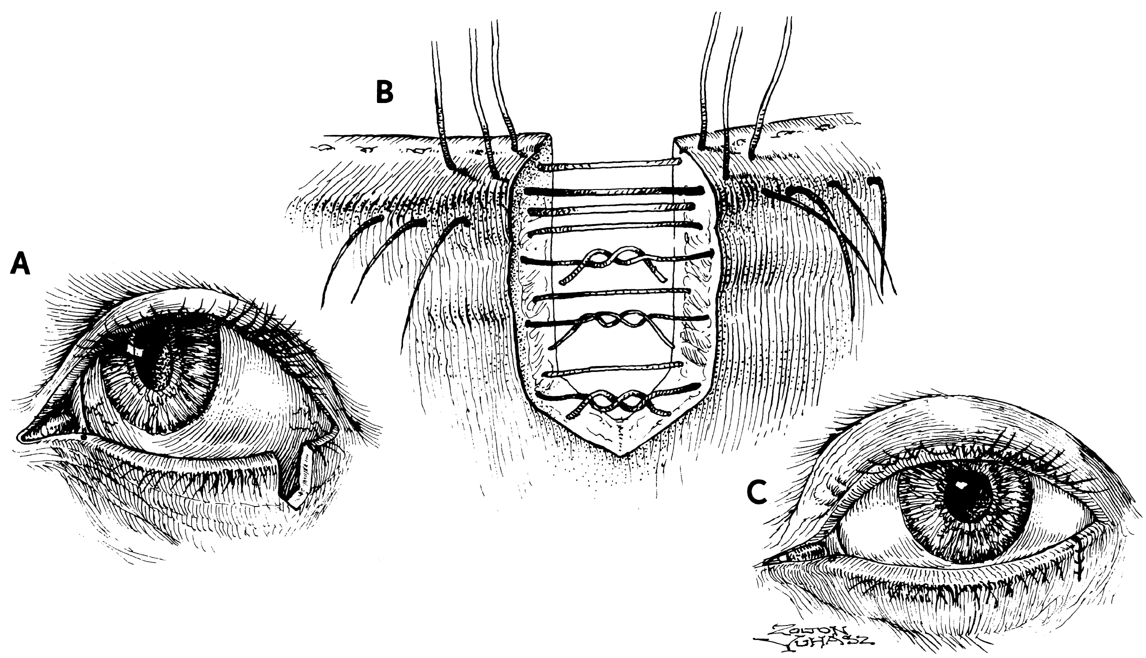


Figure 6–73. Lower lid wedge resection. Technique of lid shortening. **A**, Excess full-thickness lid is excised. **B**, Sutures are placed to perfectly align the wound edges, especially at the lid margins. **C**, Shortened lid in its improved position. Figure 6–41 shows a case where this approach was ideal. (From Levine RE.[1] With permission.)

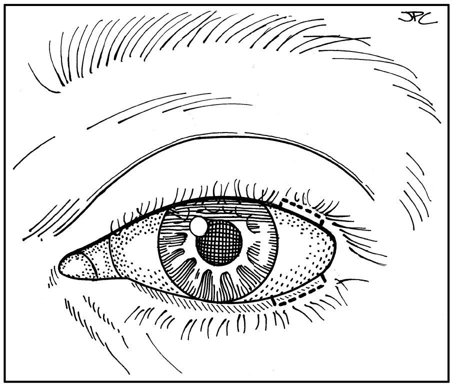
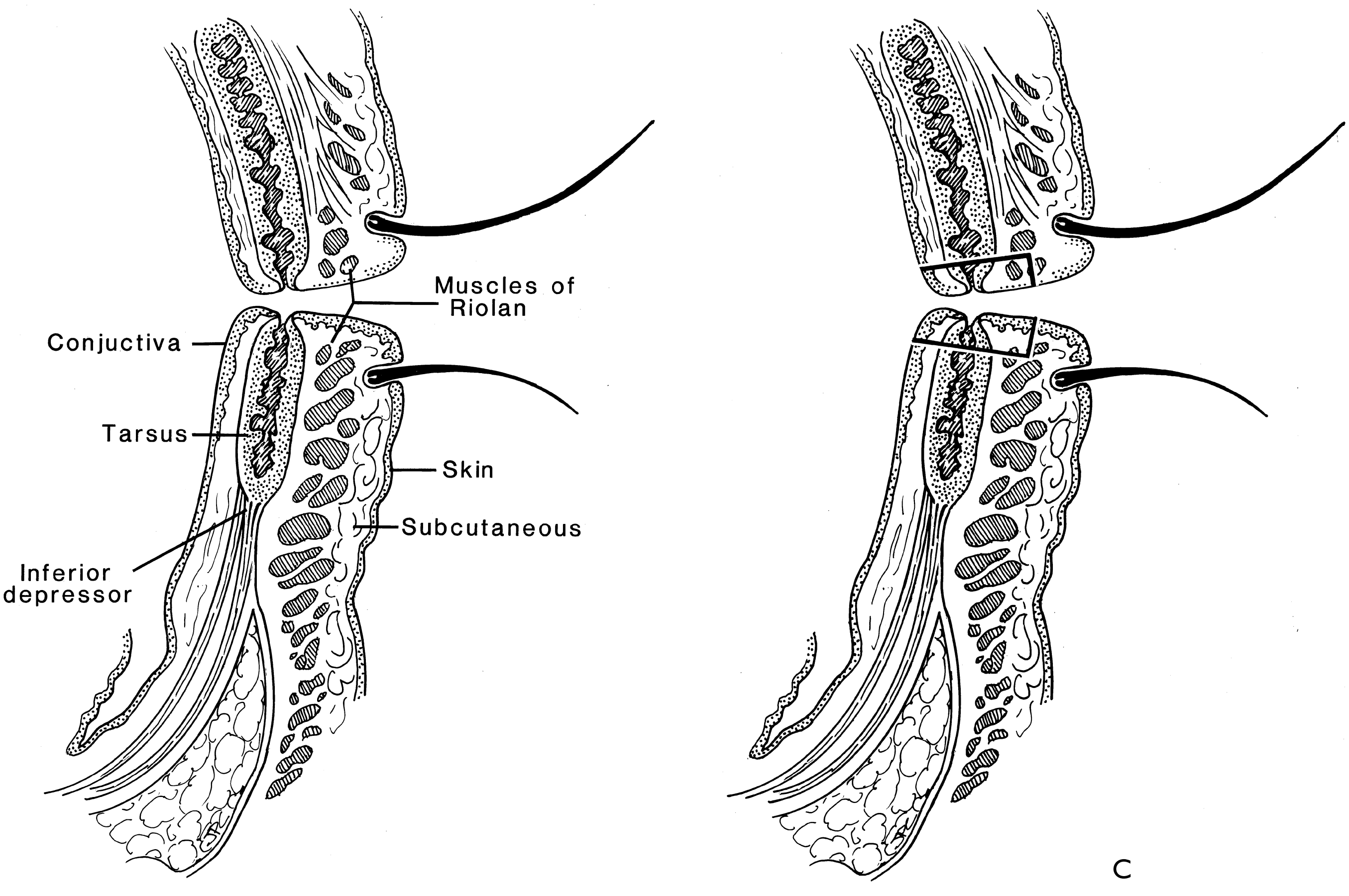
A


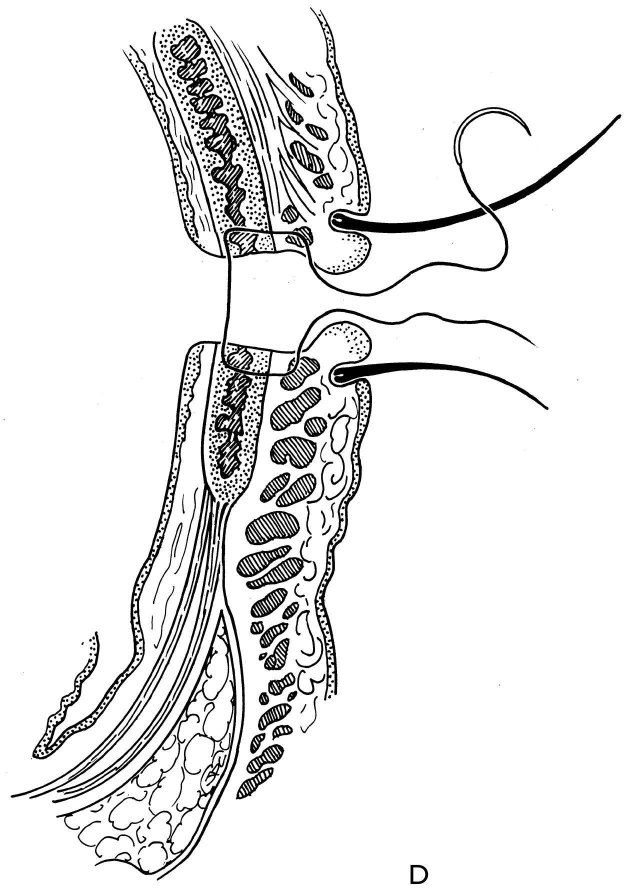
Figure 6–74. Lateral tarsorrhaphy technique. The technique described attempts to achieve the following goals: (1) elevate the lower eyelid to improve eyelid closure especially when combined with other procedures, (2) preserve the integrity of the eyelashes avoiding trichiasis and lid notching, (3) ensure the surgical site forms a "non-spreading band" and a permanent weld, and (4) maintain vision and aesthetics. **A**, The location and intended sites of resection along the tarsal plates. **B**, An anatomical cross-section of the eyelids is useful to appreciate the tissues resected to achieve the proposed goals of this procedure. **C**, The area resected includes opposing surfaces of the upper and lower lid margins with care to preserve the lashes (skin, muscle, follicles).



B C

periosteum of the zygomatic maxillary complex and a subperiosteal dissection is performed over the zygoma, the maxilla, lateral and medial to the infraorbital nerve and down to the buccal sulcus. We usually use a buccal incision to obtain adequate mobilization of the cheek. This allows one to maintain the subperiosteal dissection plane more effectively with minimal risk or injury to the overlying soft tissues. Care is taken not to injure the infraorbital nerve. Care must also be taken not to traumatize the buccal fat pad when dissecting laterally. The anterior superficial fibers of the masseter are lifted off the anterior aspect of the inferior part of the zygomatic arch. The periosteum is released at the piriform fossa, over the canines and laterally on the maxilla, forming a full thickness myocutaneous flap (Fig. 6–75A).

The composite flap is moved superiorly and superolaterally to reposition the ptotic tissues into their normal anatomical position. We generally aim to obtain an overcorrection as some degree of descent of the tissues always occurs postoperatively. The elongation of the zygomaticus major muscle that occurs with this suture also may cause some desirable elevation of the corner of the mouth. Several sutures (3-0 PDS) are used to anchor the mobilized periosteum superiorly (to the inferior orbital rim) and superolaterally to the temporalis fascia (Fig. 6–75B). The number of sutures used varies according to the degree of support required (Fig. 6–76). The buccal incision is closed with a few sutures, thereby allowing drainage to occur postoperatively. Transient hypesthesia of the lateral cheek may be seen, but the sensation has returned to normal in



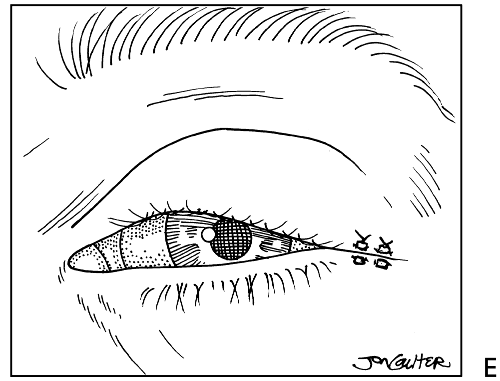


Figure 6–74. *(continued)* **D**, Mattress 6-0 silk sutures are placed. The ends of the sutures are left long enough to easily remove in 14 days. **E**, The closure is reinforced with bolsters left in place 14 days.

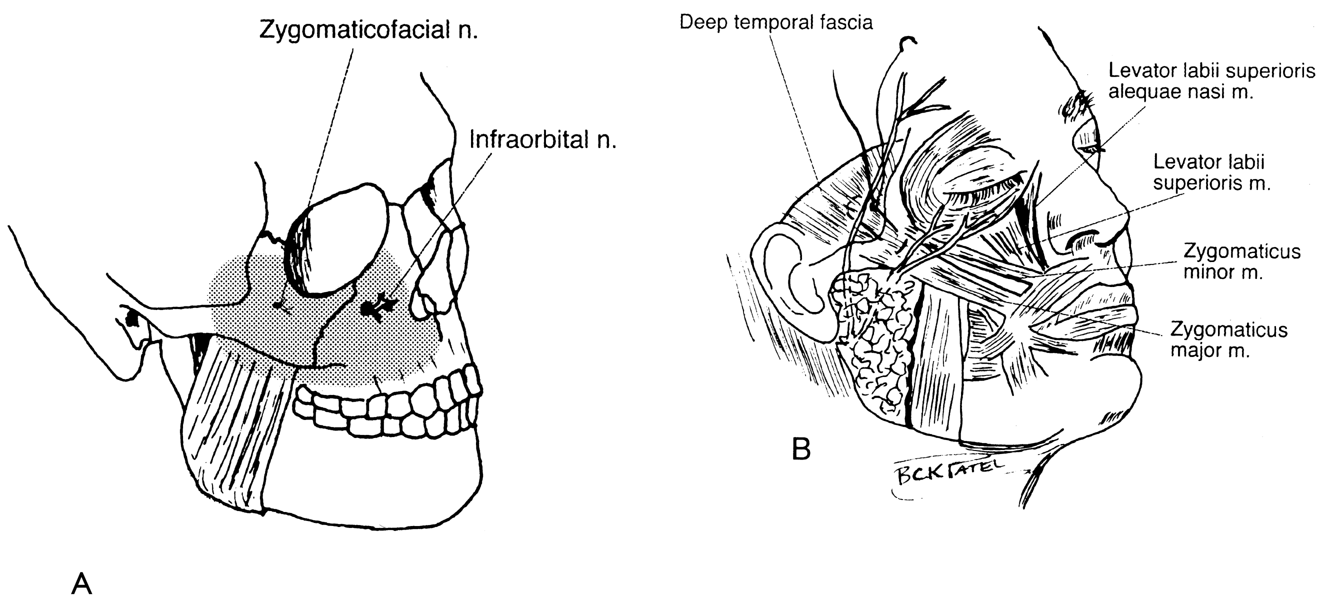
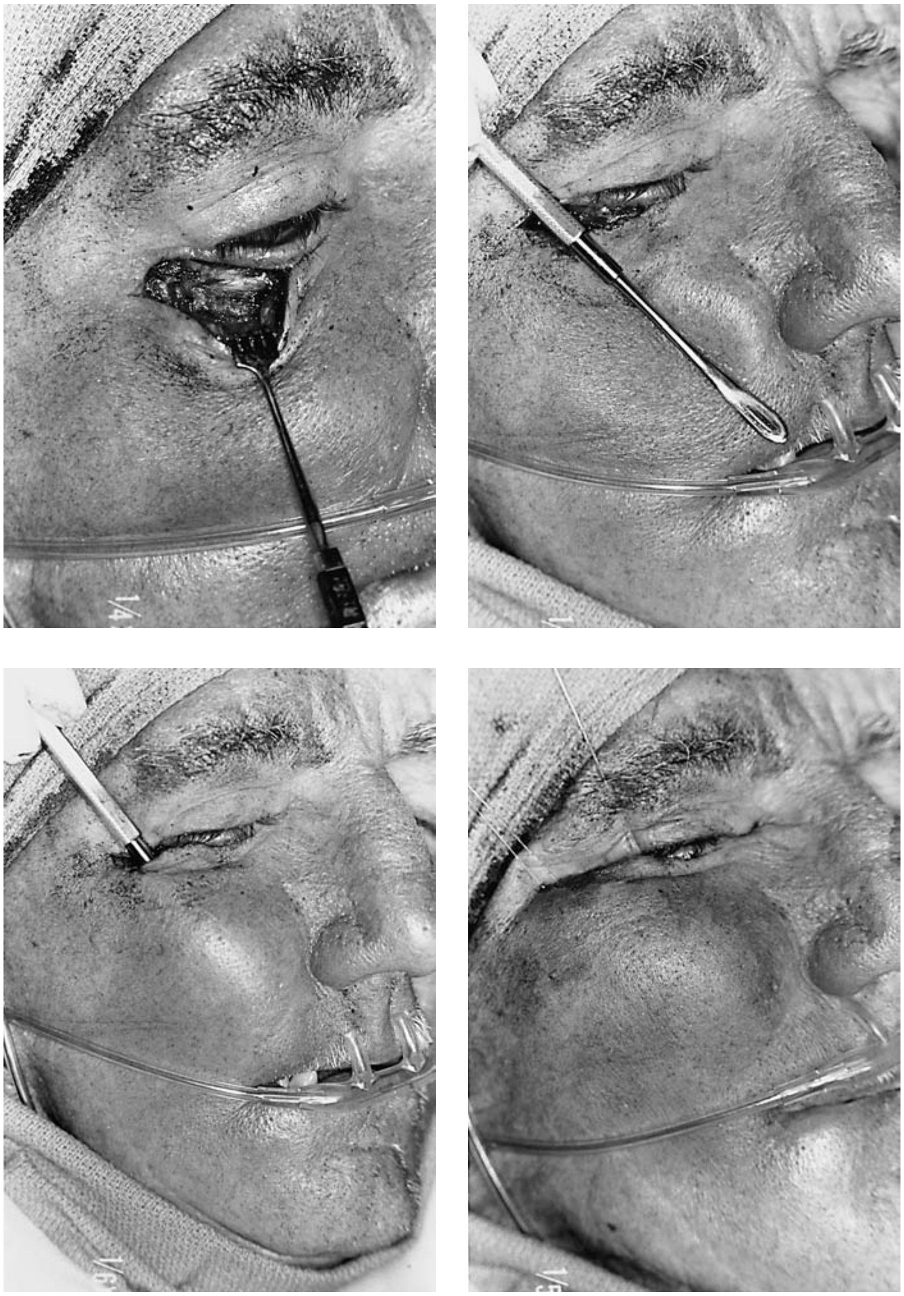


Figure 6–75. **A**, Extent of the subperiosteal dissection over the frontal process of the zygoma, the anterior third of the zygomatic arch, the maxilla, lateral and medial to the infraorbital nerve and down to the buccal sulcus. The periosteum is released at the piriform fossa, over the canines and laterally on the maxilla, forming a full-thickness myocutaneous flap. **B**, Suspension of the midfacial tissues to the deep layer of the temporal fascia. Several sutures may be used to obtain adequate elevation and support.



A, B

C, D

Figure 6–76. Midface elevation. **A**, An extended transcutaneous blepharoplasty incision. **B**, **C**, Extent of the subperiosteal dissection. **D**, Elevation of the midface with sutures in a superior and superotemporal direction.

all our cases. This procedure is frequently performed with other lower eyelid supporting procedures (Fig. 6–77).

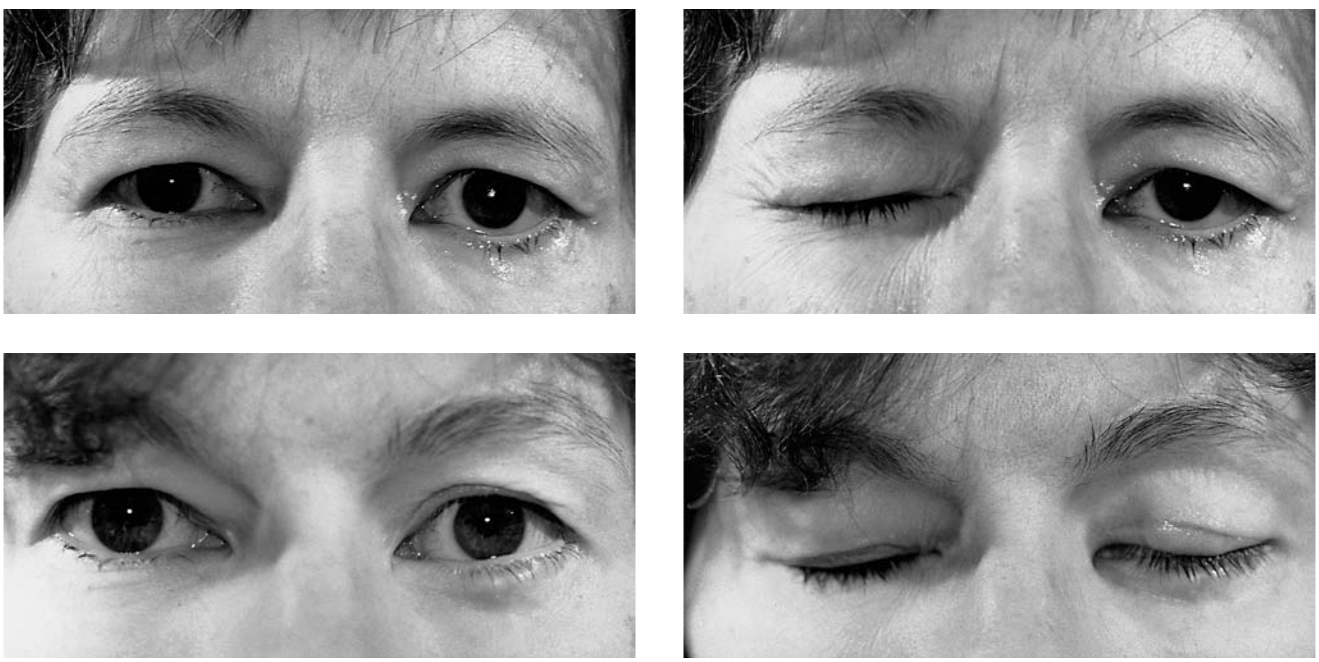
Results of Lower Lid Procedures Examples of the results that can be achieved with the above procedures used in combination are demonstrated in Figures 6–60 and 6–61.

Summary of Variety of Approaches to Restore Eyelid Function There are a variety of approaches to re-establish the position and function of the eyelids. Table 6–16 attempts to credit the originators of specific procedures when possible.

Eponyms and Eyelid This brings up the subject of eponyms, defined as the name associated with an operation based on who first described or popularized the procedure. Certainly the experienced surgeon realizes that none of us are capable of reproducing the exact procedure described by a particular author. We learn principles and then apply those principles to a particular situation. Having performed thousands of reanimation procedures, it would not be accurate for me to refer to an operation by someone's name, knowing clearly that I am not performing the operation as originally described. Further, each time a procedure is performed, it is modified to address a particular set of clinical problems. This is the art of surgery and is an essential part of correcting the almost infinite number of situations that one encounters when trying to improve the condition of the paralyzed eyelids. The ability of the master surgeon to apply principles and to extemporize to apply them to the particular situation is an essential part of being a successful reanimation surgeon. This quality is essential for all of us in the surgical discipline.

A, B

Figure 6–77. Midface elevation. **A**, Patient with left facial palsy has already had medial and lateral canthoplasty. Severity of midfacial ptosis together with a negative vector of the malar eminence caused a recurrence within a few weeks. The patient underwent a midfacial subperiosteal elevation and insertion of a facia lata lower eyelid sling. **B**, Four months following surgery. Note the improvement in the midfacial tissues and the oral commisure.



A B C D

Figure 6–78. Example of cartilage implant for lower lid combined with gold weight for upper lid. **A**,**B**, Patient with sagging of lower lid. Compare scleral show under cornea between normal right to left side. Note the lower lid lashes are drooping, irregular, and matted, a sign of long-standing total denveration (see Fig. 6–8). There is poor approximation of the lower lid to the globe contributing to poor tear distribution and drainage. The upper eyelid does not close at all with an effort to close the eyes, and the Bell's phenomenon is absent. Symptoms of exposure are severe. The prominent supratarsal fold make this patient an ideal candidate for a *gold weight*. The lower lid could be improved with a *cartilage implant* and lid tightening with a modified *Bick procedure*. **C**,**D**, Eyes open and closed following gold weight implant to upper lid, and cartilage and modified Bick to lower lid. (From May M et al.[44] With permission.)

Eponyms create confusion by suggesting that when a particular reported procedure is attributed to an author such as the Kuhnt-Szymanowski[57,58] or McLaughlin[59] lateral tarsorrhaphy technique, the procedure adheres to the original description.

This problem of eponyms is brought out clearly by an article written by Wesley and Collins.[60] The authors described an ectropion repair technique and referred to it as the McCord procedure for ectropion repair. Wesley and Collins referred to the article by McCord and Moses[61] where a lateral canthotomy and inferior cantholysis is described in order to gain access and exposure to the inferior orbit. There was no indication in this original contribution by McCord and Moses that the approach was

Figure 6–79. Results of eye reanimation by static procedures. **A**, Sixty years following facial paralysis associated with diphtheria. Face in repose. **B**, Smiling. **C**, Attempt to close the eye. **D**,**E**,**F**, One year after lid wedge, canthopexy, and brow lift procedures performed by Dr. George Buerger, an ophthalmoplastic surgeon, and mouth reanimation with fascia lata (see Chapter 7 for this approach, Figs. 7–8 and 9). **D**, In repose. **E**, Smiling. **F**, With eye closed.

intended to tighten the lower lid. Thus, we have an example of an eponym that becomes a misnomer.

The "Bick" procedure is another example of the confusion caused by the use of eponyms. Our favorite lower lid tightening technique is one that we refer to as the "Bick" procedure, yet the procedure we perform really is not what Bick described.[42] Actually, what we refer to as the "Bick" procedure is a combination of "McCord's" lateral canthotomy and inferior cantholysis and "Bick's" lateral wedge resection for shortening and tightening the lower lid (Fig. 6–53).

The use of eponyms encourages giving proper credit to our teachers and would be appropriate if we could reproduce exactly what was taught. A suggestion is to give appropriate credit to the author(s) who first introduced the surgical concept without naming the operation after the author(s). For example, the concept of including the supratarsal fold to repair a drooping brow was learned from an article by Luxenberg (1973).[62] Although the principle reported by Luxenberg was used, the procedure was not referred as the Luxenberg procedure (see Fig. 6–24). Nuances of techniques are often not published, but instead authors refer to the eponyms and so the eponyms live on. It would be preferable if authors described their surgical technique as well as their rationale for what they have described. Hopefully we have satisfied this recommendation by providing figures and legends that describe the surgical procedures we use.

Lacrimal System

The Wet Eye

Tear Function The facial reanimation surgeon must be just as comfortable analyzing and correcting lid position problems as with the tear system. If the evaluation is beyond the limits of the expertise of the reanimation surgeon, then consultation with an ophthalmologist is mandatory. An intact or restored tear system greatly enhances the success of restoring upper and lower lid position.

Lavrich and Nelson[63] discussed disorders of the lacrimal system and described tear function, source, and drainage. The authors pointed out that tears are a vital component of the visual system, protecting the eyes by lubricating them, and thus providing oxygen and antibacterial substances. Tears are critical to maintain the integrity of the cornea, and without tears, vision as we know it would not exist.

The *tear film* is a complex structure composed of three layers. The innermost layer is mucin, produced by goblet cells scattered all over the conjunctiva, and serves to wet the cornea, allowing the tear film to spread evenly over it. The middle layer is aqueous and is made up of secretions mainly from the lacrimal gland. The outer layer is oily and arises from glands along the lid margin as well as from within the tarsus. This lipid layer stabilizes the tear film and reduces evaporation. This critical tear film is provided by a *basic tear production* that has no known stimulus or specific innervation.

Overflow tearing referred to as *epiphora* is a result of *reflex tearing* that is produced by the main lacrimal gland. This gland sits in the lacrimal fossa in the superior-temporal aspect of the orbit. It is divided into an orbital and a palpebral lobe separated by the levator aponeurosis. *Irritative reflex tearing* is by sympathic and parasympathic efferent neurons. There are a number of neural pathways that produce tearing. Tearing is induced by physical irritation via the trigeminal nerve through the central nervous system as with physiogenic tearing or crying and bright light.

Tear Dysfunction Doane[64] presented the importance of the interaction of the eyelids and tears in corneal wetting and the dynamics of normal human eye blink. When the eyelids do not approximate as with facial paralysis and there is exposure with evaporation of the tear film, dry spots appear usually within 15 to 30 seconds at scattered locations on the corneal surface. Normally the *blinking action* of the eyelids occurs before the actual formation of dry spots, and this action is required to re-form the tear film layer. This requires that the blink interval be shorter than the film break/break-up time. Doane studied the dynamics of eyelid motion during blinking in normal subjects and its implications of the interaction between blinking and corneal wetting.[64] Typically the closure occurs in about 80 milliseconds. This normal reflex blink interval cannot be restored by any reanimation procedure. However, by re-establishing eyelid approximation and the lower lid position against the globe, the tear distribution and drainage mechanism can be restored to some extent. Further, there is compensation to some extent for evaporation by reflex tear production.

Impairment in the reflex production of tears or an abnormality in the drainage system needs to be recognized and corrected if possible. The patient must be motivated to produce a voluntary blink at least six times a minute. The presence of a Bell's phenonemon is helpful because as the patient voluntarily attempts to approximate the eyelids, the globe rotates up underneath the upper lid. This helps to mix the tear fluid and spread it over the corneal surface. Doane[64] demonstrated this process by placing fluorescein solution in the lateral corner of the eyelid junction. This solution became well mixed after only one blink of the eyelids, and it was noted that the drop first runs along the lower tear meniscus and the lower edge of the lower eyelid. As the normal blink is completed, the upper lid then touches this strip of solution, and as it opens, it carries the fluorescein over virtually the entire surface of the globe. This same process could be reproduced to some extent with a voluntary blink, providing the upper and lower lids approximate. Normally the lower lid demonstrates horizontal and nasal movement with blinking. This function directs the tear film nasally toward the lacrimal puncta.

One other function that is lost with facial paralysis is the pressure placed on the globe by the intact functioning periobicularis oculi muscles with eye closure. This is an important factor in the corneal wetting mechanism, because it provides a wiping action that cleans off the mucin layer of the tear film adjacent to the corneal epithelium. This mucin layer is thought to become contaminated by the overlying lipid layer, impairing the wetting ability of the mucin. The mucin acts as the natural detergent of the tear fluid and needs to be replaced with each blink reflex action.

McLaughlin[65] reviewed epiphora associated with facial paralysis and pointed out that evaporation is responsible for increased reflex tearing secondary to exposure. *Evaporation* not only leads to the tear film break-up, but because water evaporates and electrolytes do not, the salt content of the tears must rise. This has been demonstrated, and the *increased salt concentration* may be another factor causing irritation to the eye with an increase in lacrimal secretion.

Evaluating the Lacrimal System The classic article describing the lacrimal secretory system and its treatment was provided by Jones.[66] The author pointed out that a disturbance in the lacrimal system may result in decreased, increased, or pseudo-increased tearing. *Epiphora* from hypersecretions due to *obstruction of the lacrimal passages* is unusual with facial paralysis; however, *chronic ectropion* with inflammation and scarring can lead to inferior *punctal stenosis*. This is treated temporarily by dilation. A more permanent solution is to nip off the coruncle containing the puncta of the inferior lacrimal canaliculus.

The diagnosis can be established by the *Jones primary dye test*. This involves instillation of 0.5% fluorescein solution into the lower conjunctival sac and then waiting for 1 to 5 minutes. If dye is retrieved with a cotton applicator placed underneath the inferior turbinate, this rules out obstruction and suggests hypersecretion.

Hyposecretion and *pseudo-epiphora* from a decrease in the basal secretion leading to exposure and irritation can be determined by a series of tests. The first is the *Schirmer #1 test*, which is done without topical anesthesia with the Whatman #41 filter paper placed in the inferior conjunctival cul-de-sac as the stimulus. The paper is left in place for 5 minutes, and if the amount of wetting is less than 10 mm, it denotes a hyposecretion of both basic and reflex secreters. If the wetting is between 10 mm and 30 mm, it may denote a "pseudo-epiphora" in which the reflex secreters are compensating for a decreased basic secretion. If above 30 mm, it has no differential diagnostic value as the patient may have pseudo-epiphora, hypersection, or a normal secretion.

Basic secretion can be differentiated from reflex secretion by anesthetizing the cornea and repeating the Schirmer #1 test. If less than 10 mm of wetting occurs, a hyposecretion due to failure of the basic secreters alone is present.

Jones discussed the reflex secretion failure due to "fatigue-block."[66] This is an important consideration in evaluating tearing in the presence of facial paralysis. It is not unusual to observe exposure hypesthesia and an eye that does not respond to stimulation over the conjunctiva or cornea in the presence of facial paralysis and chronic exposure. In such cases, it is important to test tearing by stimulating the trigeminal sensory receptors. This is accomplished by irritating the nasal mucosa. This is done with a dry cotton tip applicator, and the amount of tears produced is evaluated with Schirmer paper placed in the lower conjunctival cul-de-sac. If there is still no increase in wetting, this denotes a total failure of the reflex secreters. This occurs when the injury to the facial nerve is proximal to the geniculate ganglion or through the greater superficial petrosal nerve, the final pathway of the parasympathetic fibers to the lacrimal gland.

When this condition is combined with a central deficit of the trigeminal nerve as noted with resection of large posterior and middle fossa lesions, the result is devastating to the patient. The condition (consisting of lack of eyelid approximation, failure of the cornea to roll up underneath the upper lid, loss of sensation, and complete absence of tear production) is referred to as the BAD syndrome. Of all of the tear dysfunction disorders, this one in particular requires the immediate attention of the physician responsible for the care of the patient. Ophthalmologic consultation should be sought immediately, and very aggressive medical management with early surgical intervention is often required to prevent breakdown of the cornea and blindness.

In order to maintain adequate moisture for the cornea, puncta plugs, cautery of the puncta, and even parotid duct transplantation might be required.

Epiphora: Differential Diagnosis *Epiphora* is defined as symptomatic hypersecretion of tears. This becomes a bothersome symptom when the tears well up and overflow the lower lid margin onto the face. This interferes with vision and causes skin irritation. This occurs frequently with facial paralysis, primarily due to inaction of the orbicularis oculi muscle. Exposure due to lack of upper and lower lid approximation and the malposition of the lower lid creates exposure irritation as well as impairment in lacrimal drainage. If epiphora persists in spite of adequate eyelid reanimation, one should rule out irritation from eyedrops or ointment, the possibility of a foreign body, and finally the presence of *gustatory tearing (crocodile tear syndrome)*.

Gustatory tearing can be determined by performing a *Schirmer #2 test* (filter paper placed in the lower lid conjunctival cul-de-sac after application of topical anesthesia) and then having the patient chew on a lemon. Normally this produces an outpouring of saliva, but in a case where there has been degeneration and faulty regeneration due to injury at or proximal to the geniculate ganglion or along the greater superficial petrosal, excess tearing will be noted together with the hypersecretion of saliva. This is a reliable diagnostic method and is usually reinforced by an accompanying history provided by the patient who relates that the same thing happens when eating spicy or sour food. In extreme cases, this occurs even with just chewing regardless the type of food. Some patients may experience uncontrollable tearing even when anticipating a meal. This later phenomenon is referred to as *psychogenic gustatory lacrimation*. This condition is thought to result from aberrant resprouting of interrupted and regenerated salivary fibers that gain access to the lacrimal gland. This anomaly of gustatory tearing is known as crocodile tears, reminiscent of the myth that crocodiles are said to tear while eating their prey.[67]

Jones[62] discussed the variety of therapeutic approaches in such patients and referred to the work of Golding-Wood, who stated that surgical *destruction of the tympanic plexus* cured this condition. This has not been our experience in terms of consistent reproducible long-term results.

Vidian neurectomy, described by Golding-Wood for vasomotor rhinitis, will certainly influence reflex tear production on the involved side. This surgery involves a transantral or transnasal approach. A possible complication of a vidian neurectomy is anesthesia or dysesthesia over the ipsilateral skin of the nose and cheek. In addition, the procedure is technically demanding and rarely performed by other surgeons.

Jones states that the ideal treatment for gustatory tearing is to *destroy the main lacrimal gland* without damaging the accessory palpebral gland.[66] A review of the anatomy of the main and accessory lacrimal gland provided by Jones makes it clear that this is not possible because the parasympathic nerve supply of the accessory gland comes through the main gland. Further, an attempt to destroy the accessory palpebral gland would interfere with the drainage of the main lacrimal gland since the ducts of both drain through a common area.

Partial resection of the lacrimal glands is effective in countering hypersection due to faulty regeneration, but one must keep in mind that with increasing age, there is decrease in basic secretion. This might produce a dry eye problem later in the patient's life.

Lacrimal Pump System (Fig. 6–80) Impairment of the lacrimal pump system must be included along with all the other factors when evaluating a patient for epiphora. The lacrimal pump mechanism is crippled with paralysis of the orbicularis oculi muscles since with blinking or eye closure, the lacrimal sac is pulled open, drawing tears into the sac. When the eye opens normally, the sac closes, pushing the tears into the nose through a system of one-way valves. With facial paralysis, this mechanism is impaired, and in carefully selected cases, there is a place for performing a *DCR or Jones tube* insertion as an absolute last resort.

The reader is referred to a publication by Dryden and Wulk for a concise overview of the evaluation and treatment options for tearing problems.[68]

Lacrimal Gland Resection (Fig. 6–81) A partial lacrimal gland resection was performed in 10 patients, each with the *crocodile tear syndrome* following injury to the facial neve proximal the geniculate ganglion. The procedure was successful in five patients and unsuccessful in five patients. Success was evalutated by the relief of the patient's symptoms as well as objective evidence that the epiphora was not present with eating. Two of the failures were salvaged by performing DCR. Perhaps the high failure rate was directly related to our conservatism. We were very careful not to eliminate the reflex system altogether for fear of creating a dry eye syndrome. There is a fine balance between relieving epiphora and not creating a dry eye.

Although it is possible to damage the drainage sites of the lacrimal glands, because they are in the area of resection,[69,70] this has not been a problem in our experience. In view of the possibility of creating a dry eye, however, the procedure should not to be done in patients with impaired corneal sensation or a poor Bell's phenomenon.

Stasior[70] reviewed the anatomy and physiology of the lacrimal system for the cosmetic surgeon. The material presented in Stasior's article is extremely useful, particularly for those who attempt to treat the symptom of excess tearing or attempt other eyelid reanimation procedures.

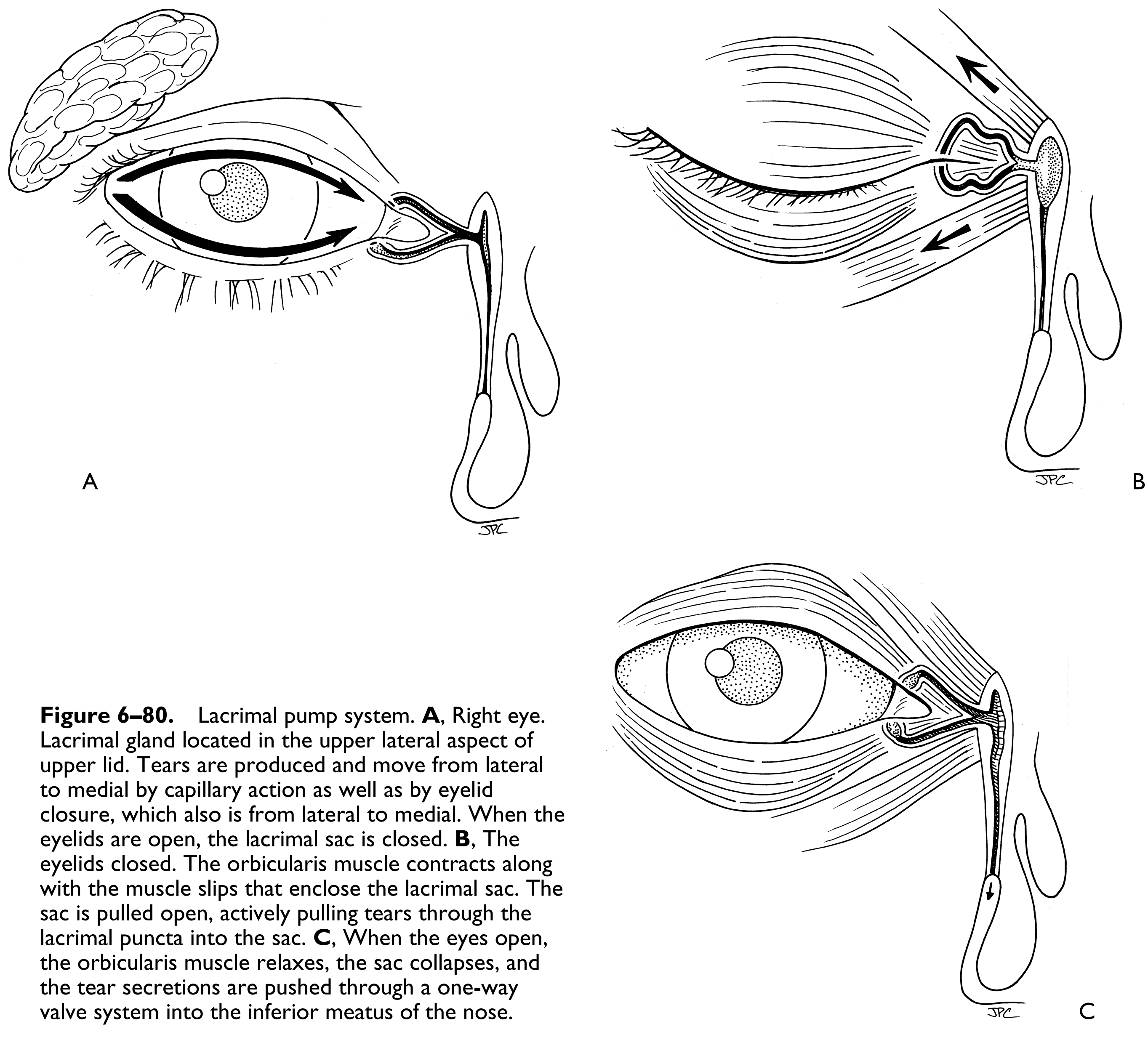


Figure 6–80. Lacrimal pump system. **A**, Right eye. Lacrimal gland located in the upper lateral aspect of upper lid. Tears are produced and move from lateral to medial by capillary action as well as by eyelid closure, which also is from lateral to medial. When the eyelids are open, the lacrimal sac is closed. **B**, The eyelids closed. The orbicularis muscle contracts along with the muscle slips that enclose the lacrimal sac. The sac is pulled open, actively pulling tears through the lacrimal puncta into the sac. **C**, When the eyes open, the orbicularis muscle relaxes, the sac collapses, and the tear secretions are pushed through a one-way valve system into the inferior meatus of the nose.

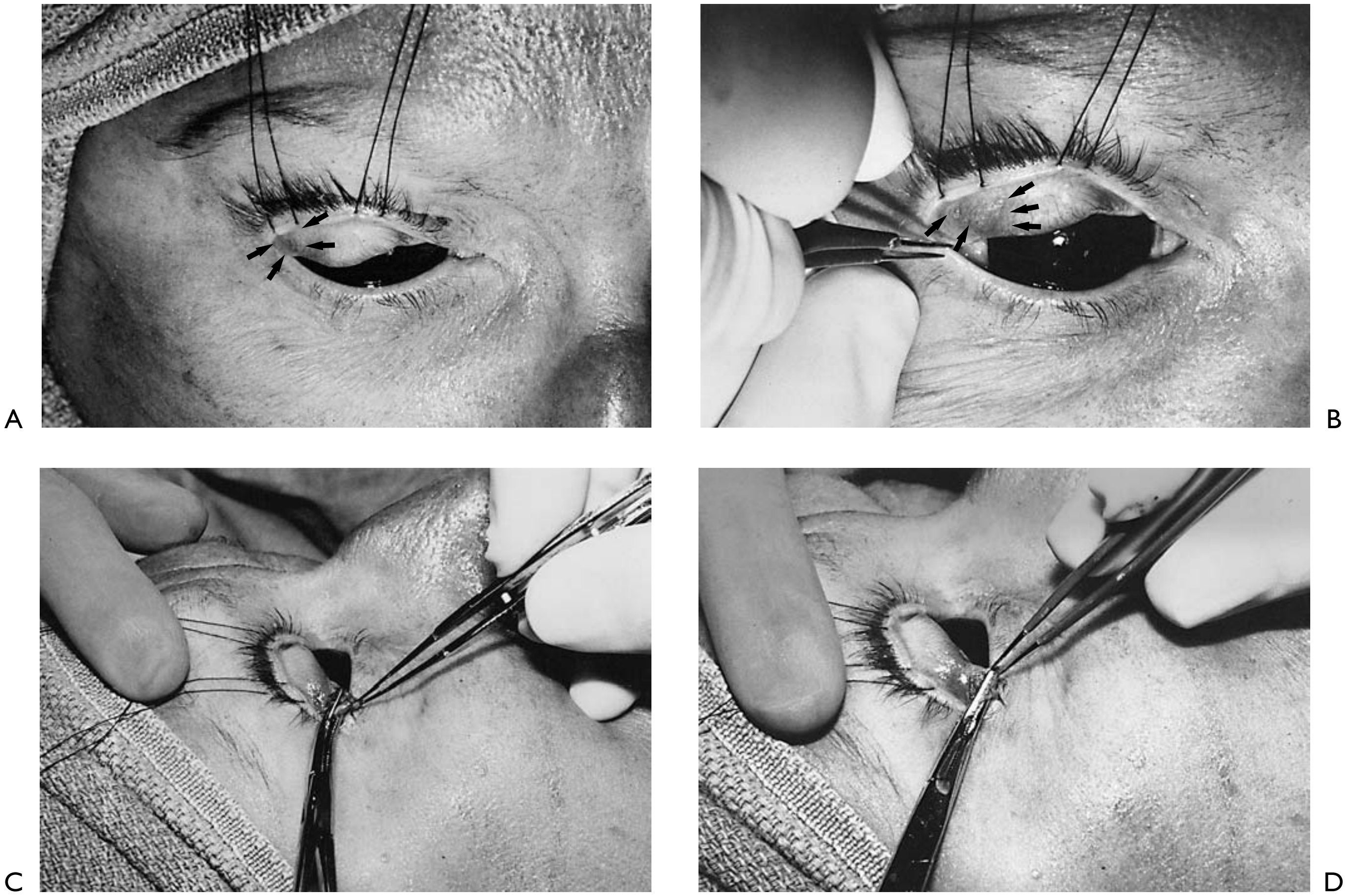


Figure 6–81. Partial lacrimal gland resection technique. This procedure is useful to treat excess tearing associated with gustatory tearing crocodile tear syndrome (see Table 6–9 for instrumentation). Proparacaine is placed in the conjunctival cul-de-sac for local anesthesia and a contact lens is inserted. **A**, An upper lid retractor (Casey)—or as in this case sutures—retracts the upper lid in the upward direction while a cotton applicator is used to push the lacrimal gland towards the conjunctiva. Portion of the lacrimal gland presents as a visible bulge (arrows). **B**, The conjunctiva over the lacrimal gland is cauterized with a Wetfield microbipolar cautery. **C**, A very small incision is made in the conjunctiva (too large an incision would interfere with the punctate openings of the main and accessory lacrimal glands). A small portion of lacrimal gland is teased out of the incision and dissected free. **D**, This portion of the lacrimal gland is cauterized and amputated. No sutures are used.

Our patient group was unique because the hypersecretion was due to facial paralysis as well as crocodile tear syndrome. These factors most likely contributed to the differences in our results compared to those reported by others with lacrimal gland resection.[69,71–73]

The Jones bypass tube and DCR are two other treatment options for epiphora. Leatherbarrow and Collin recommended combining the two procedures.[74]

Jones Bypass Tube Based on our review of the ophthalmologic literature, it appeared that the Jones bypass tube was reserved for patients who have persistent epiphora in spite of all other efforts.[74,77] Huang et al.[78] pointed out the shortcomings of the Jones bypass tube, including displacement, infection, scarring, and the fact that the device has to be worn for life. They devised a conjunctival mucosal tube as an autologous flap to be used instead of the alloy plastic pyrex tube suggested by Jones. Based on our favorable experience with the DCR in such patients, we would suggest that a DCR be performed prior to resorting to a Jones tube.

DCR The idea to perform a DCR to treat epiphora associated with facial paralysis was based on the reports of success with the Jones tube drainage procedure for epiphora. A study with a Jones tube in place showed the effect of respiration, blinking, and gravity on the tear flow mechanism.[79] This same study found that the effect of respiration was negligible, while blinking was quite important in moving tears through the lacrimal drainage passages. The authors suggested that gravity must play a role in cases of facial paralysis where blinking is impaired. Tear drainage is enhanced by making a direct opening from the lacrimal sac into the nose, eliminating the resistance of the distal system. These mechanisms observed with a Jones tube are created by a DCR and can be used to explain the rationale and success of a DCR to treat epiphora caused by facial paralysis.

History of DCR Modern lacrimal surgery is credited to Toti, an Italian otolaryngologist, who described external DCR in 1904.[9] The development of endonasal DCR was reported by Caldwell of New York in 1893.[9] West (1910) and Polyak (1911) improved upon the technique described by Caldwell.[9]

In the United States, the external DCR is the standard treatment for nasolacrimal duct obstruction, with success rates consistently above 90%.[80] The interest in endonasal DCR has grown with the popularity of this approach for sinus disease. Perhaps part of the enthusiasm was stimulated by nasaolacrimal duct obstruction that occurred as a result of endoscopic sinus surgery.[81–83]

Rice was the first to suggest an *endoscopic endonasal DCR*. After demonstrating its feasibility on a cadaver study, he successfully treated four patients with this technique.[84] As experience is gained with this technique, the results are beginning to match those achieved with the external procedure. There are reports of relief of symptoms in up to 96% of patients.[85,86] Not only are the results improving, but the advantages of the endoscopic procedure over the external approach are being defined.

Revision DCR has always been difficult through the external approach, whereas the endoscopic route offers some advantages for these cases.[87] Other *advantages of endonasal DCR* over the external approach include the ability to evaluate and correct associated pathology such as septal deviation or chronic paranasal sinusitis that may be contributing to the lacrimal obstruction. Further, endonasal DCR avoids an external incision and eliminates the possibility of a pathologic scar or injury to the medial canthus. Another theoretical advantage is the preservation of the pumping mechanism of the orbicularis muscle by not disturbing the muscle and tendon attachments to the lacrimal sac. This advantage has no significance in patients with facial paralysis.

Naturally, total familiarity with the endonasal anatomy is critical to surgical success.[88,89]

One of the most frequent causes of DCR failure is *closure of the osteotomy site*, as was noted in our experience. Perhaps the use of intraoperative mitomycin C, an antiproliferative agent, may possibly improve success rates.[90]

Alternatives to DCR have been suggested using *balloon dilation*.[91,92] Recently there has been an interest in the use of *external laser* for endoscopic DCR.[93] The authors found the holmium:YAG laser efficient to ablate both bone and soft tissue and to be particularly effective for bloodless surgery in performing endoscopic DCR.

Results Ten patients were operated to correct epiphora associated with long-standing facial paralysis. In these patients, epiphora persisted in spite of efforts to improve lid closure and to tighten the lower lid. The technique used was similar to that described by Metson[94] (Fig. 6–82).

Results were determined by the patency of the rhinostomy noted by endoscopic inspection. Further, fluorescein was instilled in the lower conjunctival cul-de-sac, and its appearance was noted endonasally by endoscopic inspection. DCR was performed in 10 patients. Six had complete relief of epiphora noted within 6 weeks of surgery that lasted until the follow-up visit 7 to 20 months later. Serial postoperative endoscopic examinations over a 6-week period demonstrated a gradual closure of the surgically created nasolacrimal fistula in two patients. One of these patients had a facial paralysis secondary to facial trauma. The bone and soft tissue injury involved the lacrimal fossa and sac. This was not appreciated at the time of initial surgery. During revision endonasal DCR, the lacrimal sac was readily reopened. Jones Silastic lacrimal tubing was used to intubate the drainage system. The nasolacrimal tube was removed after 6 months. Following this, patient's epiphora resolved. Patency of the lacrimal system in this patient was confirmed by irrigating via the inferior lacrimal puncta.

The second failure occurred in spite of a patent nasolacrimal fistula noted postoperatively. The rhinostomy was widely patent; fluorescein instilled in the subconjunctival cul-de-sac was noted in the middle meatal region by endonasal endoscopic inspection and yet epiphora persisted. This patient had significant hypersecretion thought due to crocodile tear syndrome. The epiphora was relieved by a partial resection of the lacrimal gland.

The third patient whose procedure was unsuccessful had relief of epiphora for 2 months until the nasolacrimal fistula stenosed. This patient did not desire further surgery.

The fourth failure had persistent excessive reflex tearing in spite of correcting lid position. In this patient, the objective evaluation indicated patency of the DCR-created drainage system. A partial lacrimal gland resection is being considered.

Discussion Symptomatic epiphora following facial paralysis is most often associated with impairment of one or more of the following: (1) eyelid closure, (2) lower lid laxity, or (3) a compromised lacrimal pump. In spite of correction of these defects, epiphora may persist as demonstrated in two of the four patients whose procedures failed. Excessive tear production due to facial nerve injury at or proximal to the geniculate ganglion and faulty regeneration (crocodile tear syndrome) may explain the failure in one case. This patient was the only one in this series with crocodile tear syndrome. It is interesting to note that in this patient a partial lacrimal gland resection significantly improved his symptom.

Potential *complications of endonasal lacrimal sac procedures* are similar to those seen in endoscopic endonasal sinus surgery: bleeding, orbital penetration, and scarring with restenosis. There were two patients in our series where the nasolacrimal fistula stenosed. In one patient, the DCR was successfully revised and has remained functional for 7 months, while the other patient whose procedure failed did not chose further surgery.

Stenosis of the nasolacrimal fistula can occur in spite of maximum bone removal and intentionally creating the largest fistula possible because of the unpredictability of the healing process. Silicone tube intubation was used in two patients, one at primary surgery and the other at the time of revision surgery. Perhaps the routine performance of intubation and leaving the tube in for 6 months might improve the success rate of the procedure by discouraging fistula stenosis. The use of mitomycin C is being considered.

The results with DCR for epiphora associated with lacrimal pump impairment, as with facial palsy, cannot be compared to the results of treating lacrimal obstruction, the most common indication for DCR. An 80% success rate (including the revised cases) with a low morbidity procedure is well worthwhile to add to options used to rehabilitate a patient suffering from the effects of facial paralysis.

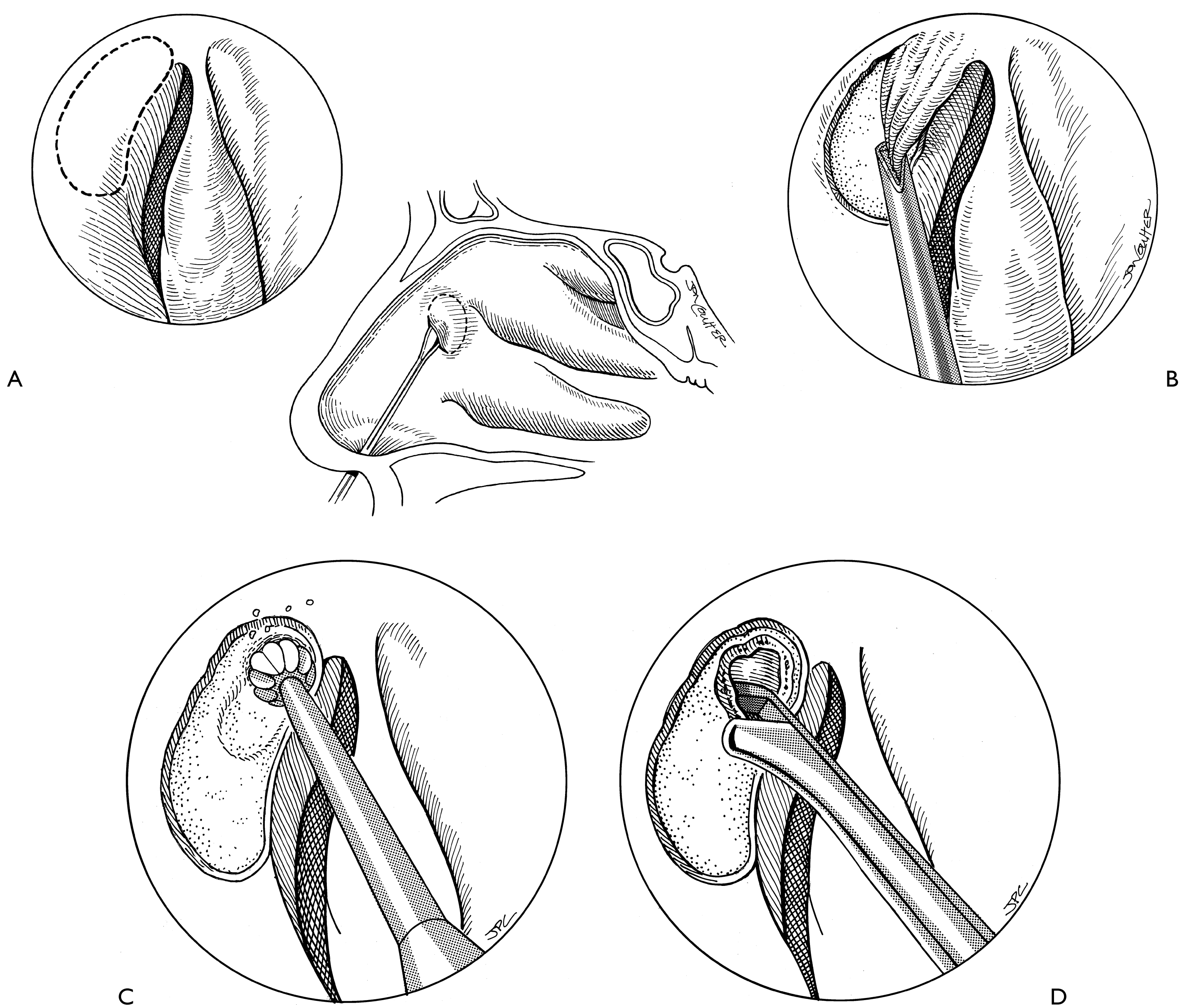


Figure 6–82. Endonasal dacryocystorhinostomy (DCR) technique. The patient is scheduled for the DCR in the ambulatory surgery center after a complete informed consent of risks, options, and benefits. The surgery is performed with intravenous sedation and local anesthesia. The nasal mucosa is decongested with oxymetazoline (Afrin), and then topical cocaine (4 cc of 10% solution) is administered on cotton pledgets. Visualization is achieved using the 0° and 30° 4-mm diameter endonasal telescope. **A**, The lateral nasal wall mucosa just in front of the anterior superior attachment of the middle turbinate is injected with 0.5 cc of 1% Xylocaine and 1:100,000 of adrenaline. A flap of mucosa is elevated off of the bulge formed by the lacrimal fossa on the lateral nasal wall. **B**, The overlying mucosa is removed using a powered microdissector. **C**, The bone is shaved down to the lacrimal sac using a tapered drill with a guarded rotating 4-mm cutting burr and continuous irrigation. **D**, The sac is exposed further by removing bone with a kerasin.

Endonasal DCR is proposed as a safe, effective method to relieve troublesome epiphora associated with long-standing facial paralysis when standard approaches fail.

"The Dry Eye"

Medical Treatment The presence of a dry eye leads to keratoconjunctivitis sicca, a condition that causes breakdown of the cornea and eventually blindness. The condition may respond to conservative medical modalities such as artificial tears, ointments, Lacriserts, mucolytics, or bandage lenses. Details of medical management have already been covered earlier in this chapter.

Punctal Occlusion Temporary or permanent punctal occlusion is considered when medical treatment fails to relieve symptoms. The surface epithelium of the globe should be monitored as well as noting the patient's symptoms. This can be done with Rose Bengal or fluorescein staining. The changes in the epithelium can be noted with the naked eye and with the help of a cobalt (blue) light, or, ideally, with a slit lamp.

The goal of treatment is to allow the surface epithelium to heal. Occlusion of the puncta can provide therapeutic benefit. It is best to perform a trial with a collagen puncta plug (Temporary Intracanalicular Collagen Implant, Eagle

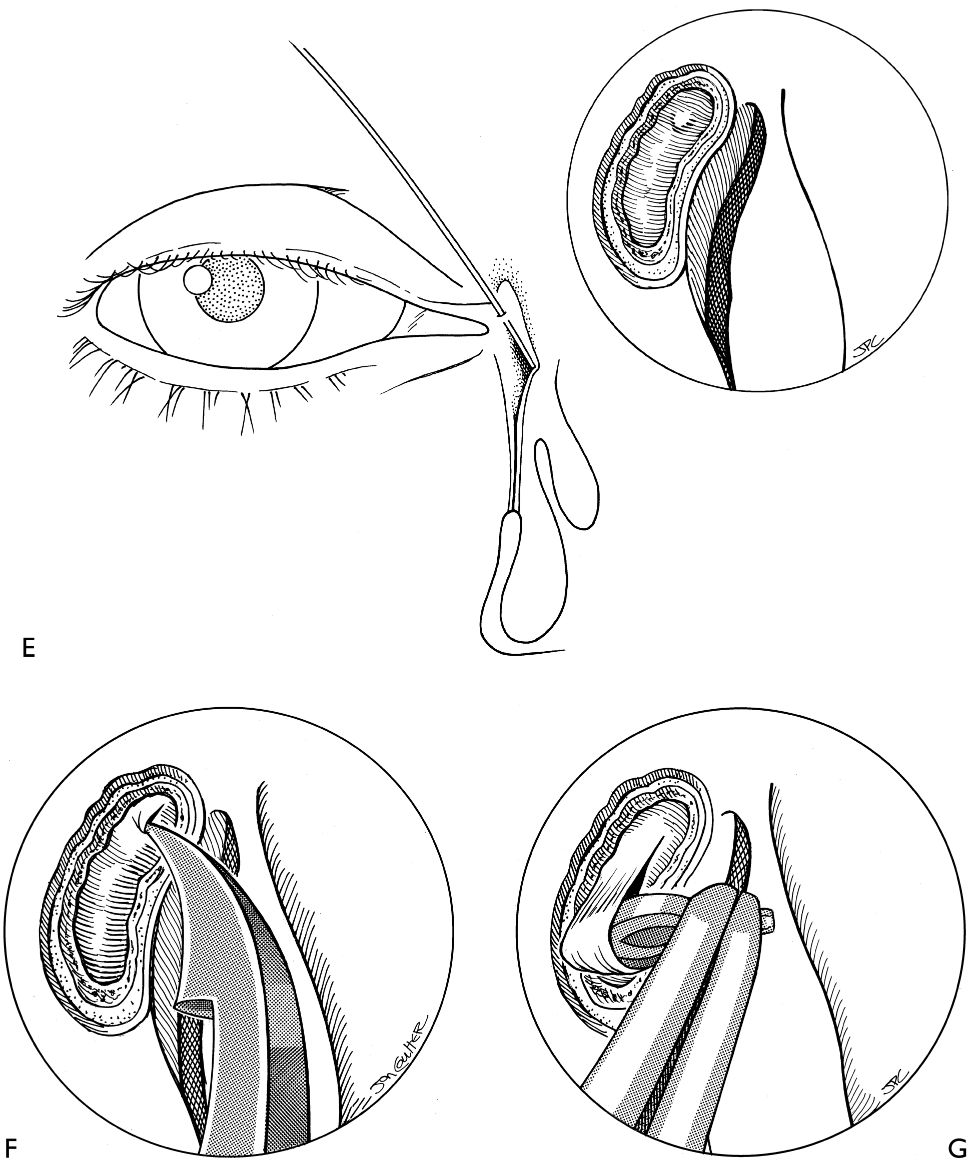


Figure 6–82. *(continued)* **E**, The puncta of the superior caniculus is dilated and probed. The probe is placed into the sac where it is observed endonasally. **F**, An incision is made through the wall of the sac with a middle ear sickle knife. **G,** A Pediatric back biter is used to enlarge the opening in the sac. Excess mucosa is trimmed using a powered microdissector. Finally, the anterior and posterior flaps of the nasal wall of the lacrimal sac are cauterized in position over the edges of the bony rhinostomy. Intubation tube is placed. The intubation tube is removed in 6 months. The patient is seen at 1 week and 6 weeks postoperatively to remove any crusts that form.

Vision, Memphis, Tennessee). If overflow tearing is noted, the plugs are removed. This rarely occurs with the dry eye associated with facial paralysis. Occlusion can also be accomplished using silicon plugs, cyanoacrylate glue, collagen plugs, or light surface cautery (Fig. 6–83). Permanent occlusion can be achieved with punctal excision, laser puncta occlusion, or deeper cautery.[95,96]

Parotid Duct Transposition Parotid duct transposition should be considered as a last resort when all medical and surgical efforts have failed to control recurrent or persistent keratoconjunctivitis due to xerophthalmos associated with facial paralysis. In the senior's author's (MM) experience managing more than 4000 patients with facial paralysis, only seven patients considered candidates for parotid duct transposition consented to have the procedure.

Parotid duct transposition is technically difficult and has a high failure rate. The *major cause of failure is that the length of the duct* might not be adequate to reach the conjunctival cul-de-sac. Kaplunovich[97] showed that only 50% of the patients undergoing sialography had parotid ducts that were long enough to be transposed to the eye without tension. Tension at anastomosis may cause leaks or stenosis, leading to obstruction and ultimately a poor outcome. Bennett[98] and Tardy et al.[99] addressed this problem by including a large cuff of buccal mucosa around the ductal orifice that could be sutured to the conjunctival cul-de-sac (Figs. 6–84 and 6–85) Alonso[100] took a slightly different approach by creating

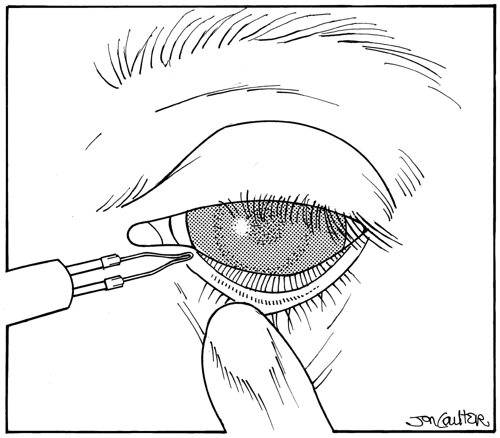


Figure 6–83. Punctal cautery, left side. Proparacaine is placed into the lower conjunctival cul-de-sac for local anesthesia, and a contact lens is inserted to protect the cornea. A fine needle or optemp cautery is used. The inferior puncta is cauterized after it is exposed by displacing the lower lid away from the globe.

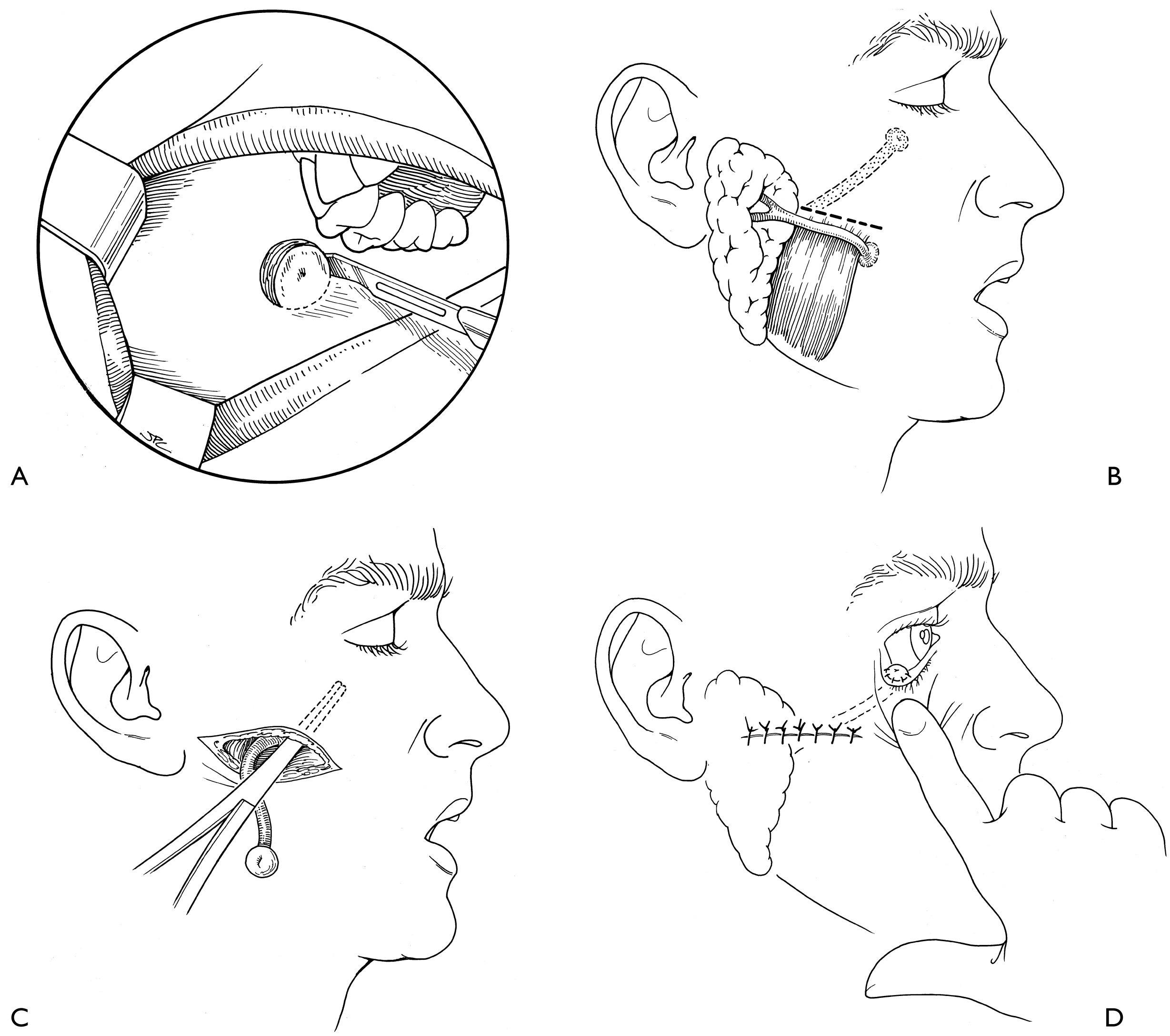


Figure 6–84. Parotid duct transposition—Bennett technique.[98] Bennett increased the length of the duct by including a large cuff of buccal mucosa around the ductal orifice that could be sutured to the conjunctival cul-de-sac. Additional length was achieved by completely dissecting the duct and mobilizing it posteriorly to the junction of the two main branches which is at the anterior border of the parotid gland. A conjunctival flap was used for additional length when necessary. **A**, Intraoral circumferential incision of parotid duct caruncle. **B**, Skin incision to dissect parotid duct with mucosa cuff attached. The incision is made parallel to and one finger below the zygomatic arch. According to Bennett, there were no cases of permanent facial weakness associated with this incision in the 10 patients in his series. **C**, Once the parotid duct is freed up, a tunnel is made by blunt dissection to reach the conjunctival cul-de-sac. **D**, The parotid duct transposition is completed, and all wounds are closed. Parotid salivary flow was noted to reach the eye in each of the 10 patients in Bennett's series. The major problem was gustatory "tear" overflow.

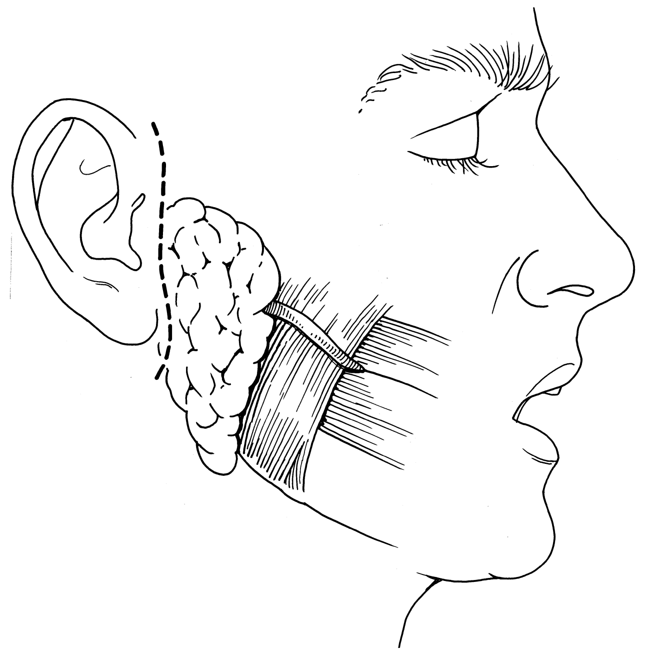


Figure 6–85. Parotid duct transposition—Tardy, Skolnik, and Mill's technique.[99] This approach was similar to that described by Bennett[98] (an ophthalmologist) except the incision to expose the parotid duct was preauricular rather than as Bennett described. This difference most likely reflects the authors' preference as head and neck surgeons.

a tube extension from the buccal mucosa (Fig. 6–86). In Kaplunovich's study, lengthening the duct with buccal mucosa was believed to increase the feasibility of a parotid duct transposition to almost 80%. However, in 20% of the cases, even with the lengthening techniques, the duct was too short and produced tension at the anastomosis.

Very few reports have described complications.[97,98,101,102] However, Shevalev[101] reported a 50% failure rate with 51 cases. The majority of failures occurred almost 4 months after the procedure had been performed. Failure to maintain moisture in the dry eye resulted from *stenosis* of the *parotid duct-conjunctiva anastomosis*. Stenosis may result from tension on the suture line that causes separation or scarring due to a short duct. This problem can be overcome with a vein graft extension.[103]

The *amount of saliva production* will influence the results. Bennett[98] stressed the importance of presurgical evaluation of parotid function. He was concerned because the most common causes of a dry eye (xerophthalmia) also cause parotid dysfunction with impaired salivary flow as well as tear production. This consideration applies to patients with facial paralysis as well. The presence of saliva production can be visualized by inspecting the intraoral parotid duct orifice while massaging the gland and/or after stimulating with lemon juice. If there are no secretions, the patient is not a candidate for parotid duct transposition.

The symptomatic *profuse epiphora* noted in Bennett's[98] patients after surgery does not occur in cases where the parotid duct transposition is performed for the dry eye associated with facial paralysis. The disruption of the facial nerve in the cerebellopontine angle that occurs with acoustic tumor surgery interrupts the secretory innervation to the lacrimal gland and possibly effects the parasympathetic innervation to the parotid gland as well. Although the secretory fibers to the parotid gland are routed via the ninth cranial nerve across the tympanic plexus (Jacobson's nerve), there are ample opportunities for these fibers to mix with the facial nerve pathways between the lesser and greater superficial petrosal nerves and the chorda tympani nerve. In some cases, the parotid secretomotor function is significantly impaired as part of the facial nerve injury through the mechanism of mixed neural pathways just described. If the secretions are scant and primarily thick mucoid in character, secretions may not reach the conjunctival cul-de-sac. In this event, the procedure will fail.

The presence of Frey's syndrome or gustatory sweating may indicate a past history of parotid surgery or injury to the auriculotemporal nerve and would be a relative contraindication for parotid duct transposition.

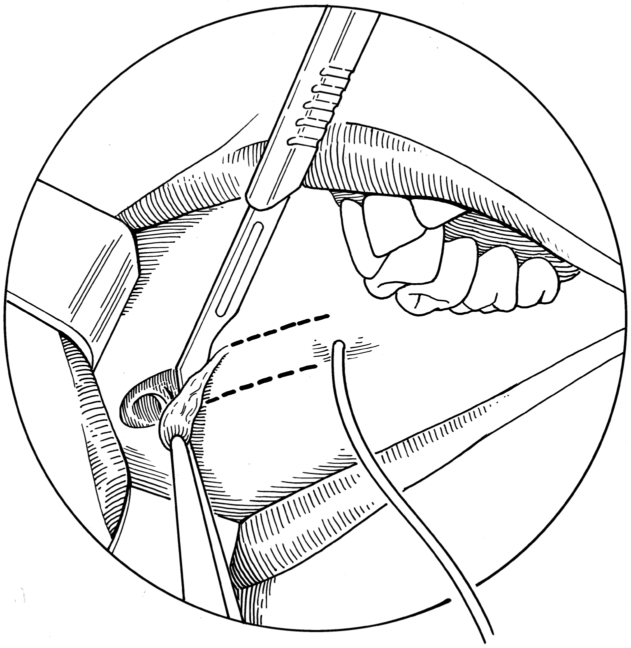
Frey's syndrome A review of gustatory sweating, auriculotemporal or Frey's syndrome will be included at this time, even though it does not relate directly to eye problems, because it has not been discussed elsewhere in this textbook. Unilateral profuse sweating in the preauricular area of the face while eating is known as gustatory sweating (Frey's syndrome).[104] The mechanism is similar to gustatory tearing. This syndrome is common and usually occurs several months following parotid surgery or injury to the auriculotemporal nerve. Presumably this syndrome is due to misdirected salivary fibers that supply the sweat glands.

This disorder can be evaluated by using Minor's iodine-starch test[105] (Fig. 6–87). An easier method involves placing tissue paper on the patient's skin over the involved area, and then the patient is given a sialogogue such as lemon juice.[106] The area and amount of wetting of the tissue paper documents the condition and its extent. Drysol cream, an antiperspirant, rubbed over the affected area every 3 days is a useful medical remedy for this disorder.

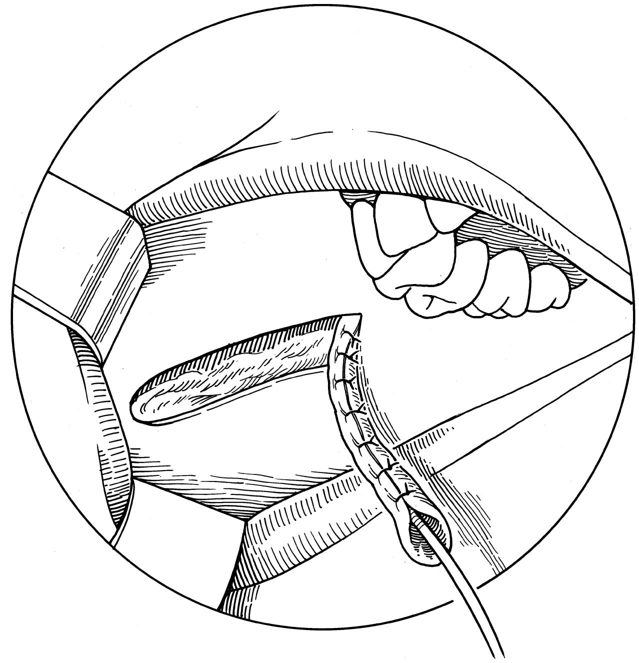
A number of surgical approaches have been reported to treat this disorder. The surgical options include sternocleidomastoid muscle transfer and superficial musculoaponeurotic system plication,[107] dermis-fat graft,[108] and musculoaponeurotic system interposition.[109] These procedures are ideally performed at the time of parotid surgery. Otherwise, re-elevating a skin flap to perform these procedures after healing introduces a significant risk of damaging the facial nerve.

In our opinion, intracutaneous injections with botulinum toxin type A is the best treatment for this troublesome disorder. This is based on personal experience treating two patients and the report by Laskawi et al.[110] The mean duration of effect in their study was 17 months in 18 patients without any side effects. The details of therapy are presented in this definitive article.

Unusual presentations of this syndrome have been reported. This condition has been noted after a subcondylar fracture of the mandible[111] where the mechanism was most likely due to injury to the auriculotemporal nerve with



A



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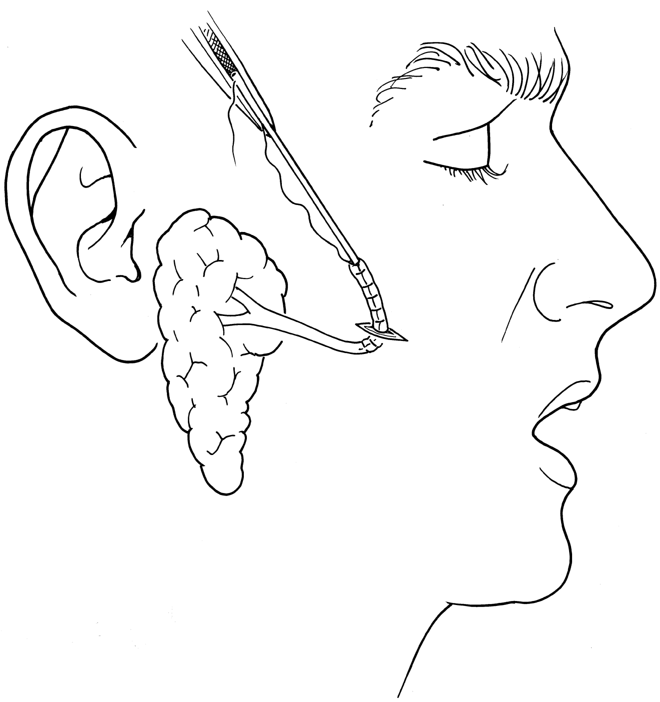
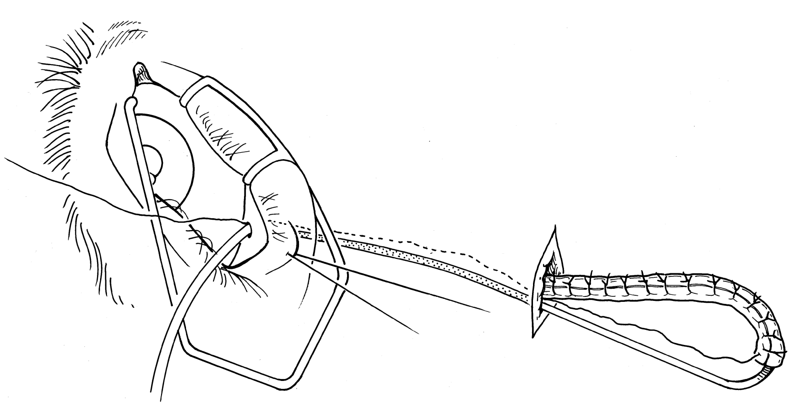


C

Figure 6–86. Parotid duct transposition—Alonso technique.[100] Alonso achieved duct lengthening to reach the conjunctival cul-de-sac by making a tube with buccal mucosa. **A**, The right parotid duct is cannulated. A buccal mucosa flap is elevated anterior to the parotid caruncle. **B**, The mucosal flap is tubed around a cannula. This adds up to 5 cm of length. **C**, The cannulated, tubed, parotid duct extension is pulled externally through a small facial incision. The exposure created by this incision would appear inadequate to accomplish the dissection required to completely free up the parotid duct as described by Bennett.[98] **D**, The duct is then transposed to the conjunctival cul-de-sac and sutured in place. The eyelids are held open with a self-retaining retractor. The cannula is removed in 3 weeks. Alonso performed this procedure in one patient with exposure keratitis due to facial paralysis.



D

Figure 6–87. Minor's test for Frey's syndrome. Patient 8 months post-parotidectomy. Iodine is painted over skin in parotid area, and then the skin is powdered with starch. Lemon juice provokes sweating over involved area. The sweat wets the iodine-starch cover which turns brown indicating a positive response.

Figure 6–88. Lucja Frey, the physician whose name is attached to auriculotemporal syndrome. The photo of Dr. Frey was restored from one published in an article by Burton and Brochwicz-Lewinski.[113]

faulty regeneration. Idiopathic gustatory otorrhea was reported by Redleaf and McCabe.[112] This unpleasant symptom was successfully treated by excision of the external canal skin and replacement with a skin graft. Gustatory sweating has also been noted in association with diabetes.[113]

Another variant of the auriculotemporal (gustatory sweating or Frey's) syndrome was reported as facial flushing in children.[114] This article described a 4-year-old male who was referred because his cheeks turned red with eating. This was first noticed when the youngster erupted some teeth and started to chew solid foods. His skin turned red, but there was no sweating. The senior author (MM) has noted this condition of flushing but no sweating in two children following facial paralysis. In such cases, evaluation for salivary flow and quality would be imperative before considering a procedure involving the parotid on the side of the gustatory sweating.

Based on these observations, gustatory facial flushing, even without sweating, qualifies as a variant of Frey's syndrome. Frey's syndrome can occur following facial paralysis due to faulty regeneration following injury of the facial nerve and is not limited to parotid surgery.

Dr. Lucja Frey described the syndrome that bears her name involving the auriculotemporal nerve, a condition characterized by the sweating of the skin overlying the parotid gland at the time of salivation (Figure 6–88). She observed that this condition arises as a result of trauma, surgical or otherwise, to the parotid gland and is due to the rerouting of the secretomotor parasympathetic fibers to supply the sweat glands in the overlying skin. She described the condition that bears her name in a paper published in August 1923. Frey was senior assistant in the neurology clinic at the University of Warsaw between 1921 and 1928 when she published her important paper. The medical year book of the Polish Republic tells us that by 1936 Frey was working in the hospital of the Jewish Religious Medical Commune at 8 Rappaporta Street, LWOW. In a series of biographical notes published in 1954, the only intimation that she married was given when her name was recorded as Lucja Frey Gustoman. She died in LWOW in 1943 at the hands of the Nazis.[115]

Results of Parotid Duct Transposition This technique (Fig. 6–89) has been successful in relieving the patient's symptoms and clearing the keratoconjunctivitis in four of seven patients (see Fig. 6–90).[103] The three failures were attributed to surgical technique in two and poor case selection in the third. The two surgical failures occurred in a effort to modify and improve the technique. The vein graft was sutured directly to the parotid duct after the mucosal cuff containing the puncta and coruncle was amputated. This lead to stenosis in both of these cases and should not be done. The third failure occurred because the duct was atrophic and unsuitable for anastomosis. It should be noted that in this patient there was very little saliva noted at the natural parotid orifice upon stimulation with lemon juice.

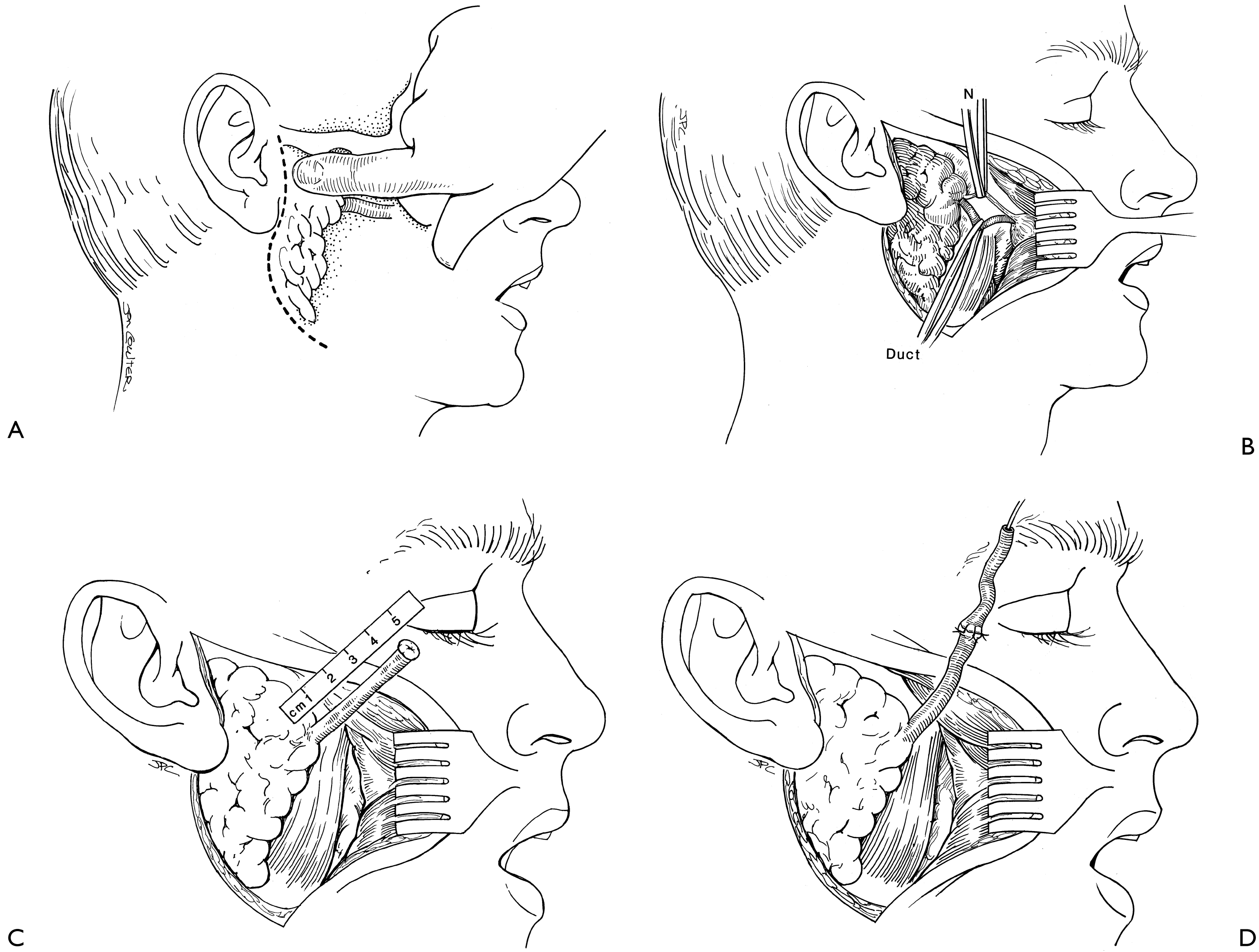


Figure 6–89. Parotid duct transposition described by May, Kay, and Weinstein.[103] A vein was used to add length to the parotid duct as a modification of Bennett's technique (Fig. 6–84). Success is dependent on the adherence to the principles described by Bennett.[98] The vein extension should address the problem of insufficient duct length. **A**, An external parotid incision is made, and the flap is elevated. The parotid duct is identified as it runs about 1.5 cm below the zygomatic arch (the width of one's index finger). Its course is deep to the superficial musculoaponeurotic fascia that lies over the masseter muscle. **B**, The buccal branch of the facial nerve is in close proximity and usually crosses over the lateral aspect of the parotid duct. The duct is freed from the facial nerve branches (N). **C**, The major cause for failure with this procedure is the duct does not reach the conjunctival cul-de-sac without tension. **D**, A vein graft eliminates this problem.

Discussion Two things were learned from this limited experience. (1) It is important to maintain the cuff of mucosa around the puncta of the parotid duct. This cuff of mucosa seems to be critical in preventing stenosis at the anastomotic site. (2) It is also important to determine that there is ample parotid flow prior to surgery. Adequate parotid secretory function is required to create adequate pressure and flow to reach the eye.

Xerophthalmos associated with facial paralysis can lead to corneal complications and blindness. Parotid duct transposition offers physiologic replacement of lacrimal secretion. The vein graft extension prevents tension on the anastomotic site and is recommended to increase the success of this procedure.

Summary of Eye Reanimation

Restoring eyelid function is the most challenging aspect of facial reanimation. The reanimation surgeon must not only restore function but appearance as well. Effective restoration of eyelid function requires attention to detail. The evaluation is tedious and time-consuming, while the surgery may be as simple as nipping the puncta or as sophisticated as is required with parotid duct transposition. Hopefully, the material presented, based on an extensive experience, will be helpful for those with less experience. Further, it is our wish that some surgeons will be stimulated to modify or introduce new approaches or overcome the problems and improve the results presented.

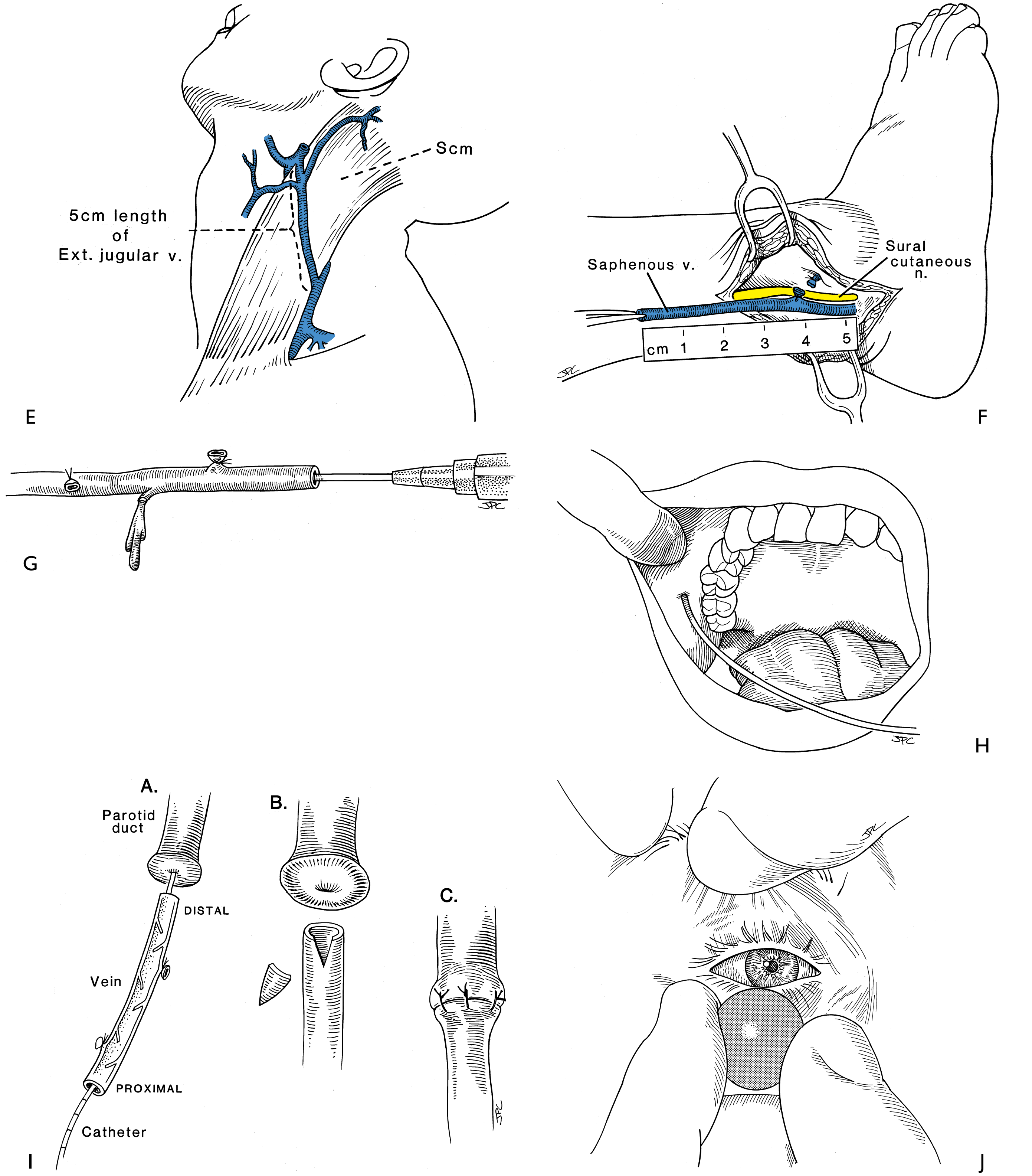
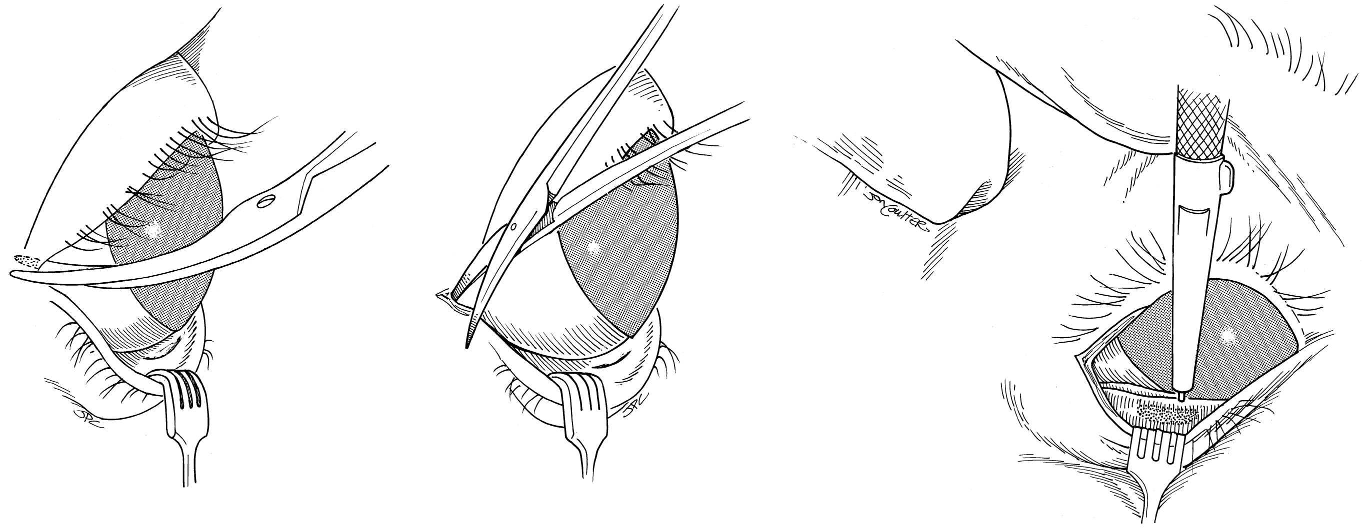
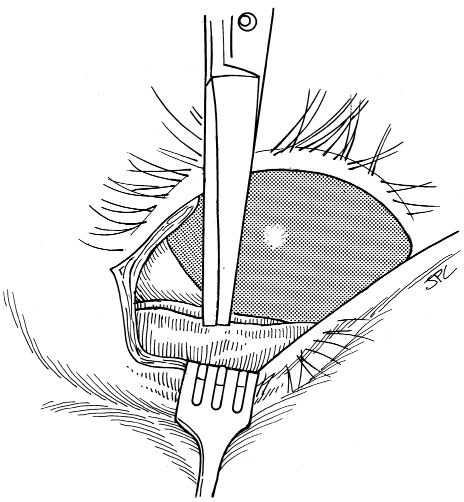


Figure 6–89. *(continued)* **E**, The vein graft may be obtained from the external jugular vein or **F**, from the lesser saphenous vein. **F**, A 4-cm segment of the lesser saphenous vein is harvested from the lower extremity posterior to the lateral malleolus. **G**, All tributaries should be ligated after testing by flushing vein graft with saline. **H**, The orifice of the parotid duct is identified intraorally in the buccal mucosa just lateral to the second upper molar tooth. A circumferential incision is made around the orifice of the parotid duct. The parotid duct with a cuff of normal buccal mucosa is dissected away from the surrounding soft tissues. **I**, By reversing the vein graft, distal end of vein to distal end of parotid duct, the valves of the vein are in a favorable direction for salivary flow (A). A notch is made in the end of the vein that is to be sutured to the parotid duct. This enlarges the diameter of the end of the vein to make a better match-up for the parotid duct (B). The vein graft and duct are anastomosed with interrupted 8-0 Ethilon sutures. The sutures are passed with the aid of an operating microscope from the outside of the buccal mucosal cuff, around the caruncle of the parotid duct, through the lumen of the vein, and out its outer covering. The sutures placed between the vein and duct create a watertight connection (C). **J**, An eye protective shield is placed. *(Figure continued next page.)*



K–M



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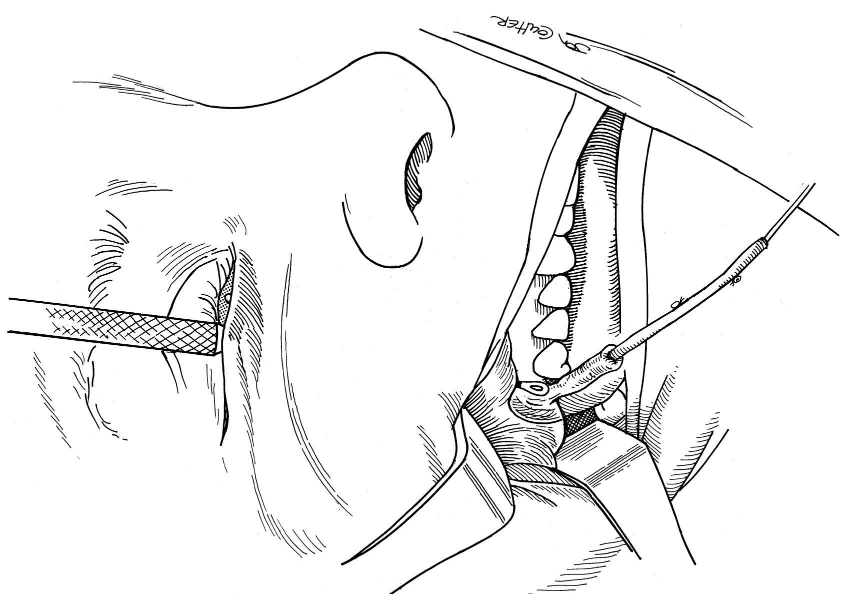

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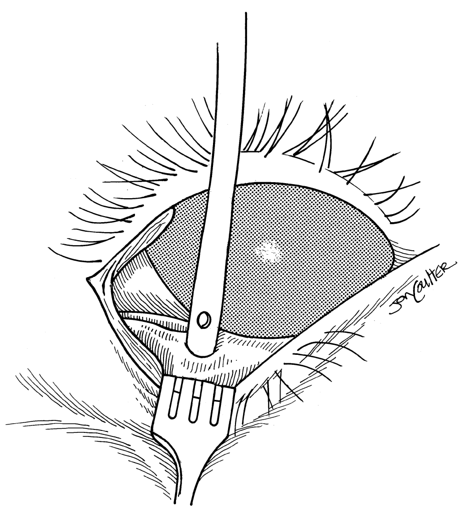


O

Figure 6–89. *(continued)* **K**, A lateral canthotomy and **L**, inferior cantholysis provide excellent lower lid exposure. **M**, An incision is made in the lower conjunctival cul-de-sac in its lateral aspect just inferior to the lower lid tarsal plate. **N**, Through this incision, a pocket is made, and the orbital rim is reached by blunt dissection. **O**, An Oliver Krona Double-End Dissector (model 35-5184-7 inch, Billing Company) is placed into the conjunctival incision and pushed in a twisting motion over the orbital rim. **P**, Then it is pushed into the subcutaneous plane toward the surgical site in the mouth until the end of the passer becomes visible. A 5-0 Prolene suture is passed through the eye of the passer and through the vein.

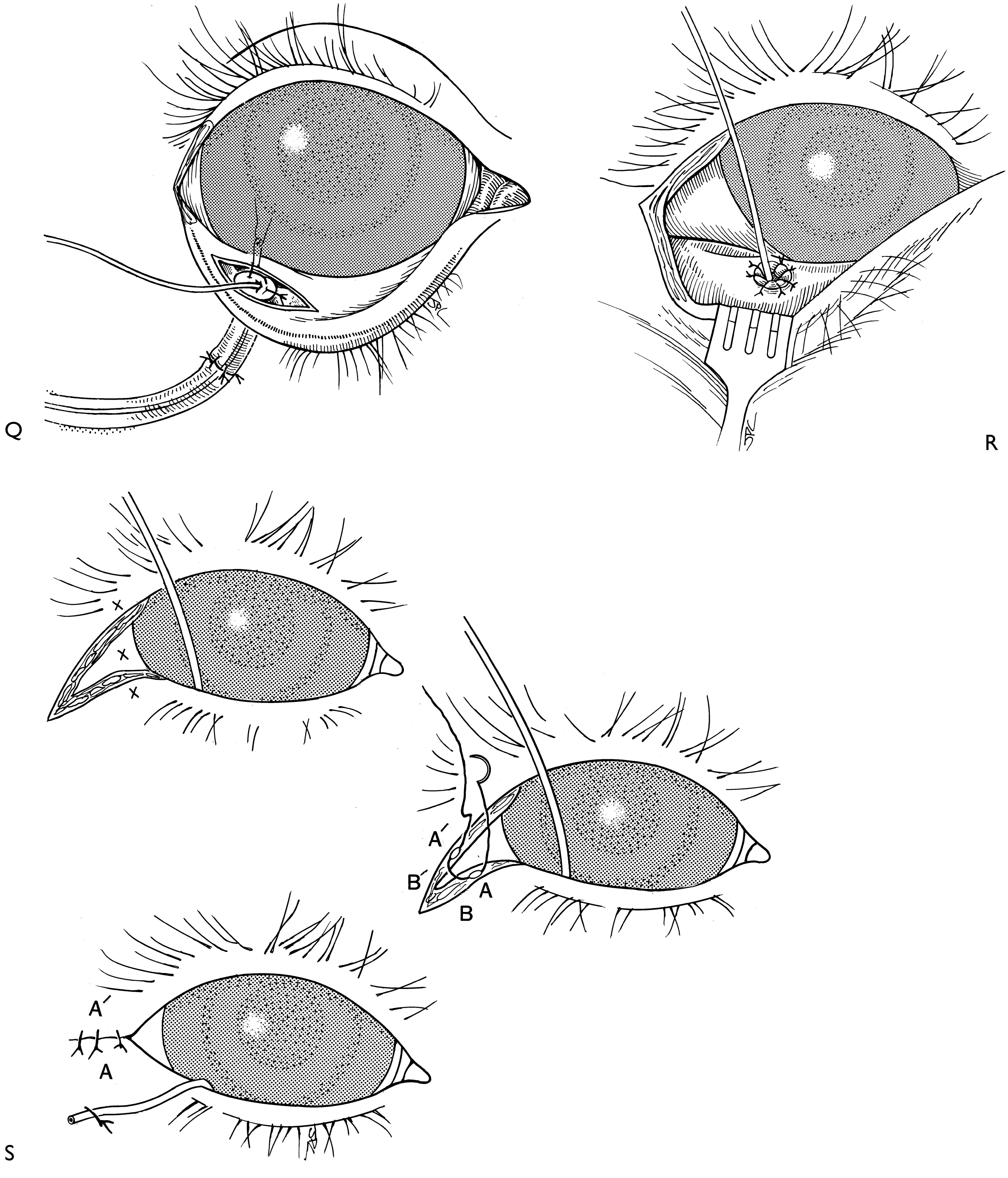
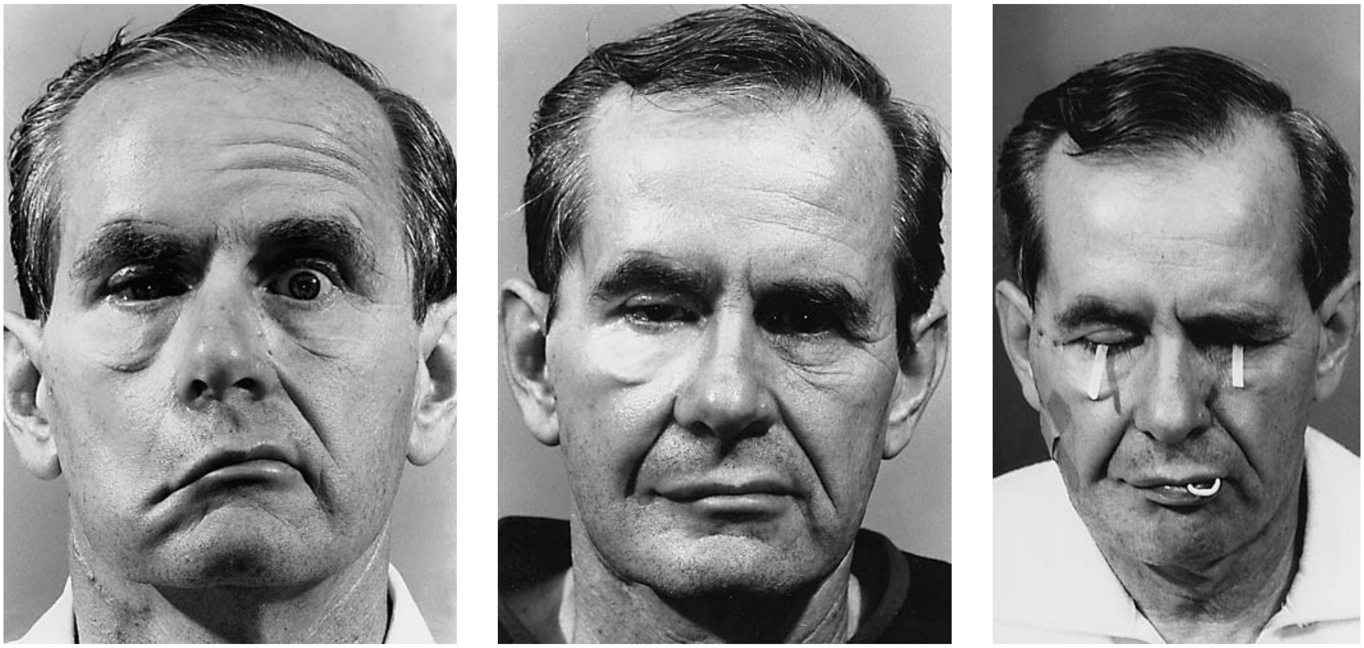
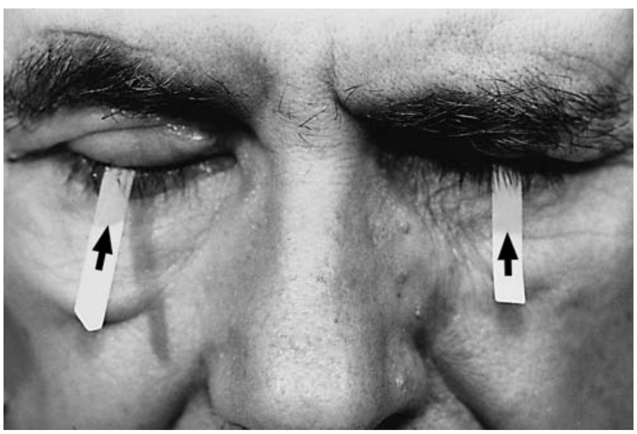


Figure 6–89. *(continued)* **Q**, The passer is withdrawn through the tunnel out the conjunctival incision. Any surplus vein is trimmed, and **R**, the end of the vein is sutured to the conjunctival wound edges with 7-0 Vicryl in an interrupted fashion. **S**, The eyelid and buccal mucosal incisions are closed. Clindamycin is administered intravenously during the 24-hour perioperative period. Comments: Steps A-D demonstrate overview and problem with short duct correction with vein graft. The external approach (A-D) is useful when combined with other procedures that require an open approach (nerve repair, temporalis muscle or free muscle transfer, static procedures). Otherwise, a closed approach is preferred.



A–C



D

Figure 6–90. Result with parotid duct transposition. Patient was 2 months post-acoustic surgery and cranial nerve V and VII deficits. He had the BAD syndrome. Progressive kerato-conjunctivitis threatened corneal breakdown in spite of aggressive medical measures. A conjunctival flap-plasty was recommended along with medial and lateral tarsorrhaphy by the managing ophthalmologist. An alternative rehabilitative program was performed. This included the following in a staged fashion: (1) lower lid tightening (Bick), (2) gold weight implant, (3) brow lift, (4) cartilage implant to lower lid, and (5) parotid duct transposition. The eye exposure inflammatory changes resolved. Other reanimation procedures were performed to address the midlower face including minicross face graft, 12-7 jump graft, and GoreTex nasal lateralization. **A**, After acoustic surgery and eye reanimation procedures. **B**, The patient 2 years post-reanimation. **C**, The candy sucker (lollipop) acts as a sialogogue. **D**, Note the symmetrical staining of filter paper strips (arrows).

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7

Regional Reanimation: Nose and Mouth

Mark May, M.D.

The procedures described in this chapter are all static in design and indicated to "touch-up," "fine-tune," or augment the results achieved with the techniques presented in Chapters 2 through 6.

There are a variety of materials used for static suspension. Tantalium and Marlex mesh have been reported in the past, and more recently Gore-Tex has been used. These alloplasts become incorporated into the tissues after being anchored with sutures. However, all these materials have a tendency to form granulomas and have a high rate of extrusion. Lyophilized dried fascia is well integrated but tends to be structurally weak and fragments easily. The patient's own tissues are ideal for static procedures. Fascia lata and palmaris longus tendon are recommended because they are readily harvested with limited morbidity. Further, their length and tensile strength are quite suitable to suspend or lateralize the nose and corner of the mouth.

The major problems encountered around the nose and mouth include nasal obstruction, upper lip droop, corner of mouth droop, asymmetry of mouth at rest and with smile, and lower lip asymmetry.

To achieve the desired effect, suspension and lateralization may be combined with commissureplasty, cheiloplasty, wedge resections, muscle plication, resection, or transposition.

The experience with static procedures is reviewed in Chapter 1 (see Tables 1–2 through 1–5). Details of the digastric transposition procedure to correct lower lip deformity is described in Chapter 4 (see Figs. 4–20 and 4–21).

The common problems involving the nose-mouth region that can be improved with static procedures are illustrated with the following case examples.

Table 7–1 Equipment for Fascia or Palmaris Longus Transplant Suspension Techniques

Special Instruments and Equipment
Fascia stripper (N295-Storz) (to obtain fascia or palmaris muscle tendon)
Extra arm table (to place arm to take palmaris muscle tendon)
Large, right-angle Mixner clamp (to pull disect tunnel around zygomatic arch)
Deschamps ligature carrier, blunt point, left and right 15-2255, 15-2256 (Pilling Co.) (to pull fascia or palmaris tendon around zygomatic arch
Straight sharp ligature carrier (to pull palmaris tendon from lip, lip-cheek incisions to incision over zygomatic arch)
Tools used to place miniplate noted in Figure 7–2D
Drain–TLS closed suction drain (#6640 Portex Surgical, Inc.)
Sutures
4-0 Nurolon (Ethicon Co.), C-5546, and RB-1 taper needle (for suturing muscle to lip)
2-0 Nurolon (Ethicon Co), C-526T, and CT-2 tapered needle (to suture tendon to itself around zygomatic arch)
5-0 clear Prolene (Ethicon Co.) 1739G (for subcuticular wound closure)
6-0 mild chromic (Davis and Geck Co.) (326-13, CE-2) (to close skin)

Table 7–2 Gore-Tex Graft Used as Static Procedure to Lateralize Nasal Ala or Suspend Corner of Mouth

Special Instrumentation
Reese scissors P6574 (Padgett KC MO)
Ligature carrier
Miniplate system (see Figure 7–2D)
Hall micro E drill system
Eyelid set
Bipolar Bovie console
Gore-Tex graft 1 mm (15293-10)
Clindamycin 600 mg dissolved in 30 cc normal saline to irrigate wound and soak Gore-Tex

Sutures
4/0 Ethibond ×557 (to attach Gore-Tex to corner of mouth)

Drains
TLS closed suction drain (#6640 Porex Surgical Inc.)

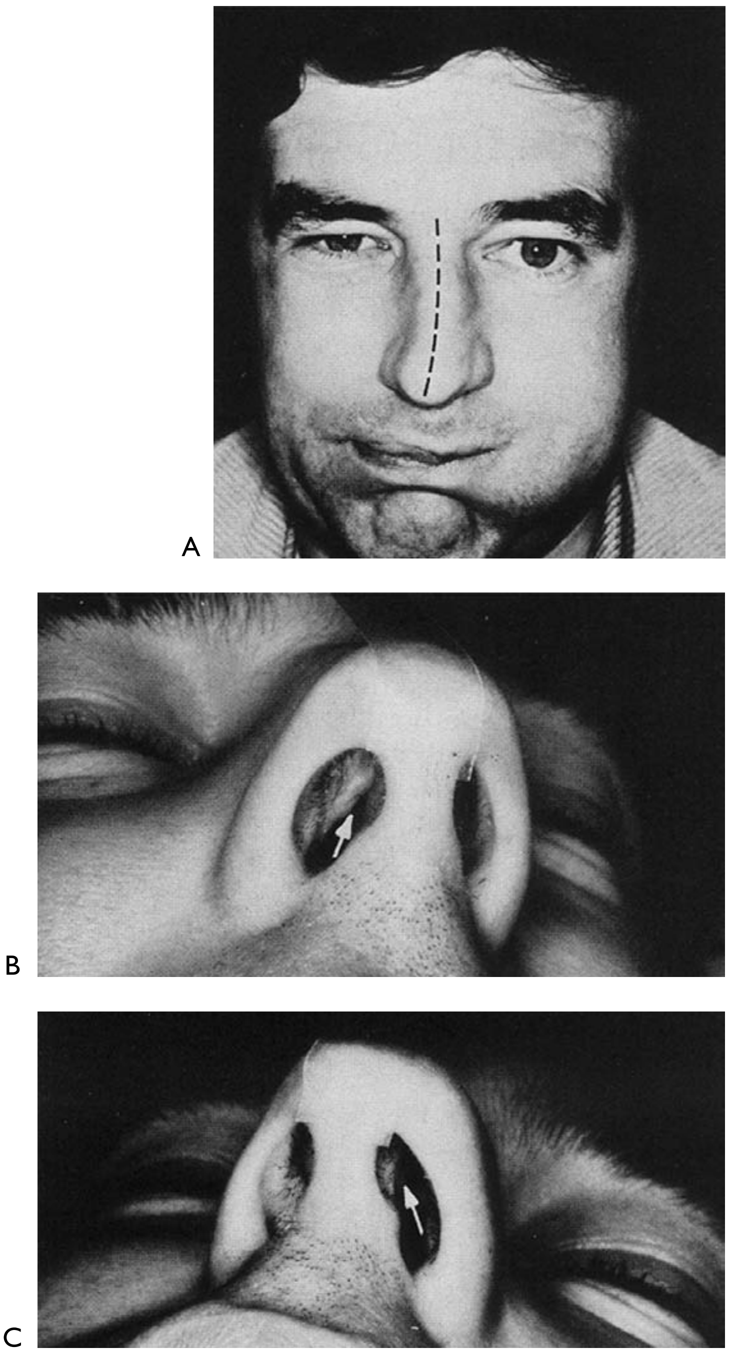


Figure 7–1. Nasal obstruction resulting from facial paralysis. **A**, Patient with faulty regeneration following right-sided facial paralysis. Note asymmetry when he attempts to blow out cheeks. Right eye closed, demonstrating synkinetic movement. Also note reversed C-shaped deformity of external nasal pyramid from nasal bones to tip. **B**, Patient complained of nasal obstruction from onset of facial paralysis that became more symptomatic by fourth month after onset because of faulty regeneration. Note collapse of angle between caudal edge of upper lateral cartilage and septum on the right. **C**, Normal relationship between caudal edge of upper lateral cartilage and nasal septum on the left. This patient was treated successfully with a nasoseptorhinoplasty and did not need an alar lateralization procedure. (From May M et al.[1] With permission.)

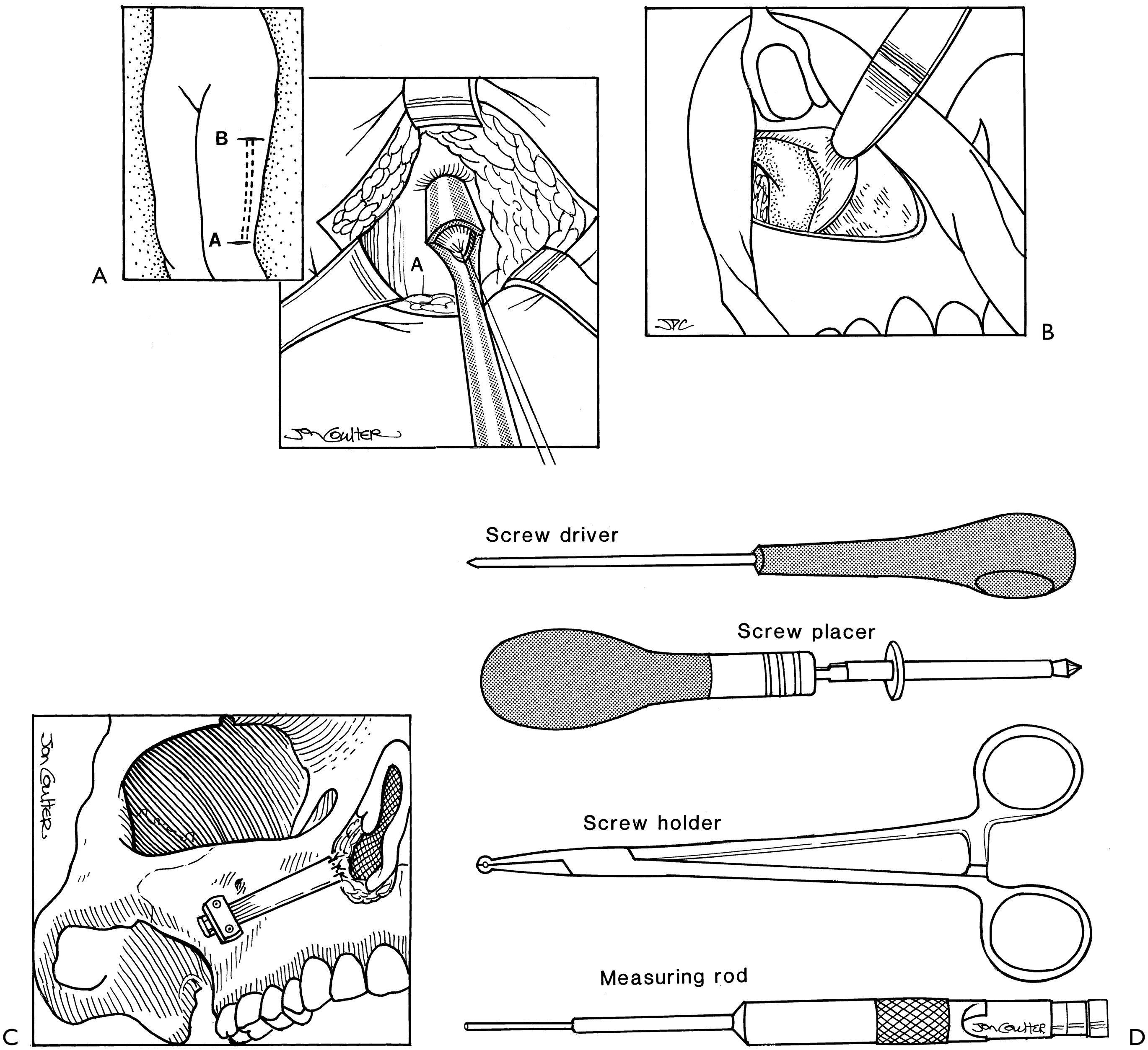


Figure 7–2. Nasal lateralization: fascia lata suspension and fixation with miniplate. Internal approach. **A**, Fascia lata taken from left thigh. An incision is made in the lateral thigh just above the knee (A). A tongue of fascia is pulled through a fascia stripper, and an appropriate length of graft material is taken. A counter incision is made at level (B) and the upper end of the fascia is divided. The fascia graft is then pulled inferiorly through incision (A). **B**, A buccolabial incision is made and periosteum is elevated exposing an area of the lateral ascending buttress of the maxilla. **C**, The fascia strip is fixed to the fibrocartilage base of the lateral nasal ala with 4-0 monofilament permanent sutures. The fascia strip is pulled laterally to create tension. Tension is maintained as the lateral aspect of the facial strip is fixed to the maxilla with a miniplate. A drain is placed in the surgical site prior to closing the wound. The wound is closed with a 4-0 chromic suture in a running locking fashion. (See Table 7–1 for instrumentation and suture materials.) **D**, Tools used to place miniplate.

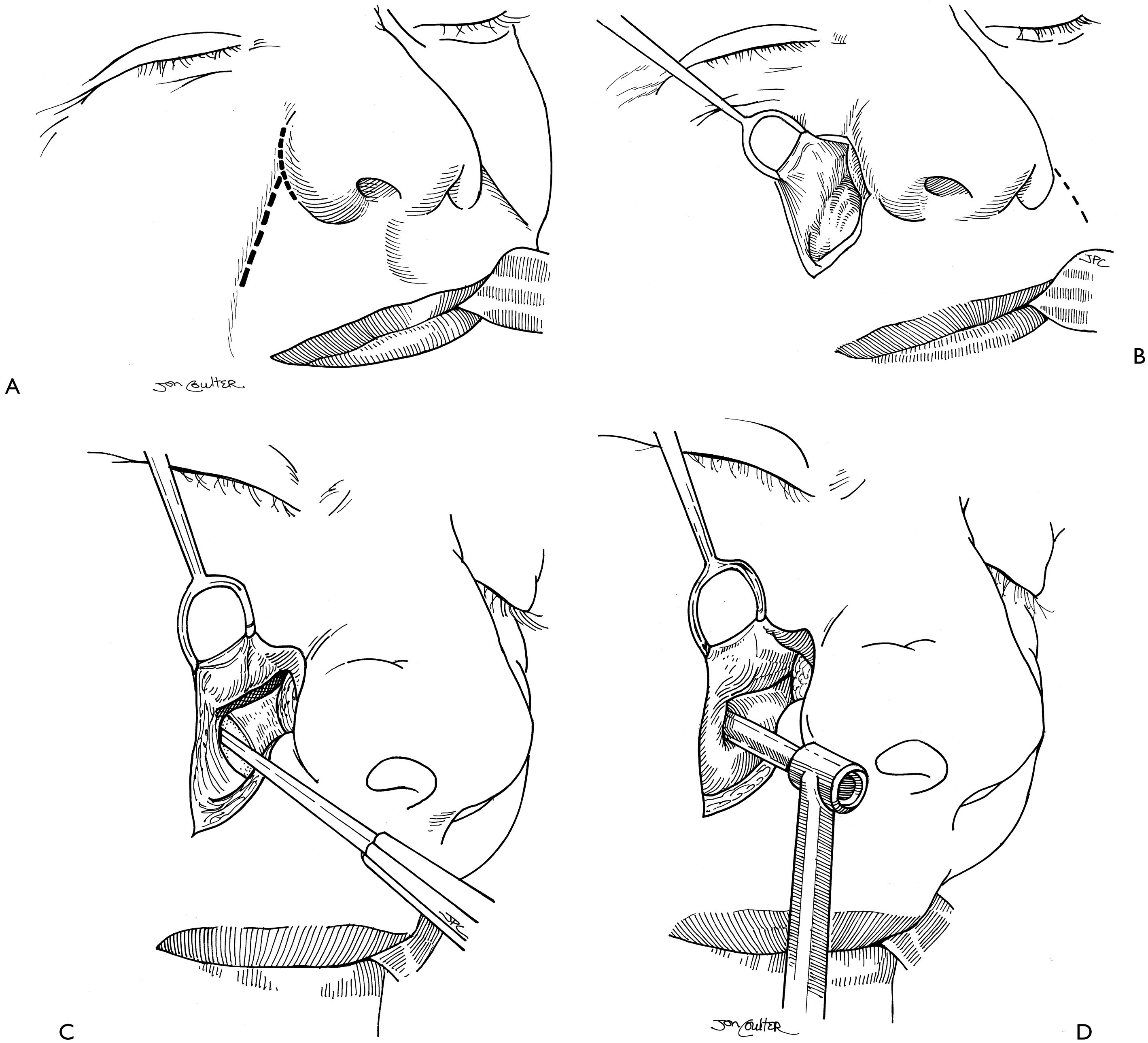
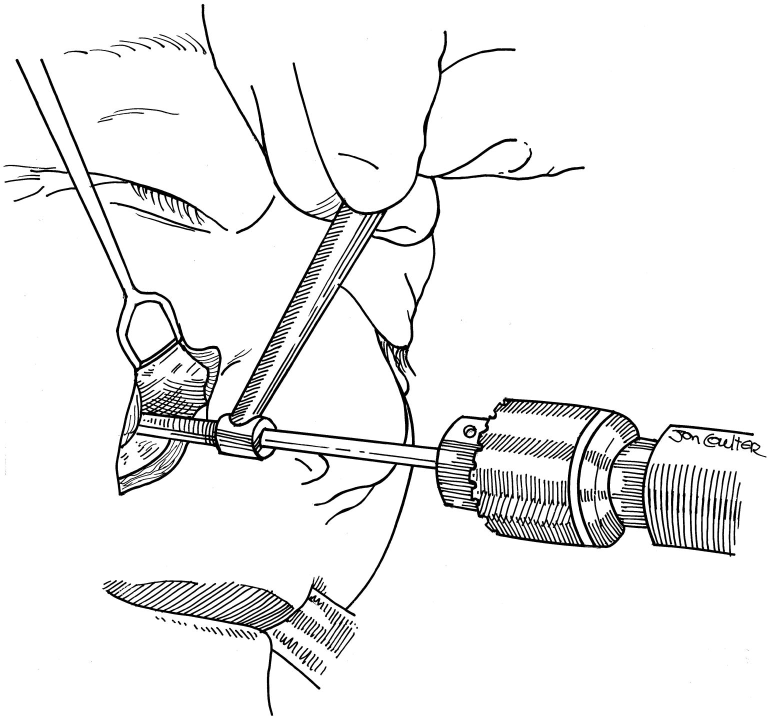


Figure 7–3. Nasal lateralization: fascia suspension and fixation with Mitek Mini Quick Anchor (Mitek Surgical Products, Inc., Norwood, MA). External approach. **A**, Incisions are made in the alar-facial and nasolabial crease. **B**, The deep aspect of the alar base is exposed. **C**, The periosteum is elevated exposing the lateral ascending buttress of the maxilla. **D**, A drill guide is placed perpendicular to the exposed area of maxilla in a position to produce the proper direction and tension for securing fascia from the alar base with a Mitek Mini Quick Anchor.



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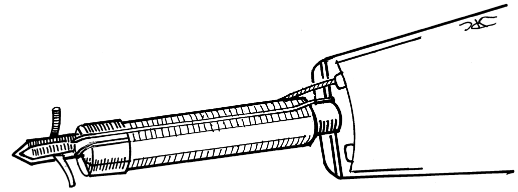

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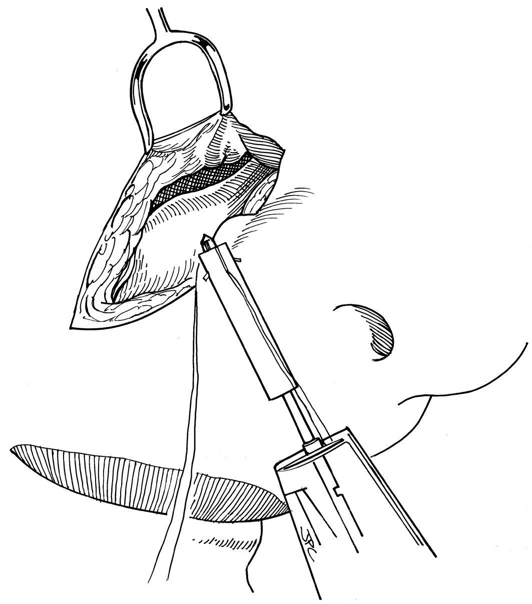

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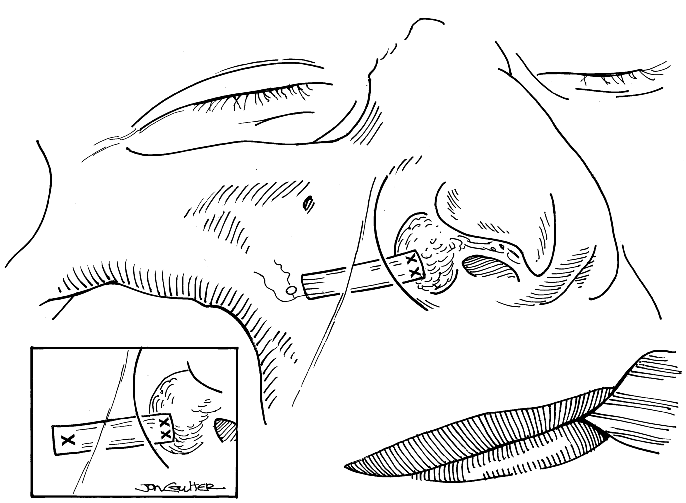


H

Figure 7–3. *(continued)* **E**, A drill hole is made into the maxilla (ideally into the lateral ascending buttress and not through the face of the maxilla). **F**, A close-up of the end of the inserter with Mitek Mini Quick Anchor. Note the harpoon design. Once it is placed into a prepared hole in the bone, the metal "whiskers" keep it in place. **G**, Mitek inserter with mini quick anchor is used to push the anchor into the hole created in the maxilla. Braided polyester suture and two needles come already attached to the anchor. **H**, The fascia is first attached to the alar base with 4-0 monofilament permanent sutures. Then, under lateral tension, the fascia is fixed to the maxilla with the sutures attached to the anchor. The wound is then closed in layers after the insertion of a TLS drain. The suction drain is brought from the surgical site out of a separate puncture through the skin. (See Table 7–1 for instrumentation, suture materials, and type of drain used.)

A-B

Figure 7–4. Nasal lateralization and upper lip suspension. Patient had a 2×2-cm epidermoid cancer resected that involved the skin in the right lip cheek crease region. Following this surgery, there was nasal collapse and upper lip droop on the operated right side. The rehabilitative procedure performed 2 years following the cancer resection is illustrated in Figure 7–3. Two months later, **A**, in repose. Note the barely noticeable healed scars are in natural skin creases. The nasal ala is in a normal position and nasal obstruction has been relieved. **B**, Smiling. The drooping of the upper right lip has been significantly improved.

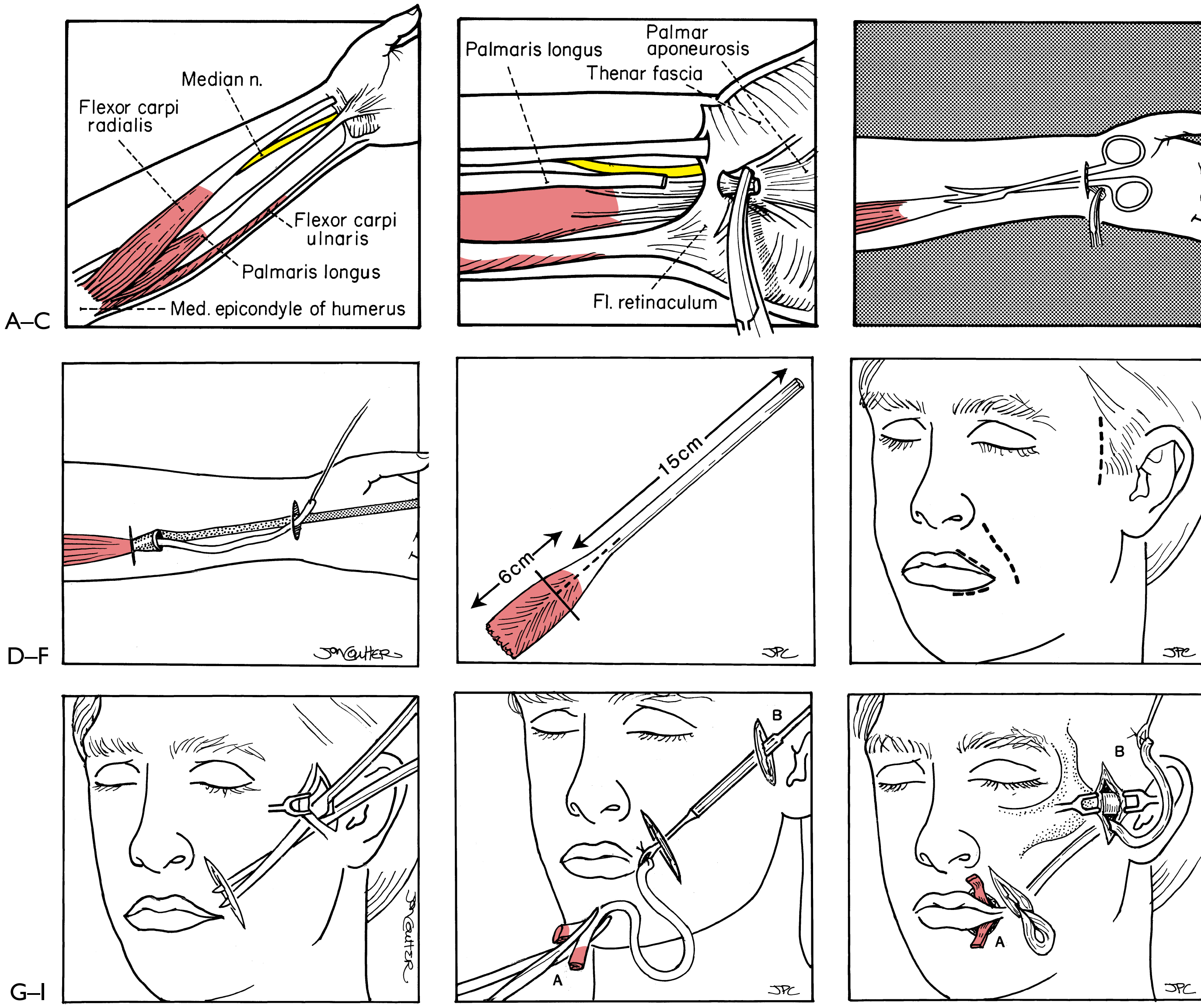
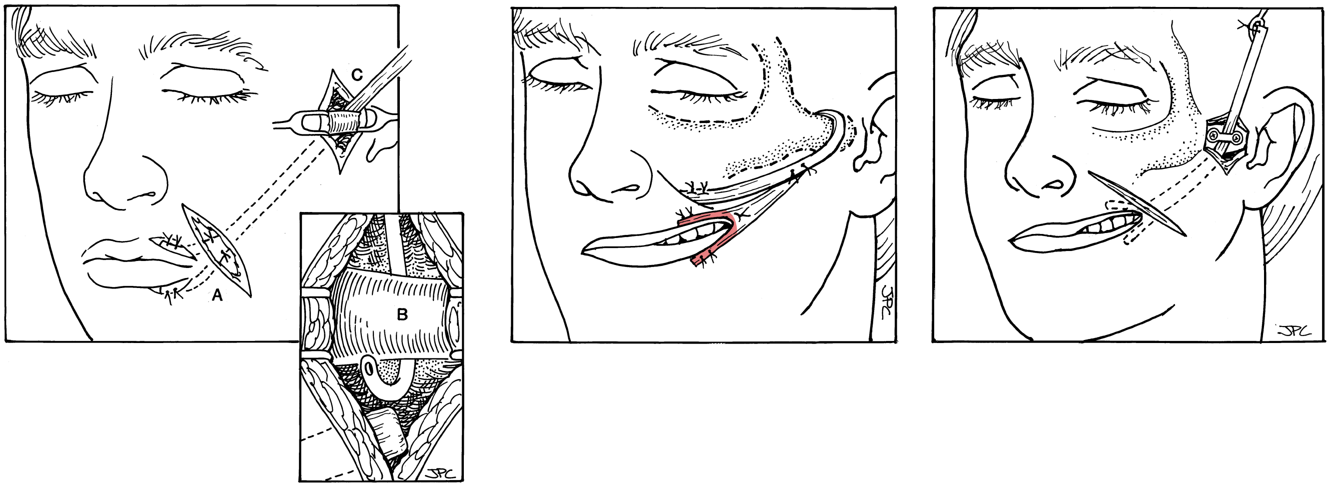
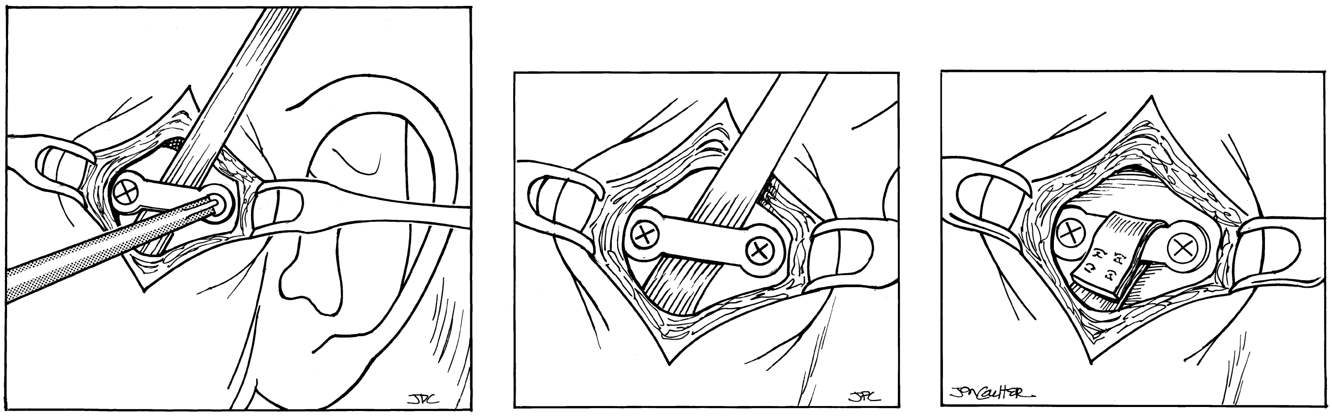


Figure 7–5. Palmaris longus muscle tendon reanimation technique (instruments used are listed in Table 7–1). **A**, The major landmarks and anatomical structures used for performing the palmaris longus muscle dissection are illustrated. **B**, Distal aspect of the palmaris longus tendon has been divided just as it inserts into the palmar aponeurosis. It should be noted the palmaris tendon is absent in 20% of patients. The presence of this tendon can be determined preoperatively by asking the patient to oppose the thumb to the little finger and flexing the wrist. The tendon can be found at surgery just deep to the skin and thin subcutaneous tissue through an incision that is made must behind the forearm palm crease. Structures at risk are the median nerve and the flexor carpi radialis tendon. The tendon of the palmaris longus muscle bisects the palmar crease; the flexor carpi radialis is deeper, thicker, and in a more lateral position when the forearm is rotated to place the thumb in the lateral position. **C**, The proximal end of the palmaris longus tendon is grasped with a clamp, and the soft tissue around the tendon is separated with a long scissors to about the lower third of the forearm. **D**, A fascia stripper is used to dissect the tendon away up to the junction between tendon and muscle, located about a third of the way up the forearm. At this point, the fascia stripper may not pass easily, and it may be necessary to make an incision through the skin over the fascia stripper. The wound is opened down to the tendon-muscle junction. The scissors are then used to dissect the muscle free from the surrounding structures so that the fascia stripper once again can be advanced toward the medial epicondyle of the humerus. The fascia stripper is rotated to divide the muscle. Tendon and muscle can then be removed and set aside. **E**, Approximately 20 cm of muscle tendon is harvested. The tendon is the useful portion of the graft. The majority of the muscle is removed since it does not hold sutures well and tends to tear when placed under tension. **F**, Three incisions are made: one in front of the sideburn to expose the zygomatic arch, one in the lip-cheek crease, and one along the vermillion. Note that the vermillion incision along the upper and lower lip is not joined at the corner of the mouth. **G**, A tunnel is developed between the subcutaneous tissue and superficial musculoaponeurotic system (SMAS) fascia. Respecting this plane is important in cases with residual facial function. Staying lateral to SMAS avoids injury to facial nerve fibers. **H**, A ligature carrier is placed through the zygomatic incision site (B) and out the lip-cheek crease incision. The proximal end of the palmaris tendon is sutured to the ligature carrier. The distal (muscle) end of the palmaris muscle-tendon graft is trimmed and bisected (A), leaving a portion of the tendinous connective tissue attached to each half of the muscle. **I**, The muscle-tendon is pulled through tunnels made between the lip-creek incision and along the upper and lower lip vermillion (A). The ligature carrier is pulled out with tendon attached (B).



J–L



M–O

Figure 7–5. *(continued)* **J**, The muscle-tendon is fixed with 4-0 Nurolon sutures to the upper and lower lip submucosa and fixed again, through the lip cheek crease incision (A). A tunnel is dissected around the zygomatic arch with a large right-angle Mixner clamp, and then a Deschamps ligature carrier is passed into the tunnel (B). The tendon is sutured to the carrier and the tendon is pulled out of the upper wound with the tendon deep to the zygomatic arch (C). **K**, The muscle end of the tendon is fixed to the lateral aspect of the upper and lower lip and corner of mouth so when the tendon is pulled around the zygomatic arch, a smile is created. This created smile should be overcorrected because it will always loosen to some extent. Fixing the fascia to the lateral aspect of the mouth in the lip-cheek area produces a pleasant smile and a natural lip-cheek crease without disturbing the patient's ability to open the mouth to its full extent. The oral aperture is severely limited by perioral or circumferential placement of a graft and should not be done. Then tendon is fixed on itself with 4-0 Nurolon sutures. The excess tail can be trimmed or used to reinforce the lip-cheek crease. **L**, **M**, **N**, **O**, Miniplate fixation is another option to fix the tendon to the zygomatic arch. Then the tendon is pulled under the miniplate before it is tightened down. Once the desired overcorrected smile is created, the plate is tightened (**M**, **N**). The excess tail is trimmed, and the remainder is fixed on itself with 4-0 Nurolon sutures. All wounds are drained and closed. (See Fig. 7–2D for miniplate instruments and Table 7–1 for instruments and suture material used for this procedure.)

A–C

D–F

Figure 7–6. Bilateral palmaris muscle tendon suspension. Patient with severe bilateral facial motor deficit following multiple episodes of alternating facial paralysis as part of the Melkersson-Rosenthal syndrome. **A**, Face symmetrical in repose. She can not approximate her lips. **B**, Maximum effort to produce a voluntary smile. **C**, Bilateral palmaris muscle tendon suspension through lip incisions. The lip-cheek crease incision was not used for aesthetic considerations. This exposure was achieved on left and right sides. **D**, Muscle-tendon grafts were placed under tension and fixed to the zygomatic arch with miniplate (Fig. 7–5). **E**, **F**, Four years following surgery. **E**, In repose (compare **E** to **A**). Note improvement in appearance of mouth at rest. **F**, The patient can produce a pleasing voluntary smile with less effort (compare to **B**).

A–B

Figure 7–7. Results of palmaris longus muscle transposition to mouth. **A**, Five years post-partial temporal bone resection; total facial paralysis on the right side is indicated by facial sagging. **B**, One year following palmaris longus muscle tendon transposition to reanimate the mouth. Face in repose. Note marked improvement. Although corner of mouth elevation was overcorrected at time of surgery, there has been loss of the initial results. This appearance 1 year after surgery should be lasting. Most of the changes occur within the first 3 to 6 weeks.

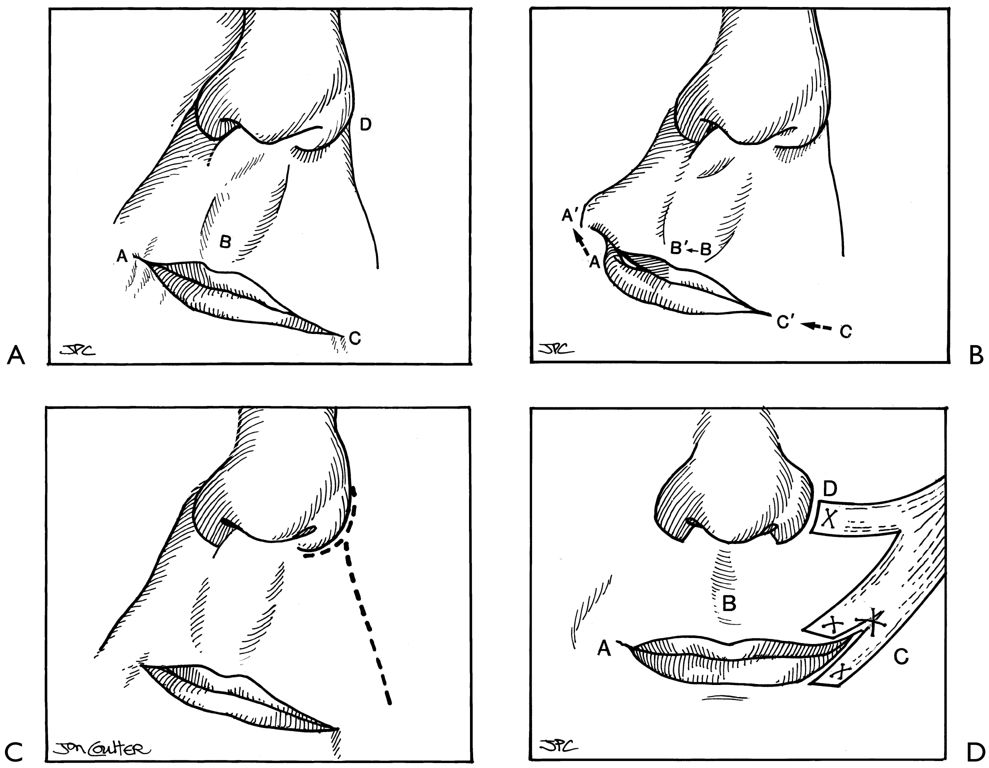
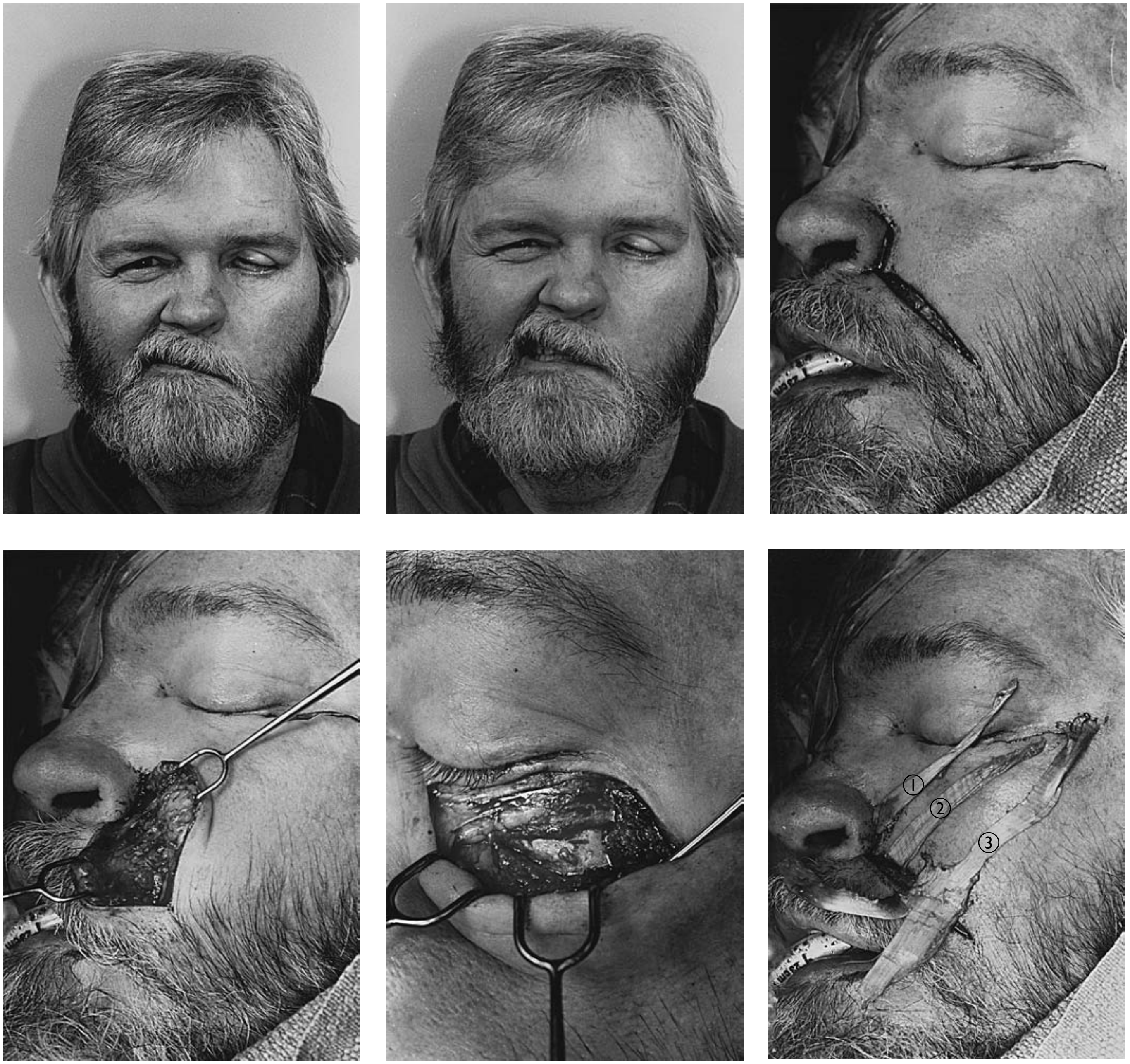


Figure 7–8. Analysis and correction of sagging mouth and collapsed nasal ala. **A**, Illustration of classic findings in a patient with total left facial paralysis. Note corner of mouth on involved side (C) droops and philtrum (B) is shifted to the normal side. The nasal ala and lip-cheek crease (D) is shifted to the normal side as well. This causes nasal obstruction and asymmetry in the perioral region. Note also, the distance between the philtrum (B) and the corner of the mouth on the normal (A) and paralyzed sides (C). The denervated periorbicularis muscles on the paralyzed side loses tone and contractility, whereas the normal half of the oral sphincter is contracted unopposed by the paralyzed side. **B**, These factors are exaggerated with the patient's effort to animate the normal side. Correction or improvement requires (1) ideally reanimating with neural reinnervation (Chapters 1, 2, and 3), (2) neuromuscular dynamic transfer (Chapter 5), or if (1) and (2) have been done, then augmentation with a static procedure is possible. **C**, The approach to this area through an alar-lip cheek crease incision gives adequate exposure and is aesthetically acceptable. (See Figs. 7–3 and 7–5 for technical details and Figs. 7–4, 7–6, and 7–7 for examples of results.) **D**, Symmetry of the mouth and alar repositioning can be achieved by fixing fascia at C and D as illustrated. The fascia or palmaris tendon is then fixed under tension to the malar bone or zygomatic arch. This static approach accomplishes two purposes: it creates symmetry at rest and produces a simulated smile. Instead of the paralyzed side being pulled by the normal side, it will remain in place. The result is a broader and more even smile (see Figs. 7–9 and 7–10).



A–C

D–F

Figure 7–9. Patient 9 months following resection of large posterior fossa meningioma on the left. There are multiple cranial nerve deficits including: V, VI, VII, VIII, IX, and X. Note the left eye turns in (CN VI deficit) and the upper lid droops with eyelid spring in place. Overclosure with the eyelid spring reduces corneal exposure (see Chapter 6). **A**, **B**, Sagging of midface, nasal ala, upper lip, and corner of mouth are the classical findings associated with a total facial motor deficit described and illustrated in Figure 7–7. The options for midfacial and mouth reanimation are limited because of the proximal location of the facial nerve lesion and multiple cranial nerve deficits. **C**, Incisions noted: (1) exposure to base of nasal ala, lip-cheek grove, upper and lower lips, and corner of mouth, and (2) to expose the orbital rim and malar bone. **D**, Exposure to attach fascia to nose-mouth area. **E**, Exposure of orbital rim to fix fascia to suspend nasal ala, upper lip, and corner of mouth. **F**, Fascial strips used for reanimation placed in their approximate position to accomplish goals of surgery. Fascia strip #1 will suspend the nasal ala to inferior orbital rim with a miniplate. Fascia strip #2 suspends the upper lip and is fixed with fascia strip #1. Fascia strip #3 is secured as illustrated for palmaris longus muscle-tendon reanimation technique (Figs. 7–5L-O).

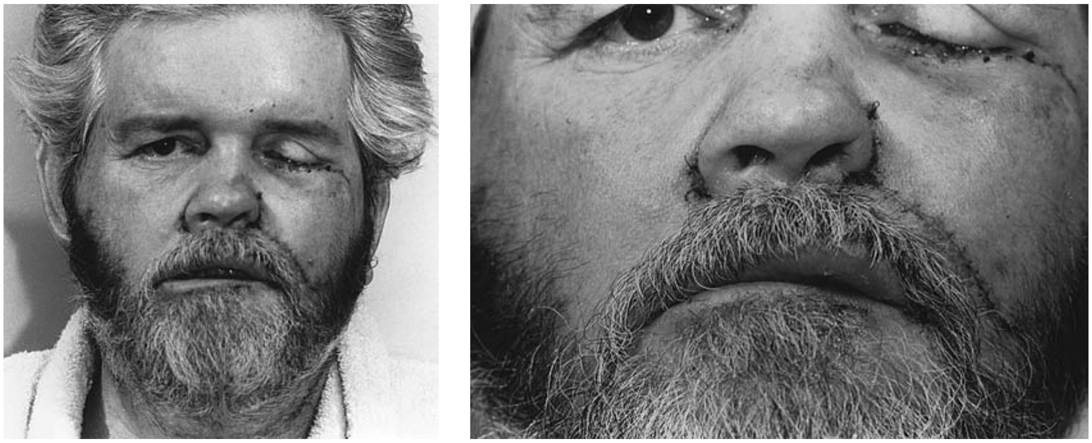
G  H

Figure 7–9. *(continued)* **G**, One week postoperatively. Note improvement achieved. **H**, Close-up. Note nasal ala is lateralized, upper lip suspended, and corner of mouth lateralized. This ideal result will not be lasting since over 3 to 6 weeks the suspended areas will come down to some extent. Perhaps more overcorrection than achieved would have been more desirable. Static procedures have a major shortcoming. One must be cautioned that too much tension to achieve the desired overcorrection may pull the fascia away from the soft tissue anchor points to the nose and mouth areas. This sense of correct tension requires experience with trial and error and luck. The limitations of this procedure as well as other static procedures accounts for only a 50% success rate. Initial failures can be salvaged by revision procedures.

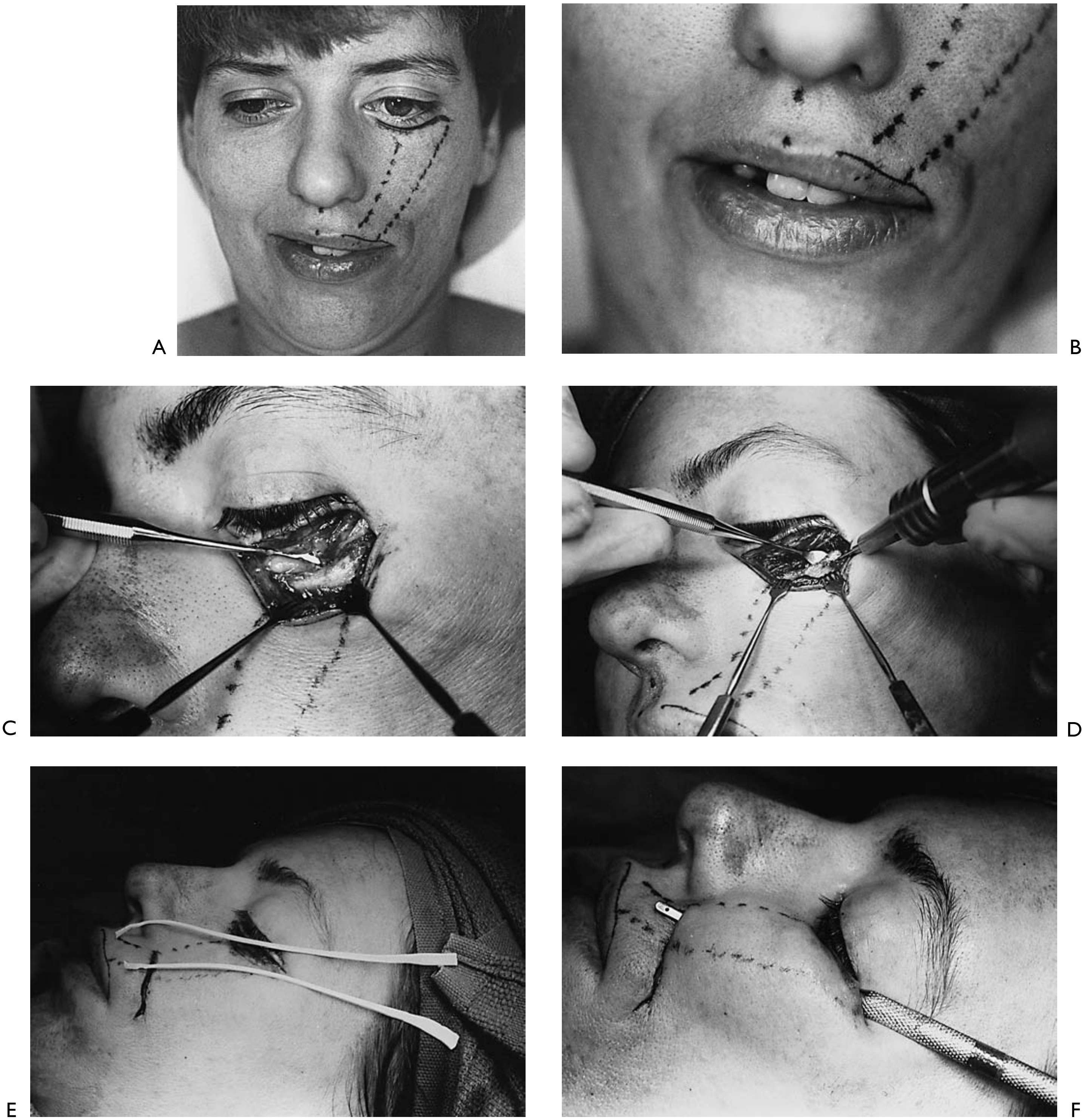
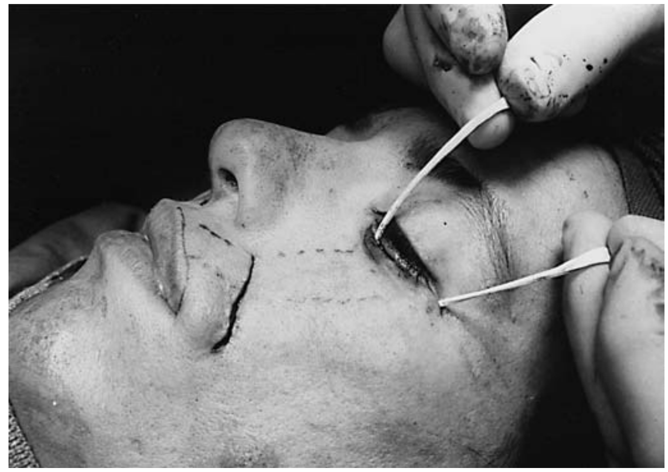


Figure 7–10. Patient with developmental (congenital) left facial paresis. There is movement present, but it is weak. There is noticeable loss of facial tone. The facial region innervated by the marginal mandibular and cervical portions of the facial nerve appear uninvolved. The areas of concern involve drooping of the lower eyelid, nasal ala, upper lip, and corner of mouth. **A**, Note the shift of the philtrum and asymmetry of the mouth involving the upper lip with sparing of the lower lip. Incisions and tunnel for Gore-Tex placement are marked on the skin. **B**, Close-up of mouth area. Ideally, the procedure is performed under local anesthesia so that "fine-tuning" of involved left side can be compared to normal side. **C**, Orbital rim exposed (see Table 7–2 for equipment and materials for this technique). **D**, Holes drilled into orbital rim. Elevator protects the globe. These holes will serve to accommodate miniscrews to secure Gore-Tex strips. **E**, Gore-Tex strips that will be used for suspension. They are stretched and placed in antibiotic solution prior to implantation. **F**, Ligature carrier placed through subcutaneous tunnel. The Gore-Tex is pulled through the tunnel from the lip-cheek to the orbital incision.


G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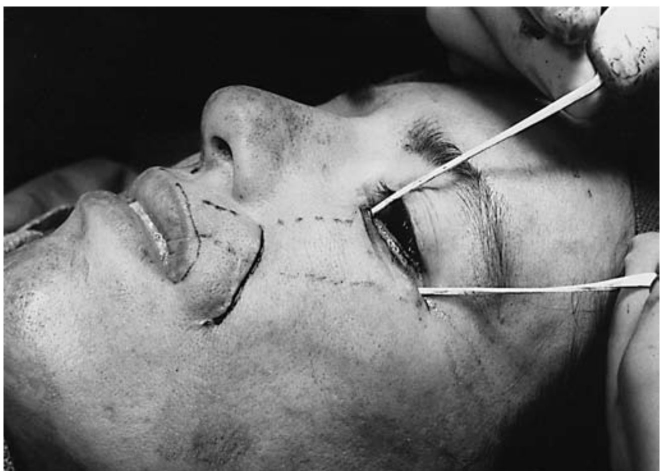

I


J

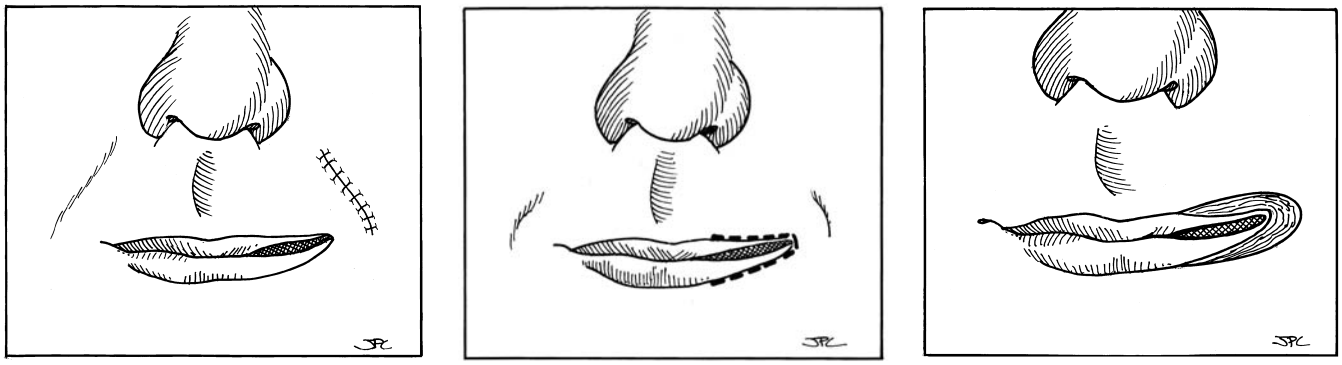

K

Figure 7–10. *(continued)* **G**, The strips are in position. **H**, One strip is fixed to the nasal alar base and the other to the lateral aspect of the upper lip. **I**, The strips are placed on tension, and the patient is asked to gently smile and then relax the mouth so that the proper tension, position, and vector can be determined to achieve the most pleasing results. **J**, Close-up of mouth before tension placed on the strips. **K**, Close-up of mouth with tension placed on the strips.
(Figure continued next page.)

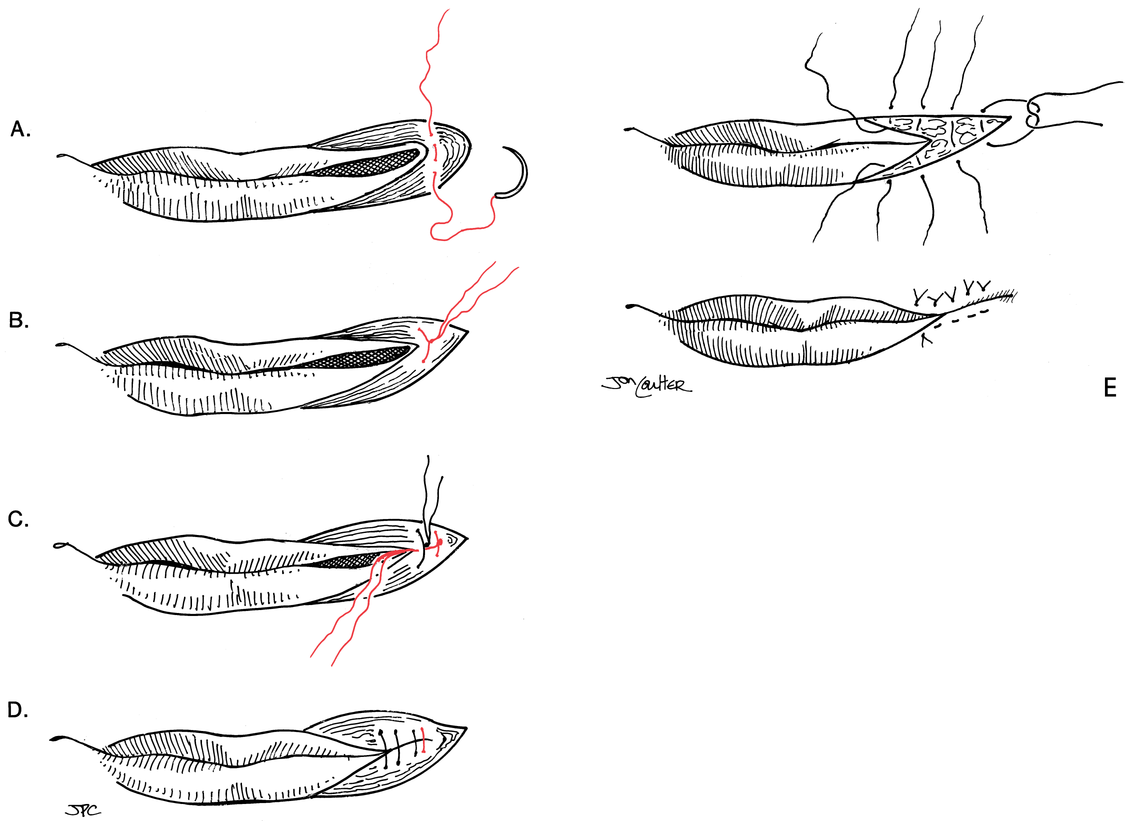
L–M

Figure 7–10. *(continued)* **L**, Six months following static suspension procedures. Compare **B** to postoperative results. There is almost perfect symmetry. [The lower eyelid appearance has been improved by cartilage implant into the lower eyelid and some tightening (see Chapter 6).] **M**, Note that preoperative facial function has been preserved and augmented by the suspension procedure. **N**, **O**, Close-up of result achieved.

N O



A–C

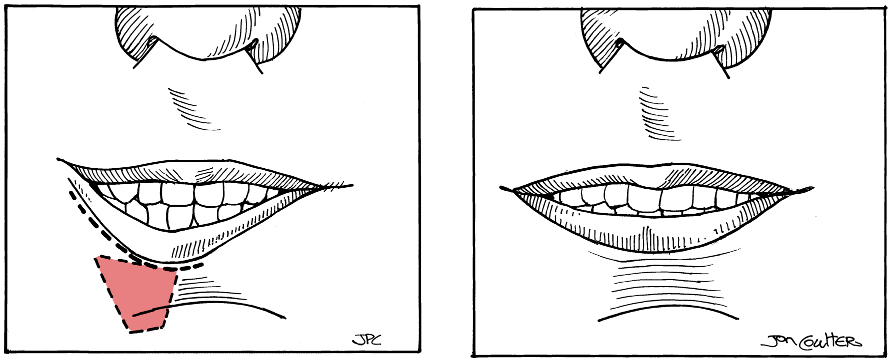


D

E

Figure 7–11. Lateral oral commissure "gaposis" correction. This defect occurs most commonly following temporalis transposition, but can occur with static suspension techniques as well. This is caused by a combination of factors: (1) the lack of tone involving the lateral oral commissure on the paralyzed side, (2) the forces placed on this area by the attached materials, especially to the lower lip, and (3) inadequate tension on the lateral commissure. **A**, Problem. Patient post-lateral oral commissure suspension. Note "gaposis." This impairs speech and oral competence. **B**, Technique to correct "gaposis." Incisions in lateral upper and lower lip vermillion extend to lateral commissure. **C**, Incisions and exposure completed. The dissection separates the lip submucosa from surrounding tissues. **D**, A through D demonstrate sequentially the key aspects of the lateral oral commissureplasty. (A, B) A 4-0 Vicryl suture (far-near-near-far) is placed into the soft tissues at the corner of the lateral commissures with care not to penetrate into the oral cavity through the mucosa. (C) The ends of this suture are brought toward the mouth. (D) Subsequent sutures are placed over the ends of the first suture. This maneuver helps to invert the wound closure. Note that the mucosal edge of the lateral commissure is rolled in. The suturing continues until the involved side becomes symmetrical with the normal side. The ends of the first suture can then be trimmed. **E**, Finally, the skin-submucosa is closed with 6-0 silk. The sutures are left in place for a minimum of 14 days to prevent wound dehiscence.

Figure 7–12. Neurolysis of marginal mandibular nerve (included to stress that this procedure should not be performed). Patient with lower lip asymmetry due to developmental facial motor weakness in the region innervated by the marginal mandibular and cervical branches. The various procedures available to treat this deformity with the risks and benefits of each were explained to the patient. The procedures included motor sensory re-education, botulinum injections, wedge resection, selective myectomy, and digastric muscle transposition (Chapter 4). **A**, Patient with developmental right lower lip deformity. **B**, Exposure of marginal mandibular nerve. **C**, A 4-cm length of marginal mandibular nerve on the normal side is resected. The nerve has been divided in its anterior extent and reflected posteriorly before dividing the proximal end. The length of nerve is resected to discourage spontaneous regeneration. The proximal and distal ends of the nerve are ligated to further discourage spontaneous regeneration. **D**, The results of the neurolysis are noted immediately and are permanent. This procedure was performed in 1968. This is the only time I used this approach. Since 1968, other techniques have been developed that are more effective with less morbidity. Note with smiling there is actually overcorrection. Now there is a paralytic lower lip defect on the normal side when compared to the paretic side. The limitations of this procedure are that the results may not achieve symmetry with one paretic side now mis-matched with the iatrogenically created paralyzed side, total denervation of the entire lower lip may cause lip biting and oral incompetence, and in patients without lower teeth, the denervated lower lip may invert into the mouth. Refer to this as the "vanishing lower lip syndrome."



A–B

Figure 7–13. Depressor labii inferioris resection (selective myectomy is preferred over neurolysis). This is performed on the normal side to correct paralytic lower lip asymmetry. This procedure does not paralyze the normal side as with neurolysis. Resection of the depressor labii inferioris balances the effect of the lack of depression on the involved side. **A**, Incision is made along the vermillion of the lower lip. The dissection is between the subcutaneous tissue and the facial muscles in this region. The depressor labii inferioris is uncovered by separating its attachments to the skin and periorbicularis oris muscle. The depressor is resected (red). **B**, The wound is closed in layers and a TLS closed suction drain is placed (see Table 7–1). The results are immediate and lasting. Symmetry is usually acceptable without loss of function.

A B C D

Figure 7–14. "Fine-tuning–touch-up" surgery. Perioral hypokinesia. Eight years post-acoustic tumor surgery and 12-7 anastomosis on left side and 5 years post-temporalis muscle transposition. **A**, Mouth at rest, good tone and symmetry. **B**, Voluntary smile is asymmetrical with classical lower lip deformity. **C**, Procedure performed under endonasal-tracheal general anesthesia. The incisions are made in the lip-cheek crease to plicate to transposed temporalis muscle, and in lower lip vermillion to resect the depressor labii inferioris on the normal side and to attach the digastric muscle on the left side (see Chapter 4). An incision is outlined at the left corner of the mouth to perform a lateral commissureplasty (see Fig. 7–11). **D**, Temporalis muscle isolated and ready to plicate to tighten the corner of the mouth. *(Figure continued next page.)*

E

F–G

Figure 7–14. *(continued)* **E**, The depressor labii inferioris muscle on the normal side is dissected free and will be resected. **F**, **G**, Mouth at rest and with smile 1 week following surgery.

A B

C

Figure 7–15. Patient 1 year post-herpes zoster oticus that involved left side. **A**, Now presents with paretic left lower lip deformity. **B**, Exposure and resection of pressor labii inferioris. **C**, Immediate results show improvement.

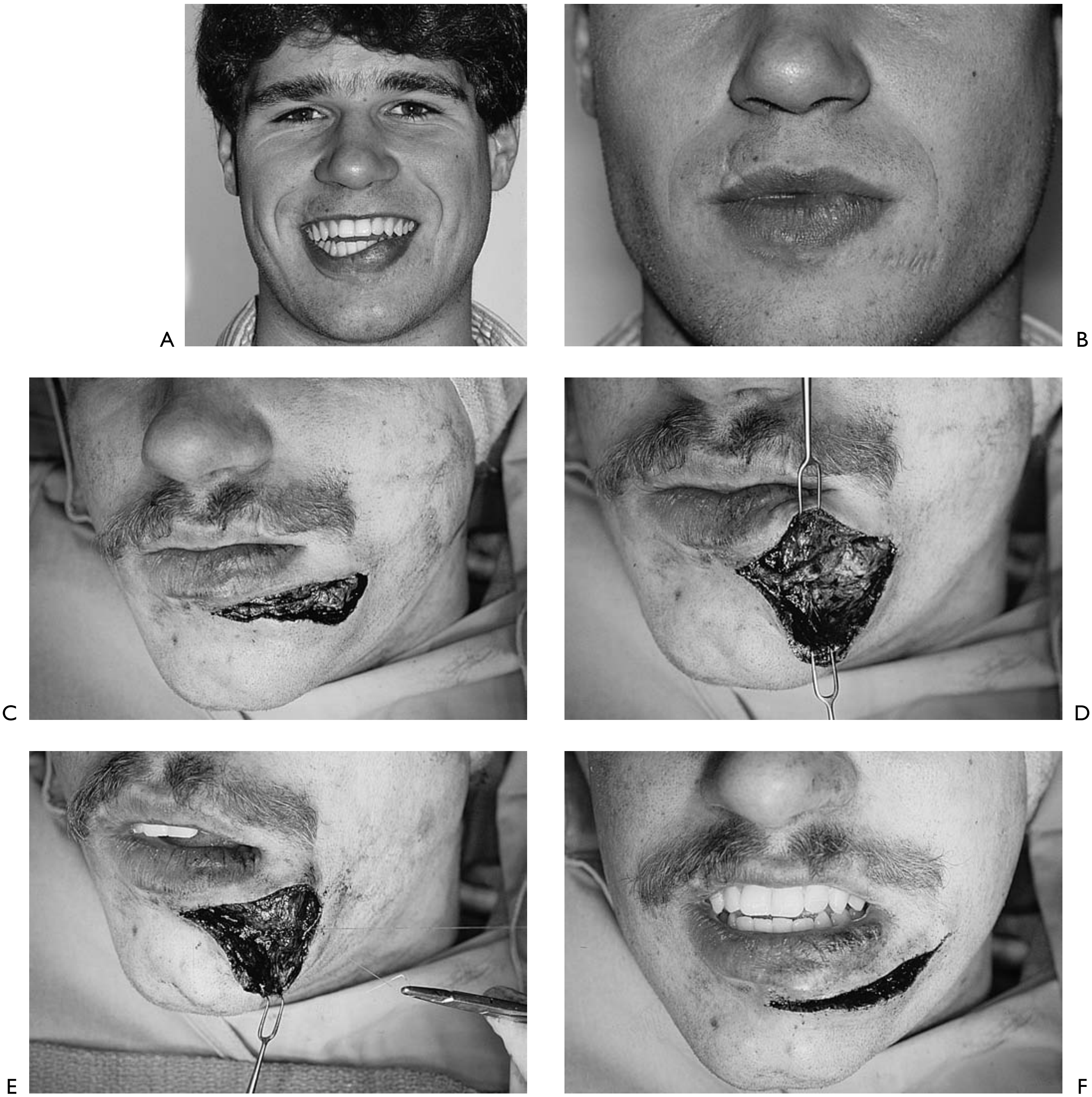
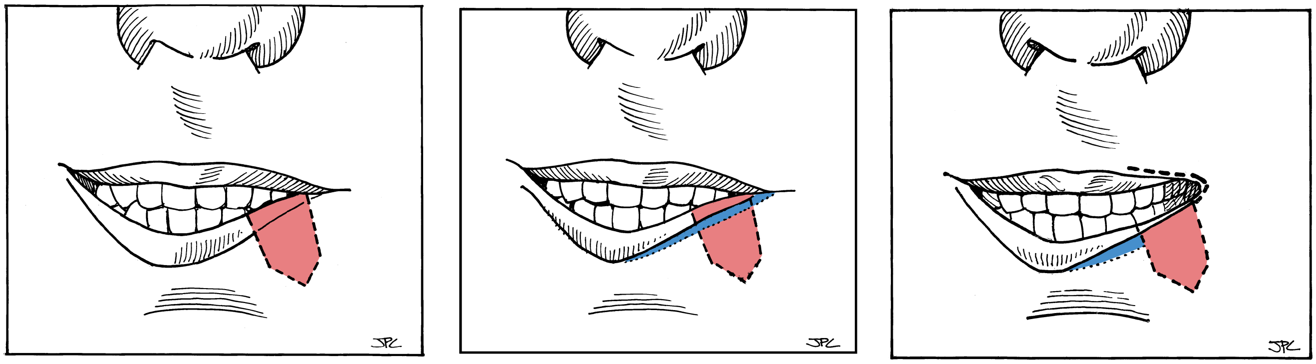
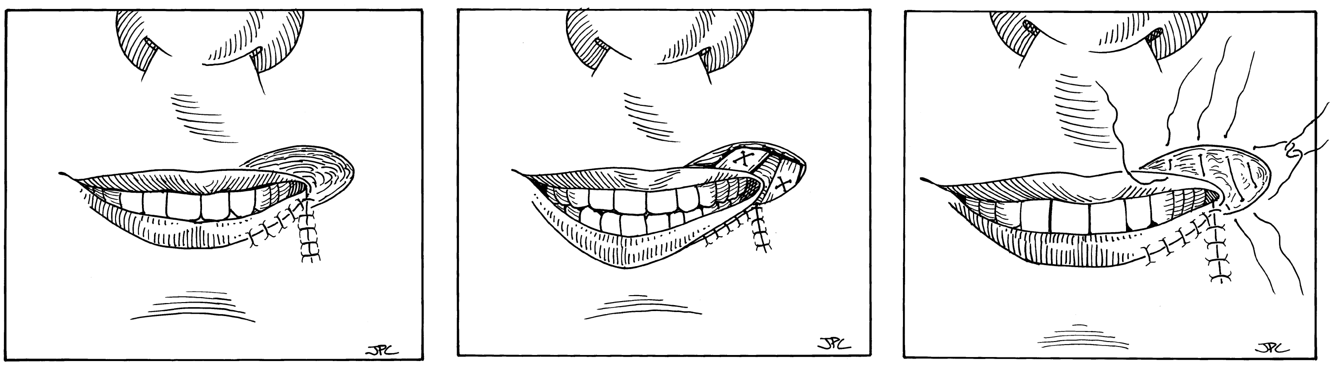


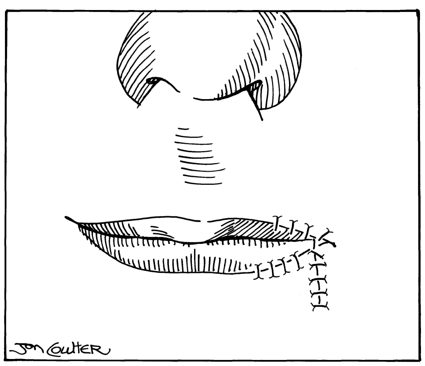
Figure 7–16. **A**, Patient with lower lip deformity following trauma caused by automobile accident. Deformity pronounced with smiling. **B**, Note scar from injury. **C**, Region of lower lip explored through scar which was resected and revised. **D**, The depressor labii inferioris muscle found was divided. From the findings at surgery, it was assumed that the muscle was not repaired following the initial trauma. **E**, The muscle was repaired. The innervation to the region was found undisturbed and was preserved. **F**, Lip function was restored in this case by repairing the depressor muscle on the involved side. In this case, it was critical to determine that the deformity was due to muscle injury and not nerve. This was determined preoperatively by using a cutaneous electrical nerve stimulator (Hilger).



A–C



D–F



G

Figure 7–17. Wedge resection of paralyzed side of lower lip. Unilateral permanent paralysis of the lower lip and the resultant defect following unilateral injury to the marginal mandibular nerve can be improved by a technique described by Glenn and Goode.[2] The paralyzed side of the lower lip is partially resected. This procedure produces the following effects: (1) shortens the lower lip horizontally (2) decreases size of oral sphincter and improves oral competence, and (3) removes a segment of denervated nonfunctioning oral musculature. **A**, A full-thickness wedge outlined is excised. The lateral limb of the wedge does not reach the lateral commissure. The width of the wedge should not be greater than one-third of the distance between the junction of the normal and paralyzed side of the lower lip and the external commissure on the involved side. The inferior extent of the wedge is kept above the horizontal chin crease. **B**, A horizontal cheiloplasty can be combined with the wedge resection if eversion of the lower lip exists or is created by the wedge resection. **C**, "Gaposis" repair (Fig. 7–11) can be combined with this procedure if necessary. **D**, The "gaposis" is corrected after the incisions for the wedge and cheiloplasty are closed. **E**, The fixation points of previously performed temporalis muscle transposition or static suspension procedure (XX) can be adjusted if a problem exists with overcorrection. **F**, The lateral commissureplasty is closed as described in Figure 7–11. **G**, Final closure is as described in Figure 7–11. A multilayered deep muscle closure prevents late separation and formation of a depressed scar.

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8

Reanimation: Dual Systems by Combining Procedures

Mark May, M.D.

The rehabilitation techniques that work have been described in the previous chapters of this section. This is the last chapter on surgical reanimation of the paralyzed face. Six case presentations have been chosen in an attempt to highlight as well as emphasize the benefit of introducing dual systems and combining the concepts proposed in the previous chapters.

Each patient with facial paralysis presents with unique problems. Therefore, with each case, I will share my reasoning process involving the following: (1) case selection; (2) how to choose the technique to best correct specific deformities; (3) how to achieve maximum rehabilitation with one scheduled procedure; (4) how to decide the best time for nerve grafting, hypoglossal-facial repair, or temporalis muscle; (5) when is it too late to repair the facial nerve; (6) how to manage recurrent benign tumors and malignant tumors; and (7) what to do when efforts fail to improve the patient's condition or make the situation worse.

The purpose of this chapter is to stress the complexities of surgically rehabilitating patients with facial paralysis. Finally, the physician who masters the material in this book will be ideally positioned to treat the patient with a paralyzed face.

Case 1 (Figure 8–1)

Reanimation 18 months following acoustic tumor surgery. A 45-year-old physician presents 18 months post-right acoustic tumor surgery. The facial nerve was sacrificed with the tumor resection. He has not been able to return to work because of eye irritation and emotional depression over his facial deformity.

Patient's Concerns

The patient was concerned about his eyes, particularly eye irritation, overflow tearing due to exposure keratitis, and the inability to close the right eye. He was also concerned about the mouth droop which made it difficult to speak clearly and drink liquids without drooling.

Examination

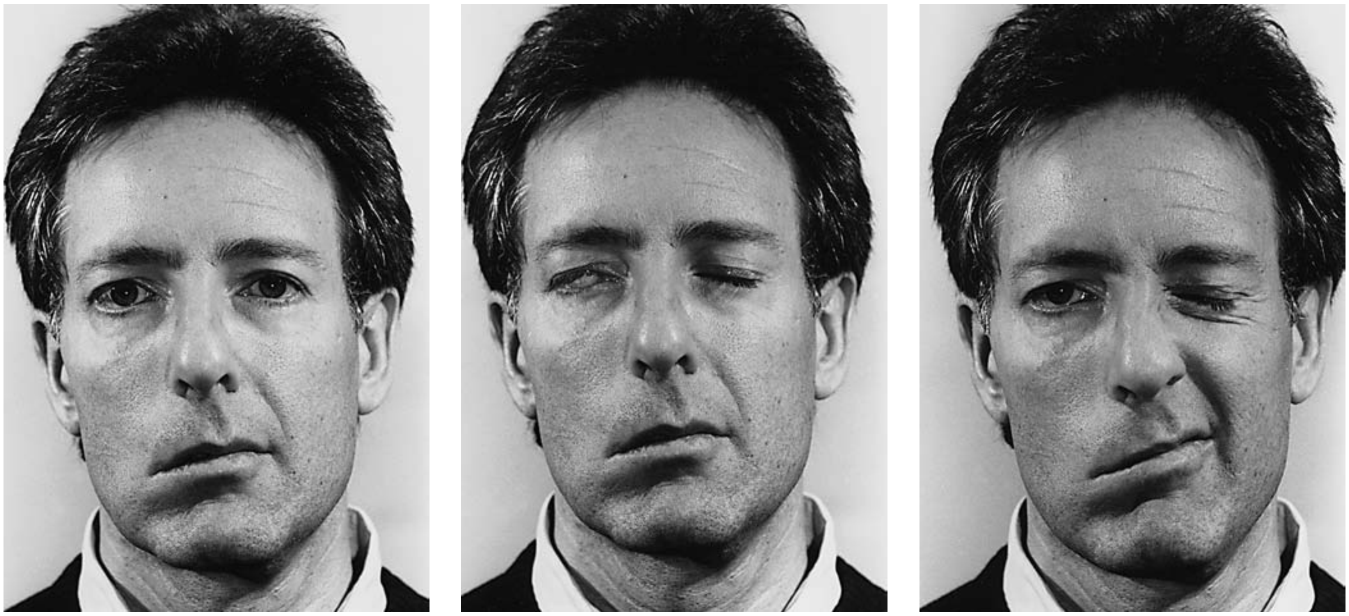
A, There are no other cranial nerve deficits; tongue and temporalis muscles are normal. On the involved right side, there is loss of forehead creases. The brow is acceptable at rest. There is a prominent tarsal-supratarsal fold. There is drooping of the lower lid, especially in the lateral half. There is slight collapse of the naso-alar fold, loss of lip-cheek crease, and drooping and asymmetry of the mouth. **B**, Incomplete eyelid closure. **C**, No movement or formation of facial creases noted as patient voluntarily contracts muscles around eye and mouth. This same maneuver was repeated with the patient in supine position to eliminate the effects of gravity. Sometimes slight movement indicating some spontaneous return of facial function will be noted with patient lying down, but will not be detected with the patient upright.

Management Options

1. *Hypoglossal-facial anastomosis* (see Chapter 3). This was offered to the patient by the referring neurosurgeon. The risk of tongue morbidity was a major objection raised by this physician-patient, considering it might further impair articulation and handling food and liquids.

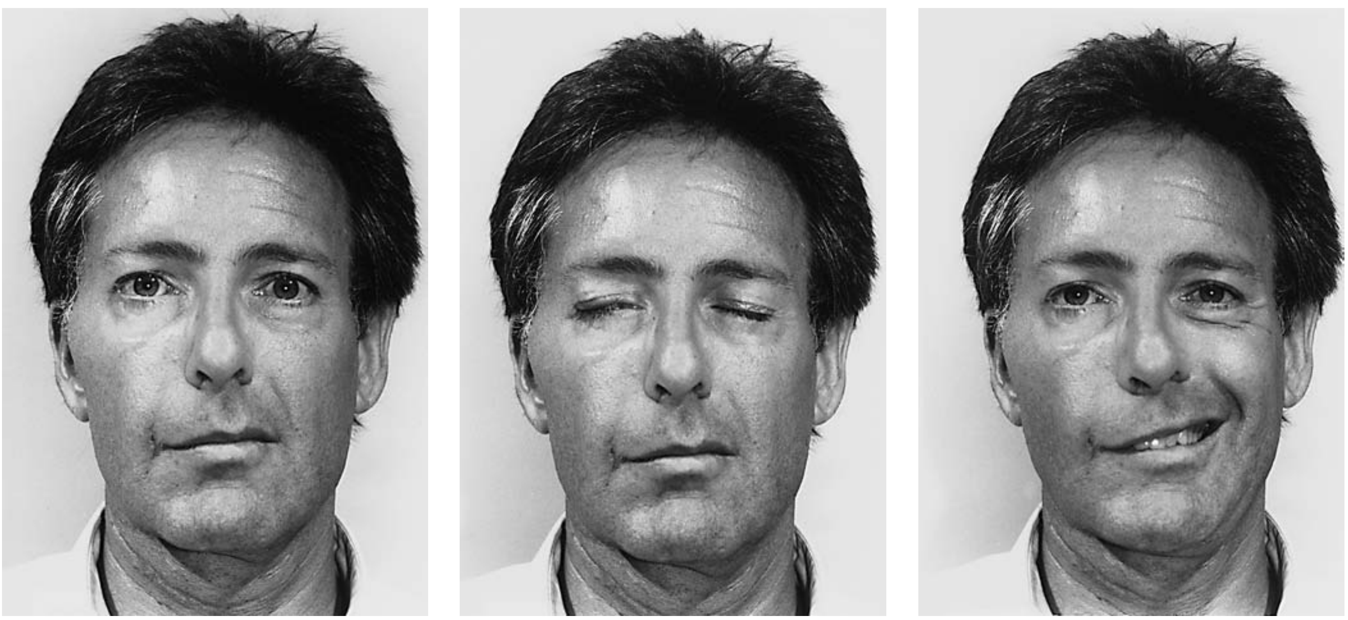
2. *Hypoglossal-facial jump graft* (see Chapter 3). The ideal time for this procedure is within 1 month following facial nerve disruption. The longer the delay, the poorer the outcome. The patient is 18 months postinjury, not too late to get some improvement with the XII-VII jump graft but beyond the ideal time period.

3. *Dual system* combining the XII-VII *jump* with a *temporalis muscle transposition* (see Chapter 4). Immediate improvement is a major advantage of the temporalis muscle. Further, it will enhance the results of the XII-VII jump graft. Considering the patient would like to be able to return to work as soon as possible, a procedure that offers immediate results is attractive.



A–C

Total right facial paralysis 16 months post-right acoustic tumor surgery.

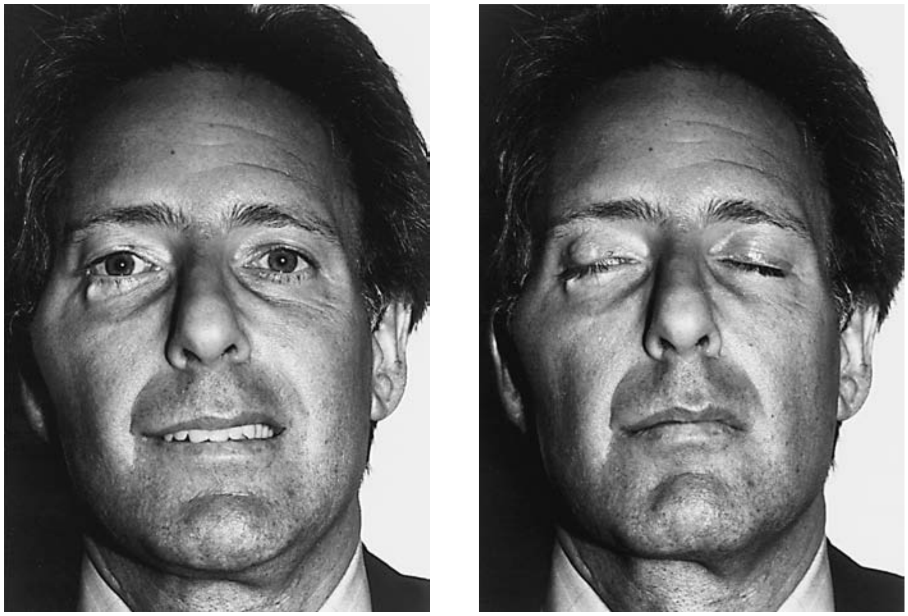


D–F

Results 4 months following temporalis muscle transposition and eyelid reanimation. It is too early to evaluate effect of XII-VII jump graft.

Figure 8–1.

4. *Free neurovascularized muscle* transplant (see Chapter 5). This procedure is not indicated whenever there is an opportunity to reinnervate the viable facial muscles, as in this case.
5. *Cross facial-graft* (see Chapter 3). This procedure is useful to motor a free muscle transplant (see Chapter 5) and as a primary procedure to reinnervate the paralyzed face when performed within 1 month of injury and not later than 6 months.
6. *Static procedures* (see Chapter 7) are reserved for "fine-tuning" or touch-up surgery to correct persistent deformities after the other procedures had adequate recovery time. This requires a minimum of 2 years for nerve repairs or cranial nerve (VII, XI, XII) substitution procedures.
7. *Eye procedures* (see Chapter 6) are absolutely indicated in this case and are part of the rehabilitation program. Eyelid closure can be improved. The brow is acceptable. A gold weight is ideal here because the upper lid has a prominent tarsal-supratarsal fold, and there is no lid retraction with effort to close the eyelids. Eyelid closure can be further improved by tightening and elevating the lower lid with a combination modified Bick and cartilage implant procedure.

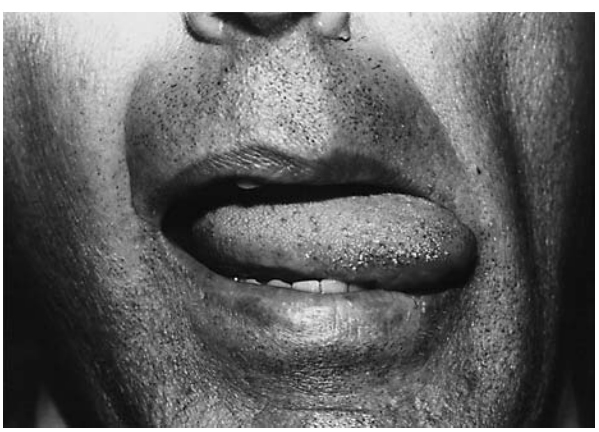


G H

Two years post-rehabilitative surgery, effect of XII-VII jump graft can be noted.

I J

Tongue function is unimpaired post XII-VII jump graft.



K

Figure 8–1. *(continued)*

After discussion of risks, options, and benefits, the patient was scheduled 1 week later for a XII-VII jump graft, temporalis muscle transposition, gold weight and cartilage implant, and lower lid tightening procedure.

Results

D, The patient in repose, 4 months post-rehabilitative surgery. It is too early to appreciate any changes from the XII-VII jump graft. The right lower eyelid is symmetrical with the normal right side. The droop has been corrected. The gold weight is covered by the tarsal-supratarsal fold. The position of the corner of the mouth is improved compared to preoperative photo **(A)**. There is a suggestion of a lip-cheek grove on the paralyzed side. **E**, Eye closed. Good eyelid approximation laterally with minimal exposure medially. **F**, Voluntary smile. The temporalis muscle attachment to the lip-cheek crease needs to be tightened.

The patient was disappointed because the corner of the mouth was overcorrected for the first 3 weeks, but then the suspension effect was lost over the following 3 weeks. Overall, the patients was pleased with the improvement, especially the eye region. The eye was much more comfortable, and he has returned to work as a family physician. In such a case, with a dual system and the likelihood that improvement would be noted because of the XII-VII jump graft, no effort was made to revise the temporalis muscle procedure (see Chapters 4 and 7). **G**, Two years post-rehabilitative surgery. At 1 year, tone and movement were beginning as a result of the XII-VII jump graft, and at 2 years, the results are significant. Note the lip-cheek groove, improved symmetry, and movement of the mouth. The effect of the XII-VII jump graft will continue to improve over 5 years. Sessions with a facial rehabilitation physical therapist was recommended. **H,** Eyes closed. The gold can be seen as a round prominence due to a fibrous pseudocapsule that forms around the implant. Most patients and casual observers are not aware of this deformity because the eyelids are open the majority of the time. Note that the gold is not visible with the eyes open **(G)**. The prominence under the lateral aspect of the lower lid is from the cartilage implant. This can be corrected, if requested by the patient, by trimming that piece of cartilage.

In most cases, only the midface and mouth are reinnervated following a XII-VII procedure. However, in some cases, function around the eye as well as the mouth will be restored. In such cases, facial creases will return, and the patient will be able to close the eyelids lightly. If this is observed, it may be possible to remove the gold and cartilage because both procedures are reversible. This would be done only in cases where the gold or cartilage was causing problems. For example, the gold may be unsightly or cause overclosure. Some patients complain that the eyelid with the gold implant tends to close when reading or they are aware of a pressure on the eye. **I**, **J**, **K**, Tongue movements are unimpaired. The XII-VII jump graft is a useful addition to the variety of reanimation options available. This procedure is reliable and satisfies a most important requirement: reinnervation to a recipient without a deficit to the donor. This is a major advantage over the classical XII-VII crossover procedure (see Chapter 4).

Case 2 (Figure 8–2)

A 52-year-old woman presents 2 years following tympanomastoid surgery for cholesteatoma and iatrogenic facial paralysis. The paralysis was noted immediately following the surgery. No effort was made to evaluate or treat this problem until now, 2 years after the facial nerve injury. None of the recommendations regarding management of this common problem, iatrogenic injury to the facial nerve during ear surgery, had been pursued (see Chapters 1 and 2). The patient anticipated spontaneous recovery based on the reassurance of the surgeon. When no recovery occurred after 2 years, she sought another opinion.

Patient's Concerns

The patient was ashamed and self-conscious of her facial appearance. Her eye on the involved side was uncomfortable in spite of frequent use of artificial tears. Normal speech and eating were impaired, and pain associated with lip biting was common. Collapse of the nasal ala on the involved side caused nasal obstruction. She wanted to know what happened to cause the paralysis and could anything be done to restore her face to normal. I told her that the nerve was most likely injured during the ear surgery and facial reanimation procedures are available to improve her facial appearance and function, but nothing can be done to restore her face to the way it was before the ear surgery. Her expectations were realistic.

Examination

The patient is 2 years post-tympanomastoid surgery. **A**, In repose. There is absence of forehead creases. The brow has lost its upward curvature. Prominence of the tarsal-supratarsal fold is prominent. Greater scleral show is noted on the involved left side due to drooping of the lower eyelid. The presence of facial creases in the naso-orbital groove on the left suggests residual innervation or evidence of spontaneous neural regeneration. The nose and mouth are pulled to the normal side, and drooping of the corner of the mouth is striking. The marked asymmetry of the lips is due to denervation of half of the oral sphincter with contraction on the right unopposed by the paralyzed left side. **B**, Incomplete eyelid closure. **C**, There is no movement of the facial muscles on the left except the inferior and anterior border of the platysma (arrow). The facial creases under the left eye (arrow) and this subtle platysma finding are evidence of a incomplete injury or some spontaneous recovery. Electromyography did not support any evidence of muscle innervation or signs of regeneration. Computerized tomography (CT) demonstrated a modified radical mastoid cavity in a sclerotic temporal bone on the operated side. Further, in the location of the tympanic segment of the facial nerve, there was a prominence suggesting neuroma.

Management Options

1. Re-explore the tympanomastoid segment of the facial nerve to determine the condition of the facial nerve and possibly perform a nerve repair. This option to repair the facial nerve 2 years after injury rarely yields useful results. However, this patient is an exception because of the facial creases and platysma contraction. The poor results with late facial nerve repair only apply to cases where it is absolutely certain that the nerve has been completely disrupted and there has been no evidence of regeneration.

2. Hypoglossal facial anastomosis. A nerve repair in the temporal bone would preclude the XII-VII procedure. However, in the event that the facial nerve was not repaired in the temporal bone, the XII-VII procedure performed 2 years postinjury is capable of producing useful

A–C

Two years following tympanomastoid surgery and facial nerve injury.

D–F

Results 9 months following interposition nerve graft repair and eye reanimation.

Figure 8–2.

facial tone, symmetry, and movement. When performed as late as 2 years after injury, the XII-VII jump graft, although an option, has not been as successful as the classical XII-VII crossover procedure.

3. Temporalis muscle transposition can be performed together (dual system) with either a facial nerve repair or XII-VII crossover procedure. This would give immediate symmetry and some movement. In addition, combining a dynamic (muscle transposition) to a reinnervation procedure decreases the work of the reinnervated muscles.
4. Free neurovascularized muscle transplantation is not an option as long as it is possible to reinnervate viable facial muscles.
5. Eye reanimation is part of the rehabilitation program in this case. The brows look good. A gold weight is ideal because of the prominent tarsal-supratarsal fold and absence of lid retraction with an effort to close the eyes **(B)**. Lower lid tightening and a cartilage strut will improve lower lid position and eye closure.
6. Static suspension of the nasal ala was discussed with the patient because of symptoms related to nasal ala collapse on the involved side.

After risks, options, and benefits were discussed, the patient was scheduled for transtympanomastoid exploration of the facial nerve and possible repair using the greater auricular nerve. If this was not possible, a XII-VII crossover procedure would be performed. The reinnervation technique would be combined with a temporalis muscle transposition and Gore-Tex suspension of the nasal ala (see Chapter 7). The eye would be reanimated with a gold and cartilage implant, and the lower lid would be tightened.

Surgery was performed 1 month later. A facial nerve traumatic neuroma was noted in the pyramidal segment (junction of the tympanic and mastoid segment at the second genu) of the facial nerve. The nerve proximal and distal to the neuroma was decompressed. The bone and neural sheath were opened from the cochleariform process to the stylomastoid foramen. There was no facial movement detected upon direct electrical stimulation of the facial nerve distal to the neuroma. The neuroma was resected. The facial nerve appeared swollen, but the endoneural surface otherwise appeared normal. The distal segment was thin, atrophic, and surrounded with a dense epineural fibrous covering the neuroma. Histopathologically the specimen had an appearance of a traumatic neuroma. A sample of the proximal end of the nerve showed healthy myelinated axons. The distal end had a sparse distribution of regenerated fibers interspersed in fibrous tissue. An interposition graft was placed between the proximal tympanic and distal vertical segments of the facial nerve. The other planned procedures were performed.

Results

Nine months later. **D**, In repose. There is facial tone and symmetry. The lip-cheek groove is present. This remarkable return of facial tone and symmetry can only occur with reinnervation and does not occur with dynamic (temporalis muscle) or static (Gore-Tex suspension) procedures. The slight elevation in the midlower lid on the left side is from the cartilage implant. This can be revised if bothersome to the patient. **E**, Eyes are closed tightly. The eyelashes approximate and overlap on the involved side. Note the skin creases around the left eye region. The cheek elevation is greater on the involved side. This represents synkinetic movement of faulty regeneration. This much movement at 9 months portends a strong recovery that will continue and peak at 2 years. Increased synkinesis and some mass movement can be expected with this type of early strong recovery. **F**, Smile. Patient is able to separate mouth movement from the eye region. This is a remarkable phenonemon, considering it is not possible to orient the regenerating axons by any technical maneuver (see Chapter 2). These results were far better than expected, and are due primarily to the nerve repair and eye reanimation procedures. It is difficult to determine how much the temporalis muscle and Gore-Tex contributed to the success in this case, and the difficulty in determining the contribution of each procedure is a problem reporting results with combination procedures.

This case proves the exception to the rule regarding the time limitation for nerve grafting. The success of the nerve graft 2 years following injury was due to the unexpected intact peripheral neural tubules confirmed by histopathologic study. This finding was anticipated somewhat by the subtle evidence of facial creases and contraction of the platysma noted preoperatively.

Case 3 (Figure 8–3)

This 42-year-old man presented with a total left facial paralysis 5 months following his fourth surgical procedure for recurrent pleomorphic adenoma of the parotid. According to the operative note, the surgeon could not separate the tumor from the facial nerve, and the nerve was not disrupted. There was no mention of direct facial nerve stimulation at the time of surgery or prior to closure. Now, the patient has a total facial paralysis and persistent tumor.

Patient's Concerns

The patient wants the tumor removed and the facial deformity corrected.

Examination

A, There is total paralysis on the left side. The brow on the normal side is quite active, forming a high arch with facial expression. Note the tarsal-supratarsal fold on the paralyzed side and that it is not present on the normal side. This is due to brow droop and loss of tone involving the supratarsal skin. There appears to be a full smile on the normal side created by elevation of the upper lip and depression of the lower lip as the corner of the mouth pulls laterally. The upper and lower teeth are prominently exposed. There is significant shifting of the nose and collapse of the nasal ala.

Management Options

1. A wide-field resection including the skin over the previous incisions, total parotid, enbloc with the facial nerve. Frozen section pathologic examination for distal tumor clearance is required. The facial nerve will be identified in its vertical segment within the temporal bone and followed out, anticipating it will course into residual pleomorphic adenoma.

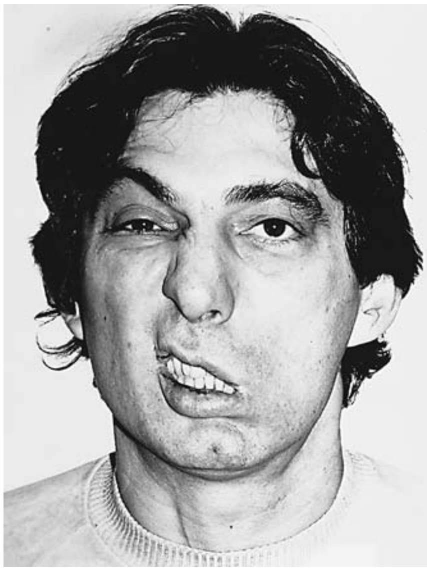
2. The upper division of the facial nerve will be connected to the distal end of the vertical segment with a sural interposition graft.

3. The lower division of the facial nerve will be connected to a part of the hypoglossal nerve, a XII-VII jump graft (see Chapter 3).

4. The mouth and nasal ala will be reanimated with a temporalis muscle transposition.

5. As a first stage, under local anesthesia and as a separate procedure, the eye will be reanimated. A brow lift, spring implant, and lower lid tightening procedure will be done.

The rationale for this plan is based on the time post-facial nerve injury. The condition of the facial nerve is not known.



A–B

Total left facial paralysis following parotid surgery for pleomorphic adenoma.

One day post-brow lift and eyelid spring implant.

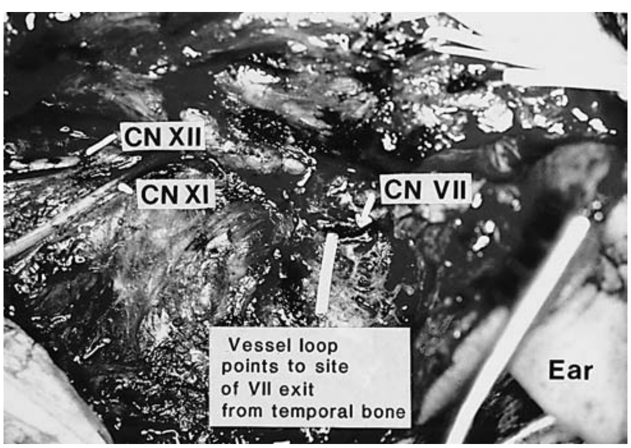
Figure 8–3. *(Figure continued next page.)*

C

Close up of **B**

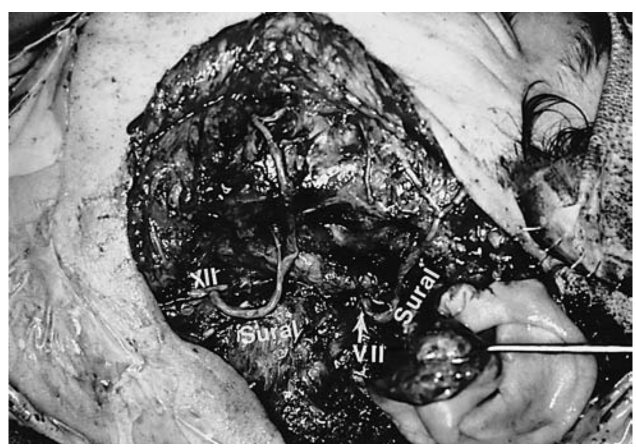
D

Patient draped for resection.



E

Cranial nerves VII, XI, and XII identified after tumor resected.



F

Dual reinnervation.

G–I
Two years later, in repose, with eyes closed, and grimacing.

J
Full smile.

K
No tongue deficit.

L
No tongue deficit.

M
No tongue deficit.

Figure 8–3. *(continued)*

The prognosis for a strong recovery would not be as promising compared to the expected results for a nerve repair performed within a month of injury. Therefore, a dual system was planned to encourage maximum regeneration from two sources.

Further, by innervating the upper face and eye region with the facial nerve and the lower face and mouth with the hypoglossal nerve, it might be possible to ensure separation of function and discourage synkinetic mass movement.[1] Adding the eye reanimation and temporalis muscle offers the patient immediate improvement as well as augmentation for the anticipated results of the reinnervation procedures.

The eye reanimation portion, which takes 2 hours, is performed separately the day before, thus reducing the operating time required for the major portion, which will take 6 hours of general anesthesia. The sural nerve is used because approximately 15 cm of donor nerve is required for two grafts. The greater auricular nerve can provide 7 cm at most (Chapter 2).

Surgery and Results

B, One day post-brow lift and eyelid spring. The lower lid was not tightened because there was good lid tone, little scleral show, and good apposition against the globe. The brow was slightly overcorrected with a tarsal-supratarsal lift (see Chapter 6, Brow Lift). There is overcorrection with the spring, causing the upper lid to droop. **C**, Close-up. The next day the major portion of the procedure was performed. **D**, The patient is draped to perform intended procedures. Notice the use of steridrapes and skin clips to hold towels on either side of intended scalp incision for temporalis muscle transposition. This portion of the procedure will be carried out following the tumor-facial nerve resection from a facial-cervical-temporal bone approach. The facial incisions include the previous parotid incision sites. The temporalis muscle will pass under the facial skin flap anterior to the site of the parotid resection and facial nerve repair. The muscle will be attached to the lip-cheek crease, the corner of mouth, and nasal ala by working under the flap. The mouth area will be approached through incisions in the vermillion without the need for a lip-cheek incision. **E**, Important structures are identified at completion of resection. **F**, Note the dual reinnervation. The sural nerve graft connects the hypoglossal to the lower division of the facial nerve. Another segment of the sural nerve is used to connect the proximal end of the facial nerve in the temporal bone to the upper division of the facial nerve in the face. Two years following reanimation surgery. **G**, At rest. The brows and upper and lower eyelids appear symmetrical as does the nose and mouth. The lips are approximated at rest. There is a slight fullness in front of the ear from the temporalis muscle transposition. **H**, Voluntary eye closure appears complete; however, with this maneuver, the lips separate at the corner of the mouth due to synkinetic contraction. In spite of the dual system, some reinnervation from the upper division via the facial nerve has reached the perioral area. The patient was asked to keep the tongue relaxed to rule out the effect of the hypoglossal nerve. **I**, Patient grimacing to demonstrate maximum facial contraction. It is clear that the majority of improvement is related to the reinnervation through the repaired upper division. I, **J**, The full smile has been restored to a great extent. The regenerative ability of the facial nerve is truly remarkable in most cases provided the surgeon performs procedures that aid in this process in a timely fashion. **K**, **L**, **M**, Following the XII-VII jump graft, there is no clinical deficit of the tongue.

Case 4 (Figure 8–4)

Facial paresis associated with recurrent basosquamous carcinoma involving the auricle. Over a 5-year period the patient was treated for basosquamous carcinoma of the left external ear with repeated excisions and then radiation therapy. Finally total excision of the external ear appendage was performed in an effort to control this tumor. There was no facial deficit immediately following the surgery. Now, one year later, the patient presents with facial paresis.

Patient Concerns

Is the facial weakness related to the ear cancer? Is the cancer coming back? What more can be done?

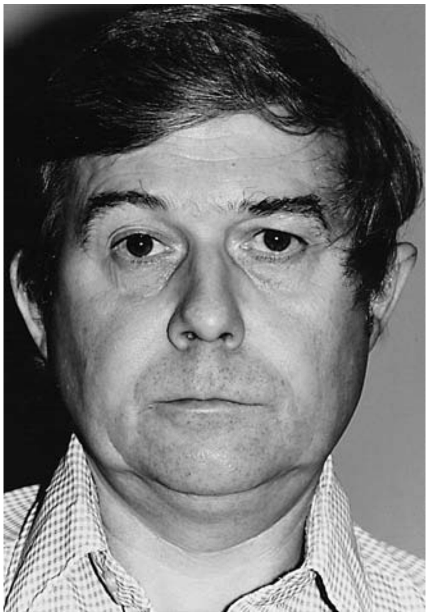
Examination

A, In repose. There is subtle evidence of facial paresis on the involved left side. There is sagging of the tarsal-supratarsal fold and scleral show under the cornea on the left side. Nostril asymmetry is the only other sign. **B**, Smile. In addition to the other eye signs mentioned, the left eye is wider than the right. The nasal asymmetry is still present. The lower lip deformity is apparent. **C**, An ear prosthesis is noted. **D**, Once the prosthesis is removed, the extent of the previous surgery can be appreciated. There is a palpable 2 × 2-cm hard mass between the mastoid tip and angle of the jaw. Note after careful palpation, there are no other nodules or masses of the skin around the ear, face, and neck. CT scan of parotid, skull base, and temporal bone showed the mass limited to the palpated area. Magnetic resonance imaging was not available at this time. Electrical testing of facial nerve and muscle function was normal. A fine needle biopsy confirmed basosquamous carcinoma.

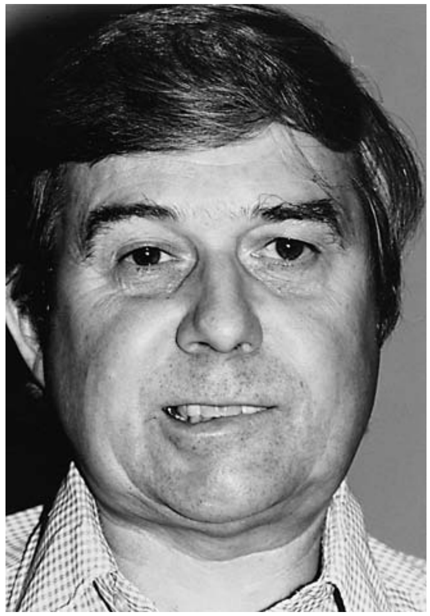
Management Options

The patient was told that the most likely explanation for his facial weakness is recurrent tumor. Because he had maximum local therapy, a more aggressive approach will be required in an effort to eradicate the tumor. The procedure will require resecting all the soft tissues in front, behind and under the ear region, including the facial nerve beyond the point where nerve repair is possible. Because the biologic behavior of this type of cancer is aggressive and is known to invade along nerves, both motor and sensory, a very wide-field resection is required. It is important to note that this patient had no sensory symptoms. Skin cancer and

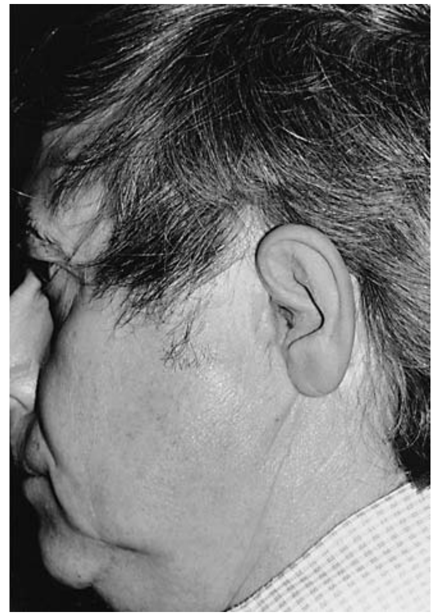
A–C



Repose.



Smile.



Note ear prosthesis.

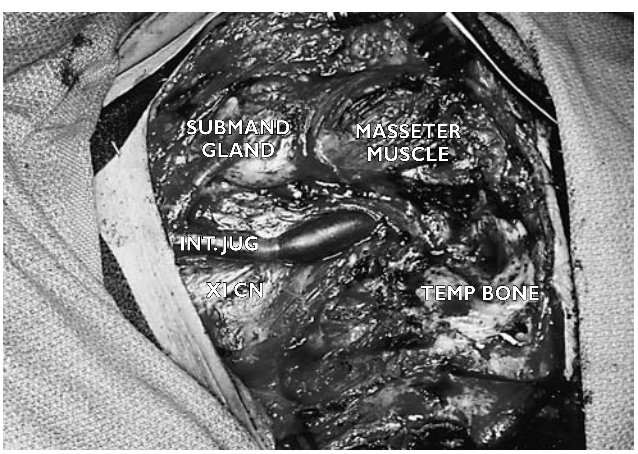
D

Without ear prosthesis.

E

Skin incisions for surgical resection.

F



Surgical bed after resection.

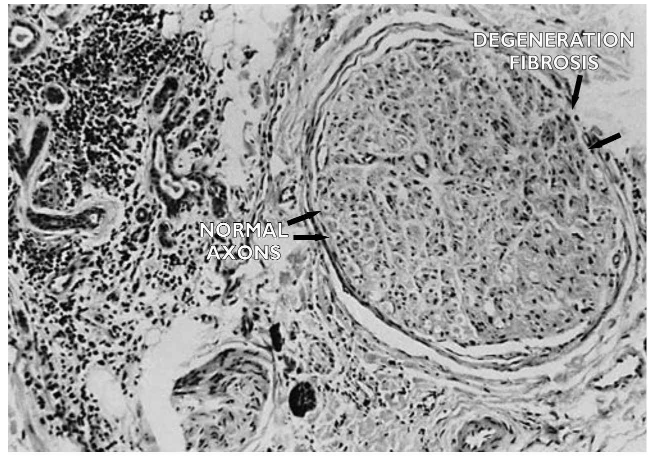
G

Wound closure.

Figure 8–4.

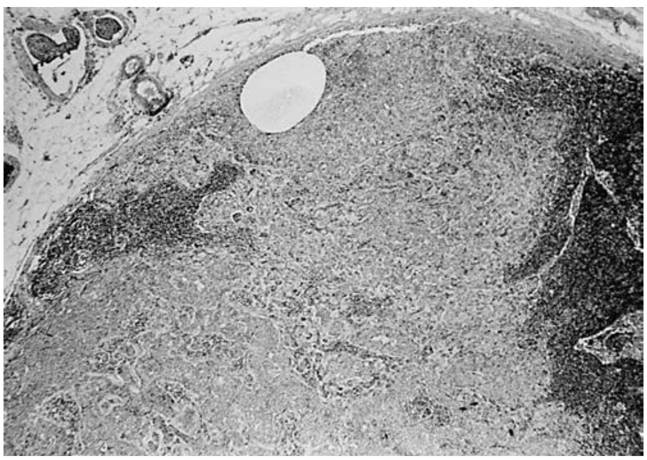
H

Tumor (arrows) diffuse.



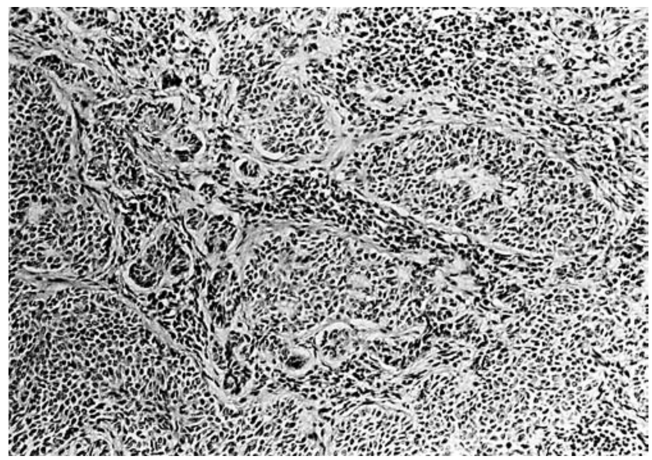
I

Tumor extends to perineurium.



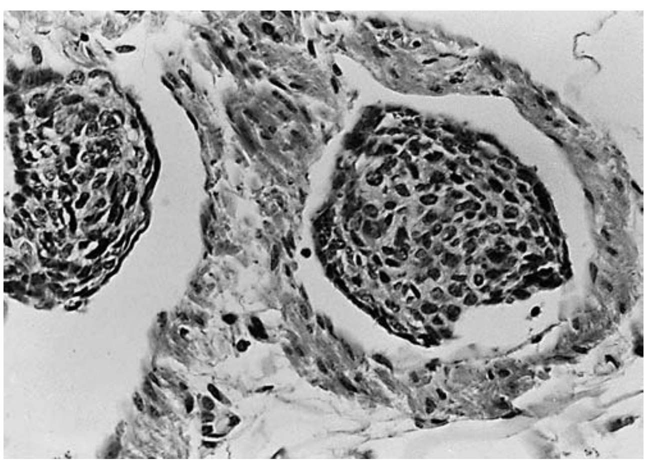
J

Metastasis to periparotid node.



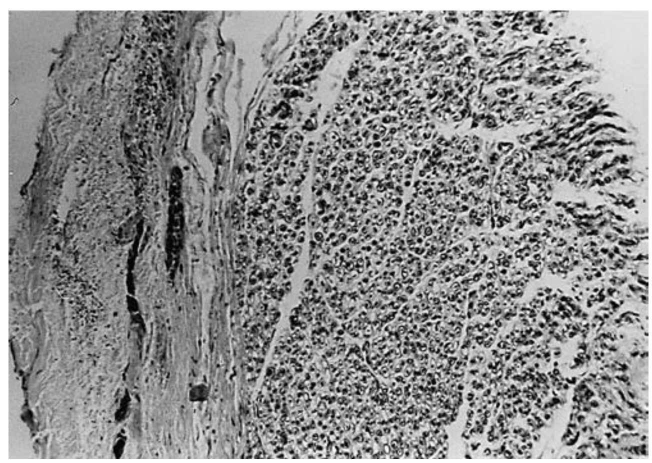
K

Higher magnification of **J**.



L

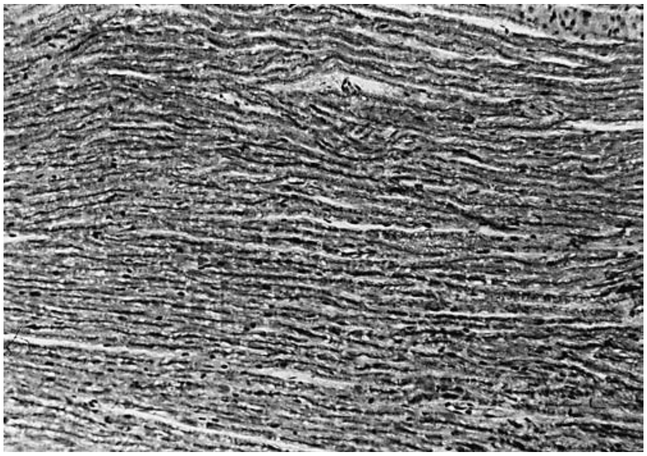
Intravascular tumor.



M

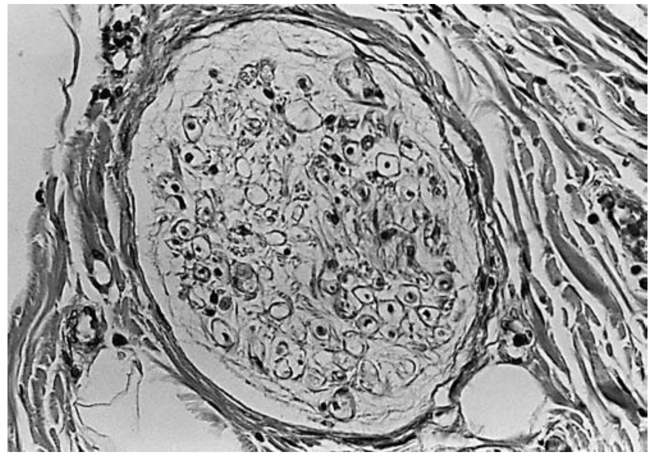
Proximal facial nerve in temporal bone free of tumor.

Figure 8–4. *(continued) (Figure continued next page.)*



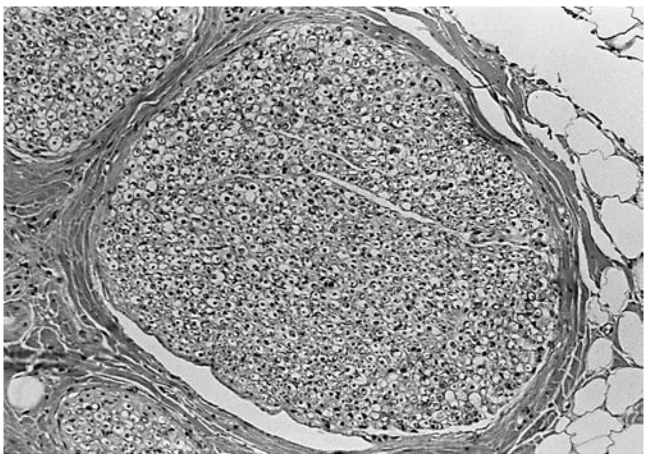
N

Proximal facial nerve free of tumor.



O

Distal facial nerve free of tumor. Early signs of degeneration.



P

Another fascicle of facial nerve distal to tumor is normal.

Figure 8–4. *(continued)*

trigeminal involvement in my experience is often associated with central extension and portends a poor chance for cure even with the most ambitions skull base procedure.

Surgery

E, Skin incisions are marked to include the skin over the previous surgical site and the skin overlying the palpable mass as well to allow a sliding flap primary closure. **F**, Surgical bed after wide-field resection. The facial nerve was removed from the fallopian canal to the proximal tympanic segment to the fine filaments that form in the buccal space. Specimens were labeled and studied for tumor involvement or clear margins. **G**, The wound is closed.

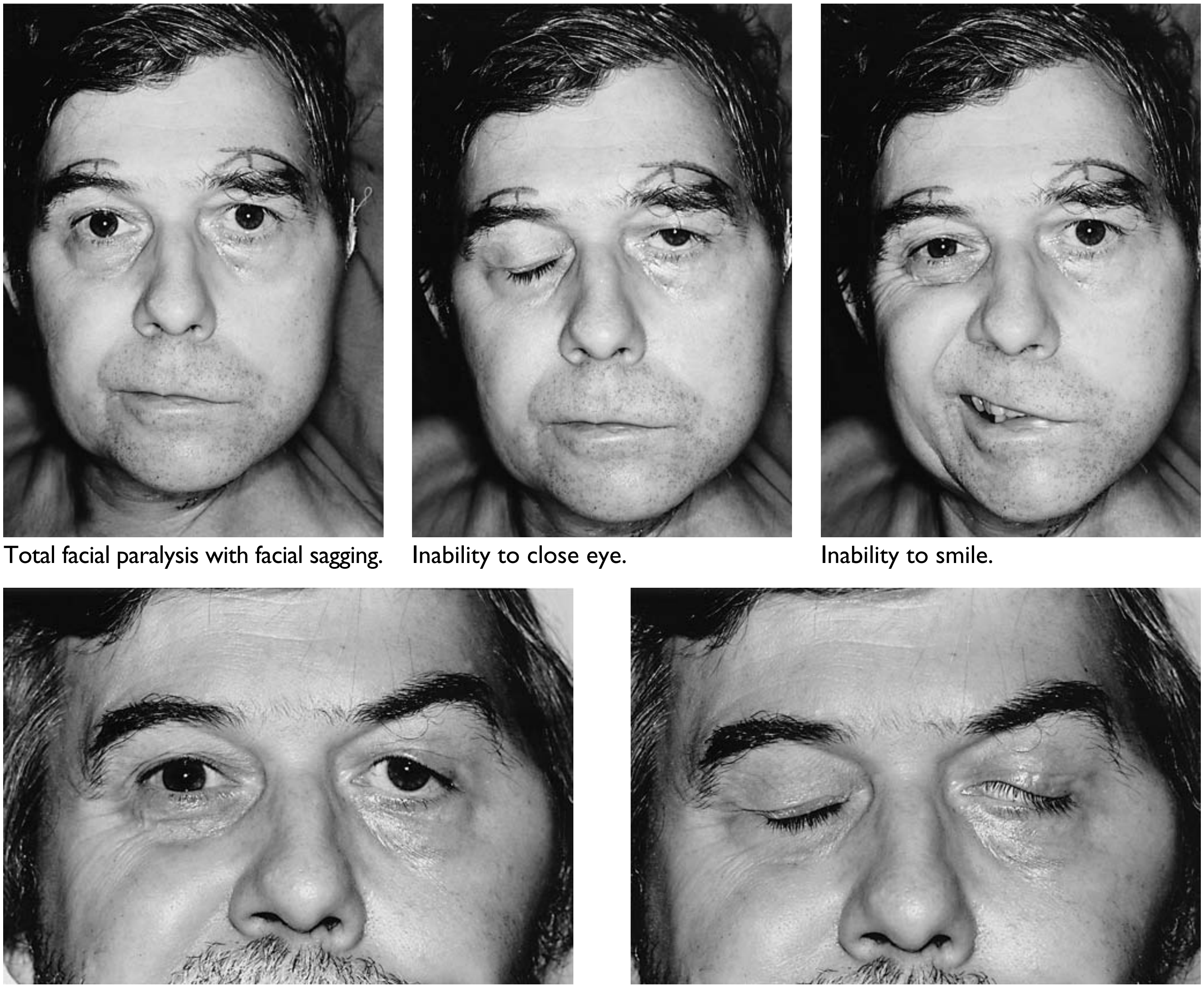
Pathologic Findings

The radicality of the surgical procedure was justified by the aggressive behavior of this tumor. **H**, Section through palpable mass. The tumor (arrows) is diffuse and unencapsulated, and extends into the parotid gland. Although there is no evidence of neural invasion, the tumor extends to the perineurium in this section. **I**, Higher magnification of **H** shows fascicle of facial nerve with evidence of viable axons, and degenerated fibrosed axons with increase in fibroblasts. H&E stain, ×40. **J**, Periparotid lymph rode with metastasis. ×25. **K**, Higher magnification of **J**. ×100. **L**, Intravascular clump of tumor. ×200. **M**, The proximal facial nerve within the temporal bone was normal and free of tumor. H&E stain, ×40. **N**, The proximal facial nerve is normal. Longitudinal section, trichrome mason stain for myelin. ×250. **O**, Facial nerve fascicle distal to tumor. No evidence of tumor, but there is evidence of early degeneration. Note the empty myelin tubes where the axon has degenerated. ×60. **P**, Another fascicle distal to tumor normal nerve.

Reanimation Surgery

Rehabilitative efforts should be delayed following surgery of this magnitude for such an aggressive tumor. The surgeon must have the benefit of permanent sections to be certain the surgical margins are free of tumor. The reconstructive options depend on the findings after facial paralysis has been created. The reconstruction, therefore, should be delayed a minimum of 3 weeks to be certain of the pathologic studies and that the wound/skin flaps heal without a problem.

Three weeks later. A reinnervation procedure was not possible because of the distal extent of the facial nerve resection. Although a graft from the proximal stamp in the temporal bone could be extended and implanted directly into the facial muscles, this was not done. This same principle could be achieved using the XII-VII jump graft and combined with dynamic and static procedures to achieve immediate improvement. This was not done because the outcome



Q–S
Total facial paralysis with facial sagging. Inability to close eye. Inability to smile.

T–U
Three weeks following reanimation, eyes open. Eyes closed.

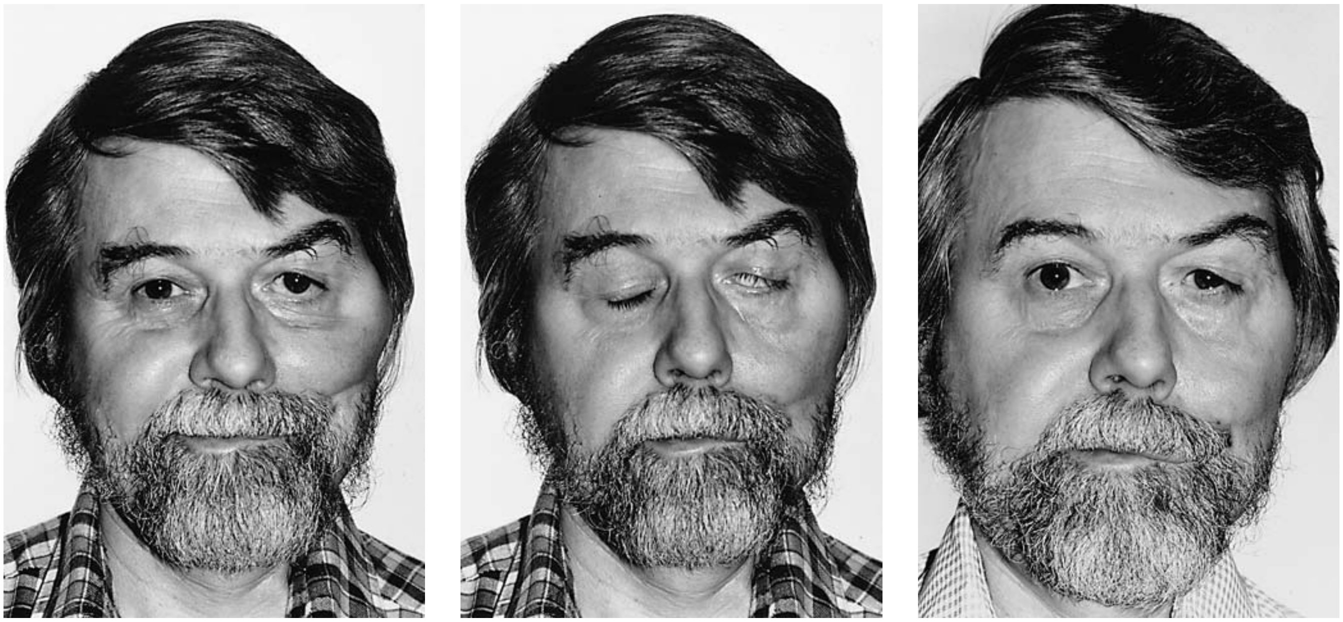
Figure 8–4. *(continued) (Figure continued next page.)*

with these procedures is unknown. **Q**, **R**, **S**, Total facial paralysis with facial sagging and inability to close the eye and smile. Note marks made for planned brow lift.

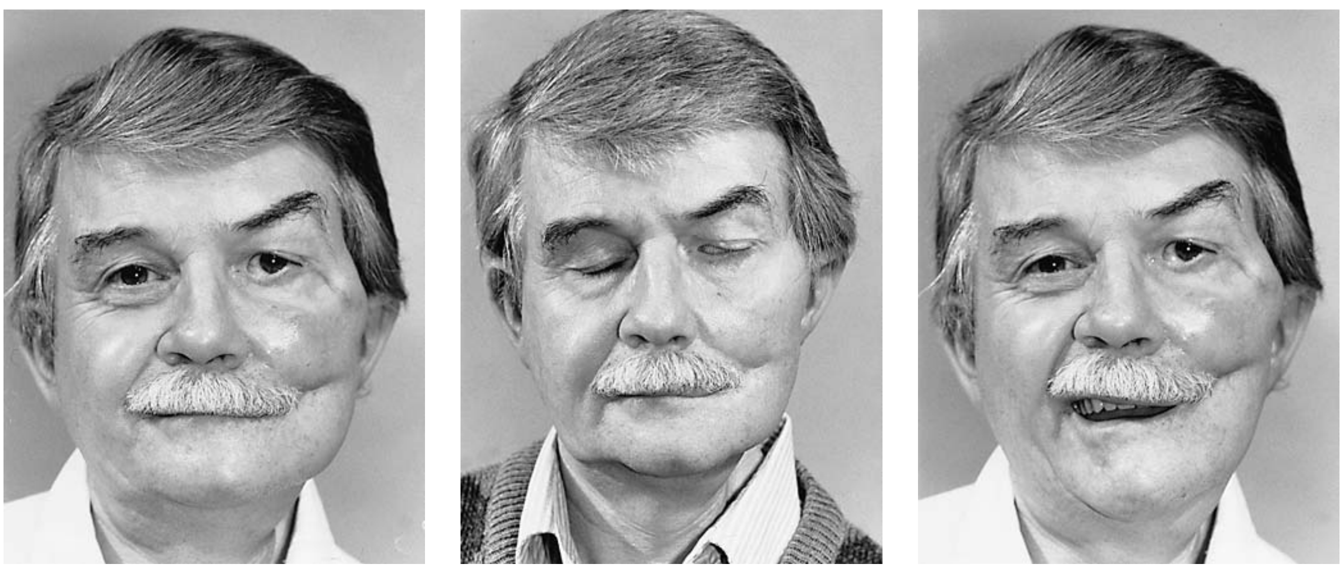
Eye reanimation included a brow lift with supratarsal fold suspension, an eyelid spring implant, and lower lid tightening. The mouth was reanimated with a temporalis muscle transposition. **T**, **U**, Three weeks following reanimation. Eyes open and closed. There is an improvement, but the results are less than perfect. The brow was overcorrected, and there is medial (gaposis) scleral show as well as inferior scleral show. A cartilage strut implant to elevate the lower lid would help. This case was treated early in our experience and before the cartilage strut was used. **V**, **W**, Six months after reanimation surgery. Note camouflage with ear prosthesis, hairstyle: hair parted on the right with left forehead covered with hair, and beard and mustache (see Chapter 9). The temporalis muscle forms a bulge, the brow is too high, and the lower lid droops. I was not satisfied with this result and felt further improvement could be achieved. Nothing further was done because the patient was delighted with the result. **X**, In an effort to improve the lower eyelid position and closure, a closed eyelid spring replaced the open spring, and a medial canthoplasty was performed. **Y**, **Z**, **AA**, Twelve years after the original surgery. There is no evidence of cancer. Compare **V**, **W**, **X**, and note the improved position of the mouth, especially with an effort to smile. The lateral and upward suspension of the mouth was augmented with a palmaris longus muscle tendon. Note how the medial canthoplasty did not hold up over time and is replaced with a web. A cartilage strut was suggested, but he was quite pleased and did not care for further surgery.

In retrospect, perhaps I was too aggressive in the approach to the tumor. Based on the pathologic findings, there were adequate tumor margins in both proximal and distal segments of the facial nerve to have been able to do a interposition graft between the proximal segment in the temporal bone and the distal segments just beyond the parotid gland. The facial reanimation results would have been superb because the facial nerve was essentially normal.

The horns of dilemna in treating aggressive malignant tumors is curing cancer versus cosmetic and functional



V–X
Six months following reanimation surgery.



Y–AA
Twelve years after original surgery.

Figure 8–4. *(continued)*

considerations. In this case, both might have been accomplished by obtaining frozen section controls. Unfortunately, frozen section controls are not fully reliable. I have treated patients where the cancer extended proximally to the labyrinthine segment in the temporal bone and distally beyond the parotid. However, in these cases, the patients had preoperative total facial paralysis. I have also observed facial nerve invasion by malignant parotid cancer without any clinical evidence of facial weakness. I suppose, if one were to err, it would be better to be more aggressive and cure the cancer, as in this case.

Case 5 (Figure 8–5)

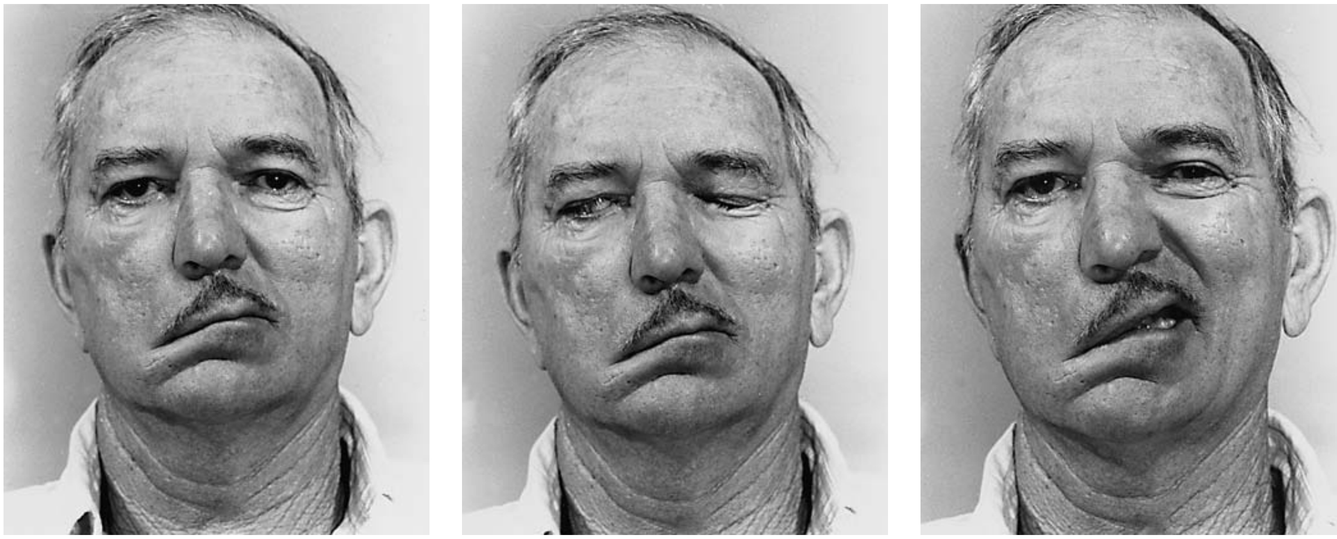
Patient referred for reanimation 5 months following resection of glomus jugulare and injury to cranial nerves VII, X, and XII. There is evidence of return of X, but persistent tongue weakness. This case is presented as a reminder that facial reanimation failures can become successful with appropriate revision surgery.

Patient's Concerns

Can eye closure and smile be restored?

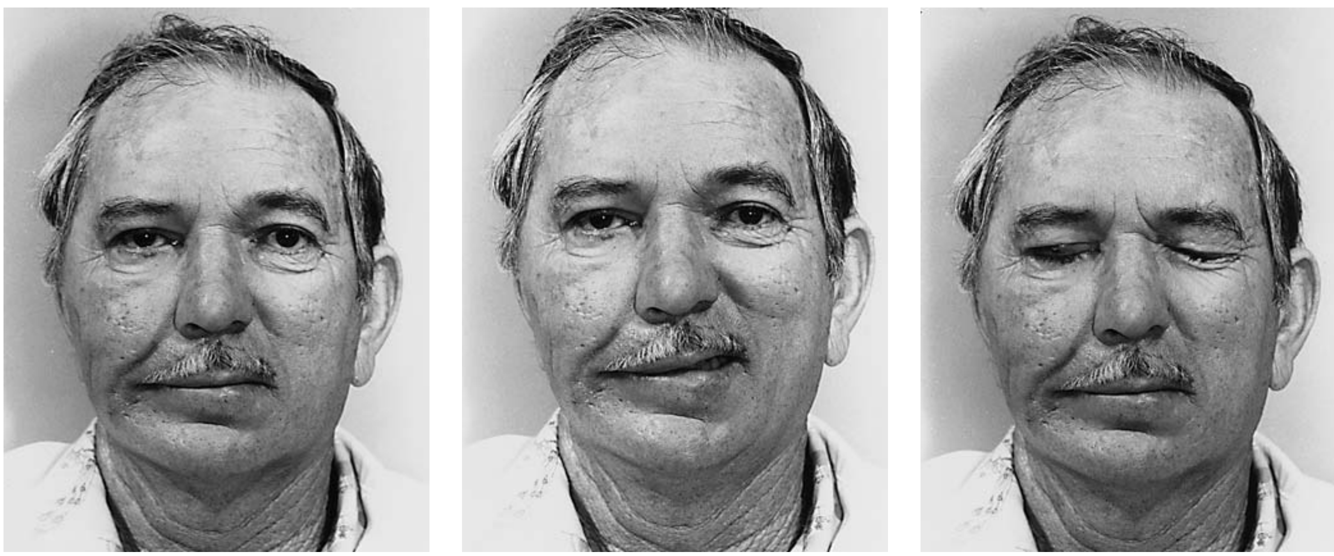
Examination

A, In repose. There is total right facial paralysis. The eye brows are reasonably symmetrical. The prominent tarsal-supratarsal fold would be favorable for a gold weight implant. There is drooping of the lower eyelid. The corner of the mouth sags. **B**, Effort to close eyes. Good Bell's phenomenon. Incomplete eyelid closure. **C**, Inability to demonstrate any movement on the right side. The smile has



A–C

Five months following resection of glomus jugulare. Total right facial paralysis.



D–F

Seven months following reanimation surgery.

Figure 8–5. *(Figure continued next page.)*

elements of a full smile with elevation of the upper lip and depression of the lower lip on the normal side. The lip-cheek crease is prominent on the normal side.

Management Options

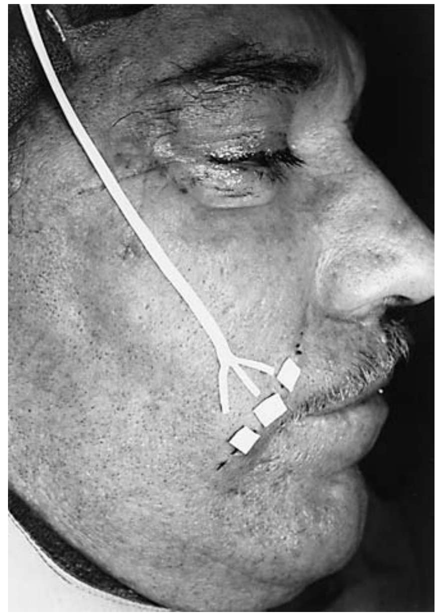
1. Reinnervation by facial nerve repair at time of the glomus surgery would have been ideal but was not done. Re-exploring the surgical bed and finding the proximal end of the facial nerve is risky because of possible injury to the internal carotid artery in a healed fibrous postsurgical bed created by a previous skull base procedure.
2. A hypoglossal-facial nerve procedure is contraindicated in a patient with evidence of a paretic tongue.
3. Eye reanimation and temporalis muscle transposition was recommended.

Results

D, Seven months after surgery, gold weight implant, lower lid tightening, and temporalis muscle transposition. In repose, the lateral oral commissure is lateralized. **E**, Attempting to smile on involved side by contracting the temporalis muscle. There is no movement created. The effect of the temporalis muscle is static and not dynamic. **F**, Closing eyes. The lids approximate, but the gold is extruding. **G**, Close-up. The most likely cause of extrusion is the unraveling of the superior lateral suture to the orbital septum (see Chapter 6).

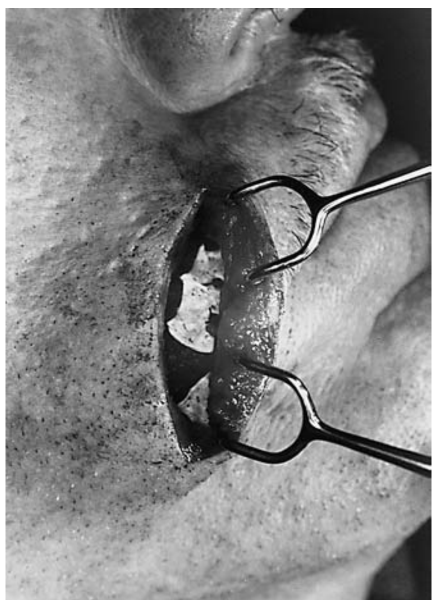
G

Gold extruding.

H

Gore-Tex suspension.

I–K

Gore-Tex placed in lip-cheek-crease.


Gore-Tex strip attached to previously imbedded Gore-Tex.


Procedure completed.

Figure 8–5. *(continued)*

Problems

Failure of temporalis muscle contraction to produce a voluntary smile and gold extrusion.

Revision

The gold was repositioned and resutured. **H**, A Gore-Tex suspension was staged to reinforce the action of the temporalis muscle. **I**, **J**, This was done by implanting three Gore-Tex patches that will be allowed to become fixed in the lip-cheek crease wound over a period of 6 weeks. **K,** They will serve to attach to the Gore-Tex strip that will be fixed to the zygomatic arch by a miniplate (see Chapter 7). These procedures are performed under local anesthesia.

Results 1-Year Later

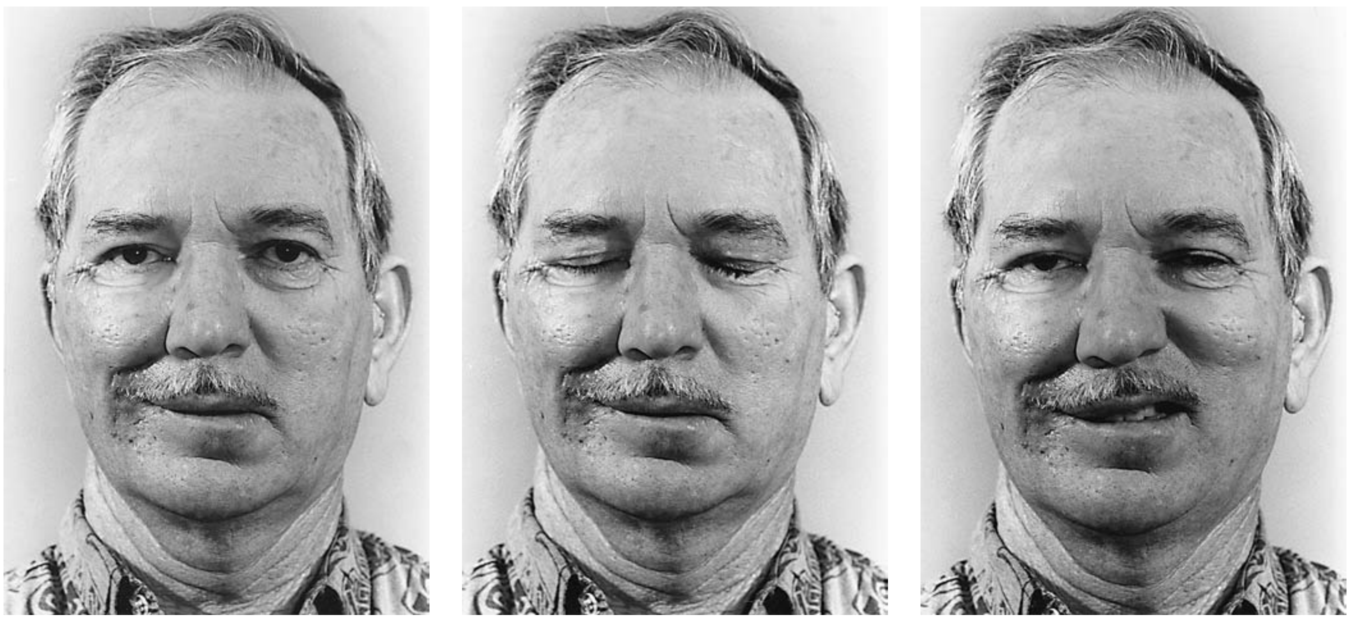
L, Eyes open. **M**, Eyes closed. Note how the supratarsal fold covers the gold weight. The implant is hardly detectable and restores eyelid closure. **N**, **O**, **P**, The Gore-Tex suspension has improved mouth position and smile.

Comment

Revision ("tune-up or fine-tuning") surgery plays an important role in achieving the best results with facial reanimation (see Chapter 7). The success of suspension procedures that require fixation to the lip-cheek crease can be improved by creating a "weld" site before attaching the muscle, fascia, or Gore-Tex. This is done in a staged fashion, as demonstrated in this case.

L M

Final results, one year later following revision.



N–P

Final results, one year later following revision.

Figure 8–5. *(continued)*

Case 6 (Figure 8–6)

This case was selected to stress an important principle of reanimation surgery: "the evil of good is better." There is a quality among most surgeons to seek perfection. This virtue must be tempered with the experience to know when to accept less than perfect. This patient presents 4 years post-acoustic tumor surgery. There is a complete flaccid right facial paralysis.

Patient's Concerns

Her major complaint relates to her right eye. There is a need to constantly keep ointment in the eye, or the eye dries out and becomes red and irritated. "The ointment is greasy and gets on everything." Further, although the eye is more comfortable with the ointment, an oily film forms over the eye that impairs vision. Finally, can something be done to improve the appearance by restoring the smile?

Examination

A, **B**, Brow position is acceptable. The supratarsal fold is prominent. This is ideal for a gold weight except there is marked upper lid retraction with effort to close the eyes **(B)**. The lower lid is ectropic contributing to tear overflow and epiphora. The nasal ala is not collapsed and not symptomatic. The corner of the mouth and jowls sag.

Management Options

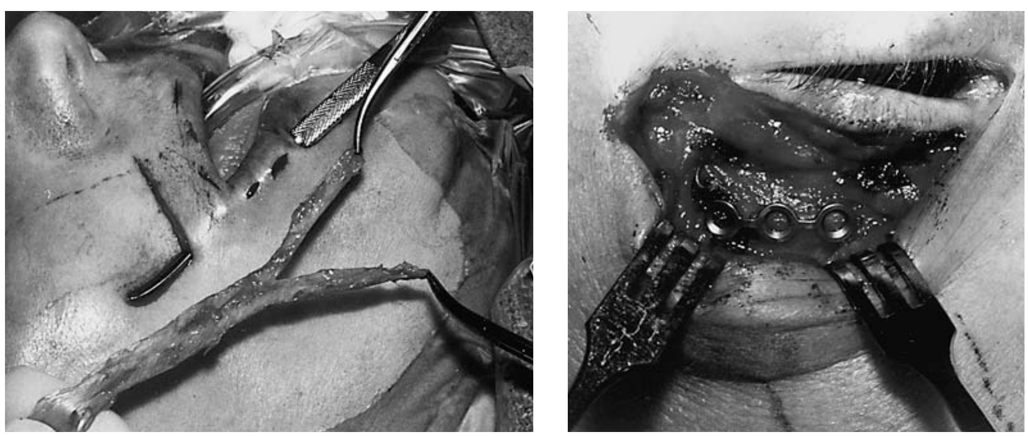
1. Opportunities for reinnervation have been lost because of the 4-year interval between disruption of the facial nerve and presentation.
2. Hypoglossal-facial nerve crossover technique performed as late as 4 years post-facial nerve disruption is capable of establishing tone and perhaps symmetry at rest, but rarely useful movement. The patient was not interested in this option because the risk of tongue impairment versus the expected minimal gain was not appealing.

A B

Total right facial paralysis 4 years post-acoustic surgery.

C D

Results 3 years post-temporalis transposition and eyelid reanimation.



E F

E, Palmaris suspension. **F**, Fixed to infraorbital rim with miniplate.

G–H

G, One week postoperative. **H**, Three months later.

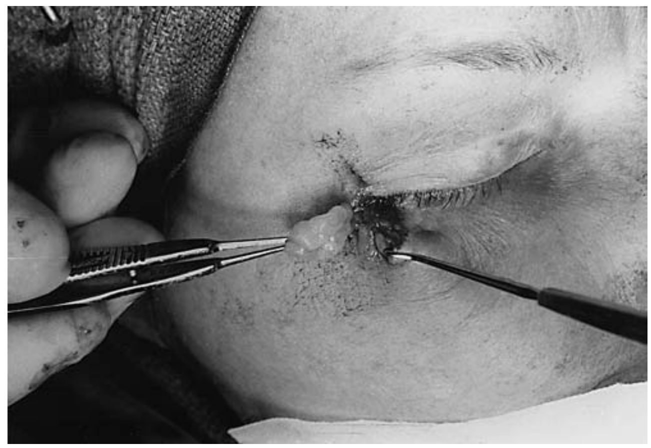
Figure 8–6.


I


J

Three months later after antibiotic treatment.


K


L

Surgical repair of scar deformities of lower eyelid.


M

Lower eyelid repair.


N

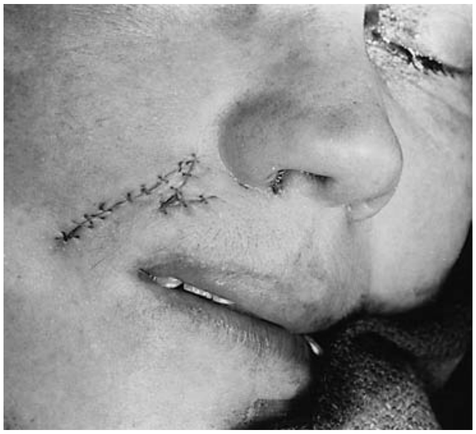
Revision of lip-cheek scar.

Figure 8–6. *(continued)* *(Figure continued next page.)*

3. Temporalis muscle transposition and free neurovascularizing muscle transplantation were two options presented to the patient to reanimate the mouth area. After risks and benefits of each were discussed (see Chapters 4 and 5), the patient chose the temporalis muscle transposition.
4. Eye reanimation is part of the surgical program. Upper lid closure was not achieved with a 1.2-g gold weight pasted on the upper lid as a preoperative trial. A 1.4-g gold weight did close the eyelid but created significant ptosis with the eye open. For this reason, an open eyelid spring was chosen as the technique to reanimate the upper eyelid. The following was proposed for the lower lid: (1) shortening (Bick) procedure, (2) cartilage strut implant, and (3) lateral tarsorrhaphy.

Results

Three years after temporalis muscle transposition and proposed eye procedures. An improvement has been achieved, and the patient is pleased. **C**, In repose. The lower eyelid



O

2-plasty lip-cheek crease.

P

Three months post-revision; in repose.

Q–R

Eyes closed.

Smiling.

Figure 8–6. *(continued)*

has been elevated and apposes the globe with relief of the epiphora. **D**, Eyes closed. The cornea is covered but there is still scleral show. The temporalis muscle attachment to the lip-cheek crease has stretched and has lost the support that was present for the first 6 months after surgery. The patient cannot produce a smile with an attempt to contract the muscle. Two weeks later an effort was made to improve the mouth. **E**, A palmaris muscle tendon was used to suspend the corner of the mouth and lip cheek crease. The tendon was fixed to the upper and lower lips as well as the lip-cheek crease. **F**, The tendon was held in place by a microplate screwed to the infraorbital rim. **G**, One week after this procedure.

Ten weeks later. An abscess formed in the infraorbital region. The patient was hospitalized, treated with intravenous antibiotics, and the abscess was incised and drained. The miniplate was removed.

H, **I**, **J**, Three months after the acute treatment and intravenous antibiotics maintained at home. Note the marked lower lid ectropion and chronic scar indentation with skin discoloration. The support for the corner of the mouth and lip-cheek crease achieved by the palmaris tendon persisted.

One month later the eyelid deformity was corrected by Dr. George Buerger, an ophthalmoplastic surgical colleague. **K**, The retracted scarred-down skin in the region of the lower eyelid and infraorbital rim was dissected free from the deep structures. **L**, Fat taken from the abdominal area was soaked in clindamycin and then implanted into the pocket created in the lower eyelid region. **M**, A lower lid transconjunctival ectropion repair and lateral canthoplasty was performed (see Chapter 6). **N**, **O**, The corner of the mouth was tightened by refixing the temporalis muscle to the fibrous tissue that formed in the lip-cheek area and lateral oral commissure area. The lip-cheek crease incision was revised with a z-plasty.

Results

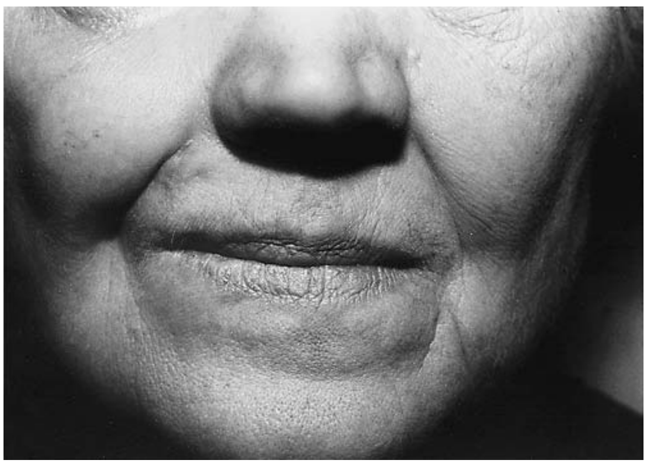
Three months postrevision. **P**, In repose. **Q**, Closing eyes. **R**, Voluntary smile created by contracting the temporalis muscle. **S**, Close-up of eyes. The postinfection deformity has been corrected. **T**, Lid closure is good with the action of the eye spring and an improved lower lid position. **U,** Close-up of mouth at rest. **V**, Voluntary smile.


S

Eyes open.


T

Eyes closed.


U

Mouth in repose.


V

Smile with temporalis muscle contraction.

Figure 8–6. *(continued)*

Comment

Reanimation surgery challenges the surgeon's ability to solve problems. Hopefully, the problems created by the surgeon can be avoided. However, they will occur even in the most experienced, expert hands. In this case, a disaster was averted, and the ultimate result was successful. In retrospect, the surgeon (MM) should have accepted the result when the patient was satisfied after the first operation.

Conclusion

Because this is the last chapter in this book that discusses surgical rehabilitation of the paralyzed face, I would like to share some important guidelines. First, "Do what is best for the patient, no matter how difficult for the doctor." Julius Lempert made this statement in response to colleagues who claimed the one-stage fenestration operation for otosclerosis was too difficult. Find the most qualified physician/surgeon to manage patients with facial paralysis since it is a most challenging and complex problem. Second, in selecting the surgical approach best suited for a particular patient, consider all the options that work, including dual systems. Third, every patient with permanent facial paralysis or paresis, total or regional, can be helped. Fourth, the surgeon should continue to work to improve a patient's facial appearance and function until the surgeon has reached his/her limitation or the patient is satisfied. Finally, appropriate consultation within or outside the surgeon's discipline is encouraged.

Reference

1. Casler Maj JD, Conley J: Simultaneous "dual system" rehabilitation in the treatment of facial paralysis. Arch Otolaryngol Head Neck Surg 116:1399, 1990.

9

Enhancing Facial Appearance with Cosmetic Camouflage

Jon P. Coulter, C.M.I., and Mark May, M.D.

The patient and surgeon realize that even the best postoperative result will be an approximation of balance between the paralyzed and unaffected sides of the face. This said, there are quite a number of steps one can take to further enhance appearance. Should the patient wish to pursue further modifications, there are many techniques available. These will be described so the appropriate options may be considered by the patient.

Corrective techniques for males and females will be discussed separately. While there are certain measures that both may employ, there are others which are gender-specific. A summary of physical characteristics of the paralyzed face and the steps which may improve them is provided in Table 9–1. It should be emphasized that each patient is unique and will have a different combination of these characteristics. Further, even these may change with time. There are a number of sources available for the patient to consult for nonsurgical enhancement of facial appearance. These include hair stylists, barbers, cosmetologists, opticians, and prosthodontists. Their professional advise can help customize the recommendations made below. A detailed analysis of individual patients and appropriate recommendations are available through the Shadyside Hospital Facial Paralysis Center*.

Because females have more options that they will consider acceptable, their opportunities will be discussed first. Bear in mind that these are generalized suggestions. They should be amended as necessary based on the individual patient's features.

Table 9–1 Common Characteristics of Facial Paralysis and Treatment Options Based on Gender

Characteristics	Male Options	Female Options
1. Lack of forehead wrinkling	• appropriate hairstyle	• appropriate hairstyle
2. Temporalis muscle bulge	• appropriate hairstyle • facial hair (beard)	• appropriate hairstyle • makeup
3. Asymmetrical eyes	• appropriate hairstyle • tinted glasses	• appropriate hairstyle • eye shadow • tinted eye glasses
4. Drooping brow	• eyeglass splint	• eyeglass splint
5. Nasal collapse and curvature	• internal nasal prosthesis	• internal nasal prosthesis • makeup
6. Irregular lip conformation	• dental prosthesis	• dental prosthesis • makeup
7. Paralyzed lips thinner than unaffected side	• facial hair	• makeup
8. Features surgically removed	• prosthesis • appropriate hairstyle and facial hair	• prosthesis • appropriate hairstyle

*Shadyside Hospital Facial Paralysis Center. Attn: Jon Coulter, 5200 Centre Avenue, Suite 211, Pittsburgh, PA. 15232

Techniques for Females

Hairstyling

Hairstyles are of infinite variety and subject to the constantly changing demands of time and fashion. Nevertheless, it is possible to discuss certain concepts that are timeless. It is recommended that the patient try to achieve what stylists describe as a sense of "movement." A static look will draw undue attention to any imbalance in the face.

Hair should be kept looking soft. Feathering and layering up will help achieve this. Hair should be bobbed and be midlength or shorter. Styles that depend on perfect symmetry and geometric edges such as the "page boy" must be avoided. They will only exaggerate the differences between the two halves of the face. They are demanding enough on nonparalyzed features. When coloring hair, it is best to use subdued rather than bright hues. A soft blond is preferable to a bright yellow-blond. Auburn is a better choice that "carrot" red. A mid to light brown color would be more appropriate than a deep brown.

There are three distinctive facial characteristics of hemifacial paralysis that a becoming hairstyle can address. These are lack of forehead wrinkling on the paralyzed side, size differentials between the two eyes, and bulging of the cheek when a temporalis muscle slip has been directed over the zygomatic arch (see Chapter 4).

Loss of muscle tone on the paralyzed side eliminates forehead wrinkling. The patient may not consider this a problem because it is scarcely noticeable at rest. An unusual appearance may result during an animated conversation or when expressing doubt or surprise (Fig. 9–1A). If this is bothersome to the patient, it is easily managed through the use of bangs (Fig. 9–1B). Other facial features, however, may necessitate a less regular cut than the one shown here.

Treatment of the differing eye sizes is a more complicated issue. Although the paralyzed eye is usually the larger-appearing eye due to nerve loss in the eyelid muscles, the situation may change with time. Should the patient undergo a gold or spring implant described in Chapter 6, or following faulty regeneration, the affected eye may become the smaller of the two (Fig. 9–2). The imbalance may be minimized by creating the impression that the smaller eye is larger than it is. To accomplish this, a pivot point should be made above the smaller eye (Figs. 9–3A,B). By expanding the forehead exposure on this side, the smaller eye will appear larger. The larger eye will be de-emphasized by the downward sweeping hair which should cross the eyebrow and approach the eye itself. Any hair approaching the smaller eye should be trimmed above the eyebrow. A variation on this style is seen in Figure 9–3C.

When present, the temporalis sling bulge may be the most distracting feature of the female patient (Figs. 9–2A,B). To minimize the bulkiness of the cheek, the hair can be swept forward to cover both the ear and the cheek (Fig. 9–4). This should be done on both sides. This hair style will also mask the loss of an ear, as may be experienced during surgery for certain tumors. The patient may wish to cultivate an exotic style that advances the hair over the paralyzed side only. This may be dramatic, but necessitates longer hair than is advisable. The more natural look is recommended.

The fullness, thickness, amount of curl, and quantity of the patient's hair will affect the types of hairstyles attainable. If the suggestions made cannot be followed due to nature's limitations, hairpieces and wigs may be employed. These should be styled along the lines discussed.

Corrective Makeup

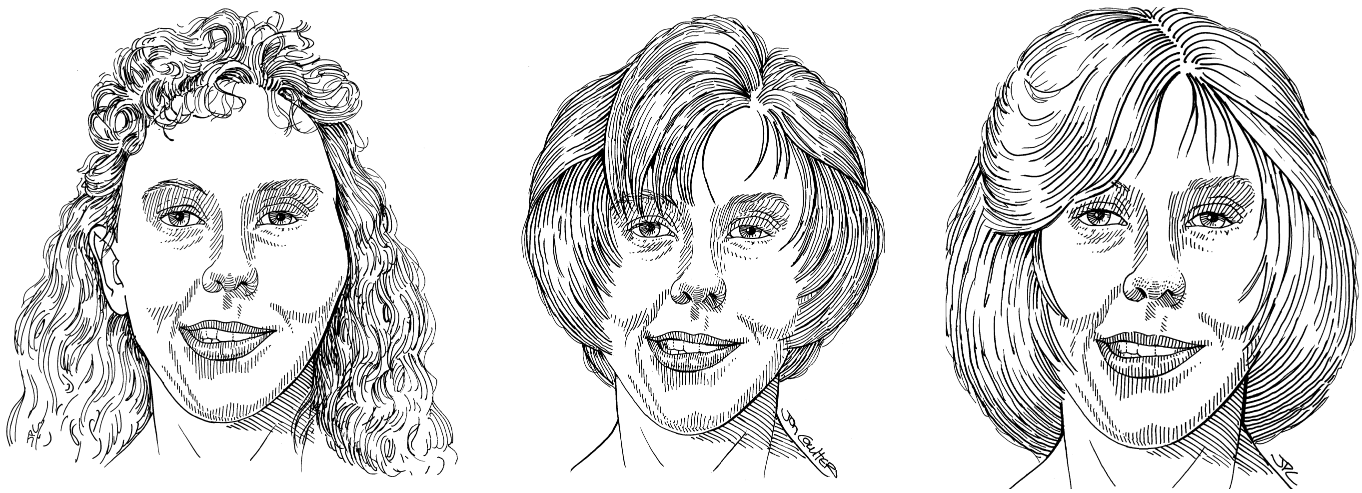
The affects created through hairstyling can be enhanced even more with proper makeup. These involve the applications of products with which most women are already familiar. With a little practice, all of the techniques

A–B

Figure 9–1. Lack of forehead wrinkling on paralyzed side. Bangs covering forehead.

A–B

Figure 9–2. Patient with left facial paralysis post-resection osseous hemangioma reanimated with temporalis muscle transposition and closed-eyelid spring. Distracting bulge caused by temporalis sling technique and narrowed left eye from eyelid spring. **A**, Patient at rest. **B**, Patient smiling.



A–C

Figure 9–3. **A**, Tracing of patient in Figure 9–2B. **B**, Pivot point in hair above smaller eye. **C**, Variation in hairstyle showing many possibilities exist within recommended parameters.

Figure 9–4. Profile view of forward-sweeping hairstyle designed to cover temporalis bulge in patient illustrated in Figure 9–2.

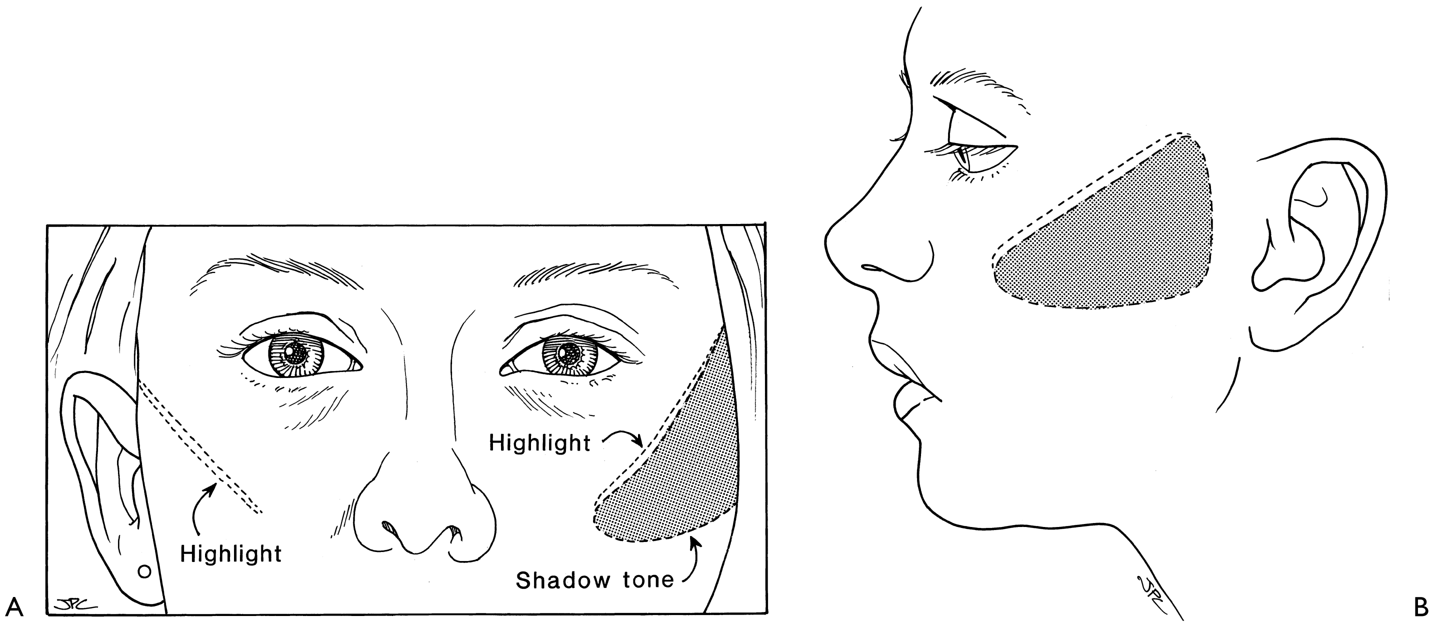


Figure 9–5. **A**, Frontal view of makeup technique to reduce apparent mass of temporalis bulge. A shadow tone is placed across the mass of the bulge as indicated. A highlight is placed along the top edge of the shadow. A matching highlight is applied to the cheek that is not paralyzed. No shadow should be placed on this side as it would undo the effect created by shading the temporalis bulge. **B**, Profile view.

to be described can be easily performed by the patient herself.

Corrective makeup helps to enhance the better facial features and downplay the results of injury and/or surgery. As a general rule, features can be accented with proper highlighting and subdued with the appropriate shadowing or shading.

A highlight results when a shade lighter than the original foundation is applied to a particular part of the face. Correct use of highlights brings out the features to be emphasized. A shadow is produced when a tone darker than the original foundation is used. Shadows minimize prominent or detracting features, making them less noticeable.

Light shades, therefore, will tend to attract attention to a feature. Dark shades, applied in moderation, will divert attention from a feature. Lighter tones will made a feature appear wider, while darker tones will make it seem narrower. These simple principles are the foundation of much of the advice that follows.

After cleaning, the initial step is to apply a foundation over the entire face. The shade should either match the natural skin tone or be slightly darker. It should be applied sparingly and evenly over the entire face. When using cream or liquid, a sponge is helpful. The foundation must be blended in especially well at the hairline and under the chin so there are no demarcation lines.

Next the patient should address the cheeks. To visually reduce the bulk of a temporalis sling, one must create the impression of a concavity. To do this, one must first decide whether there is a personal preference to use blush, powder, or foundation. Once the product is selected, the two tones must be chosen. One tone should be two to three times darker than the original foundation. The other tone should be one shade lighter. The light tone should be applied along a line that is a mirror image of the nonparalyzed cheek (Figs. 9–5A,B). The darker tone should be placed below this. A highlight, but no shadow tone, should be placed on the unaffected cheek. These must then be blended into the foundation and all lines eliminated.

Blush is often desirable to freshen the facial coloring and restore a youthful appearance. When this is the case, the patient should retain the shadow tone, but dispense with the highlight. Instead, the blush should be applied in place of the highlight. It should border the upper margin of shadow, extending from the ear forward and no farther than the pupil and upward to the base of the lower lid (Fig. 9–6).

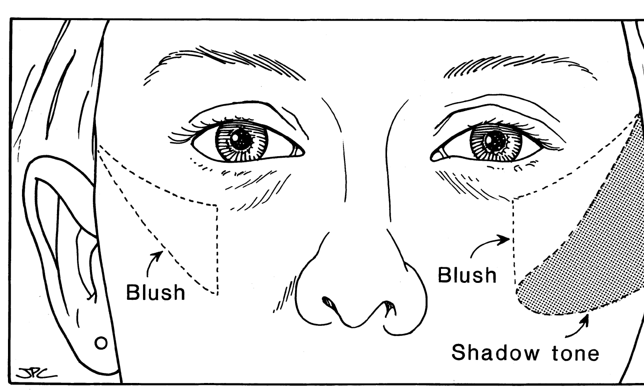


Figure 9–6. When blush rouge is used, it replaces the highlight. It should be placed above the shaded area and run forward from the ear to not farther than the pupil. It should border the lower lid, but not over it. It should be blended in as usual. Blush applied to the unaffected cheek should mirror that of the paralyzed side. Again, no shadow is applied to the unaffected side.

Frequently the presence of a curvature of the nose is exaggerated by the pull of the normal side's muscles being unopposed by the paralyzed side's muscles. This causes nasal obstruction on the paralyzed side due to nasoalar collapse. To minimize the curvature, one may place an internal nostril expander in the paralyzed side (Fig. 9–7). As with any appliance, one must follow the manufacturer's instructions. These expanders are intended for temporary use and should be removed when not needed.

One might visually reduce the curvature with makeup. To accomplish this, one can apply brown eye shadow to the paralyzed side of the nose, which will appear to be bowed toward the ear (Fig. 9–8). The eye shadow should be drawn on the curve itself. The patient must avoid carrying the dark tone into the laugh lines, as it will accentuate them. Below the eye shadow, a light shade should be placed to the base of the nostril. The base of the paralyzed nostril is darkened with eye shadow. This has the affect of raising the bottom of the "drooping" side. The outside edge of the unaffected nostril should also be darkened. This will have the effect of reducing the width of the unaffected side and make the nose appear symmetrical. Naturally, all these areas are to be blended into the foundation so their effect, but not their configurations, are perceived.

Eye asymmetry can be reduced with properly applied makeup. One approach to reducing the appearance of disparity is shown in Figure 9–9. It is recommended that a single natural (or nude) color be applied uniformly on the lid and up to the brow. Then a darker wedge is placed above the lid. The apex is toward the nose, the base is toward the ear, with a slightly wider wedge on the smaller side, drawn up to the level of the normal eye wedge. The darker tone must not be applied to the lid itself. Mascara should be avoided as it will focus attention on the eyes and actually exaggerate the differences in sizes.

If a gold implant has been inserted into the upper lid, the resultant bulge can be visually minimized, though not hidden, by applying eyeshadow with a waterproof base. This will reduce creasing and melting.

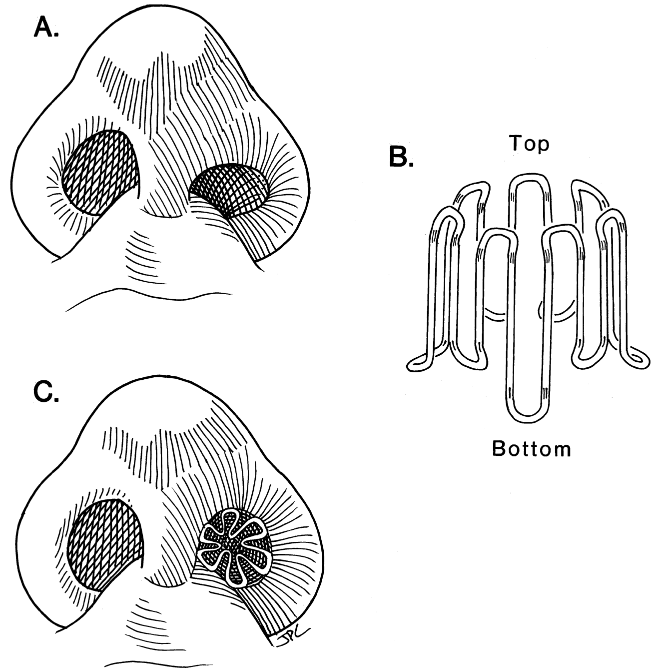


Figure 9–7. **A**, View of paralyzed (narrow) and unaffected nostrils. **B**, Breathe with EEZ appliance (Breathe with EEZ Corp., 315 Liberty Avenue, Brooklyn, NY 11207). **C**, Appliance inserted into paralyzed nostril.

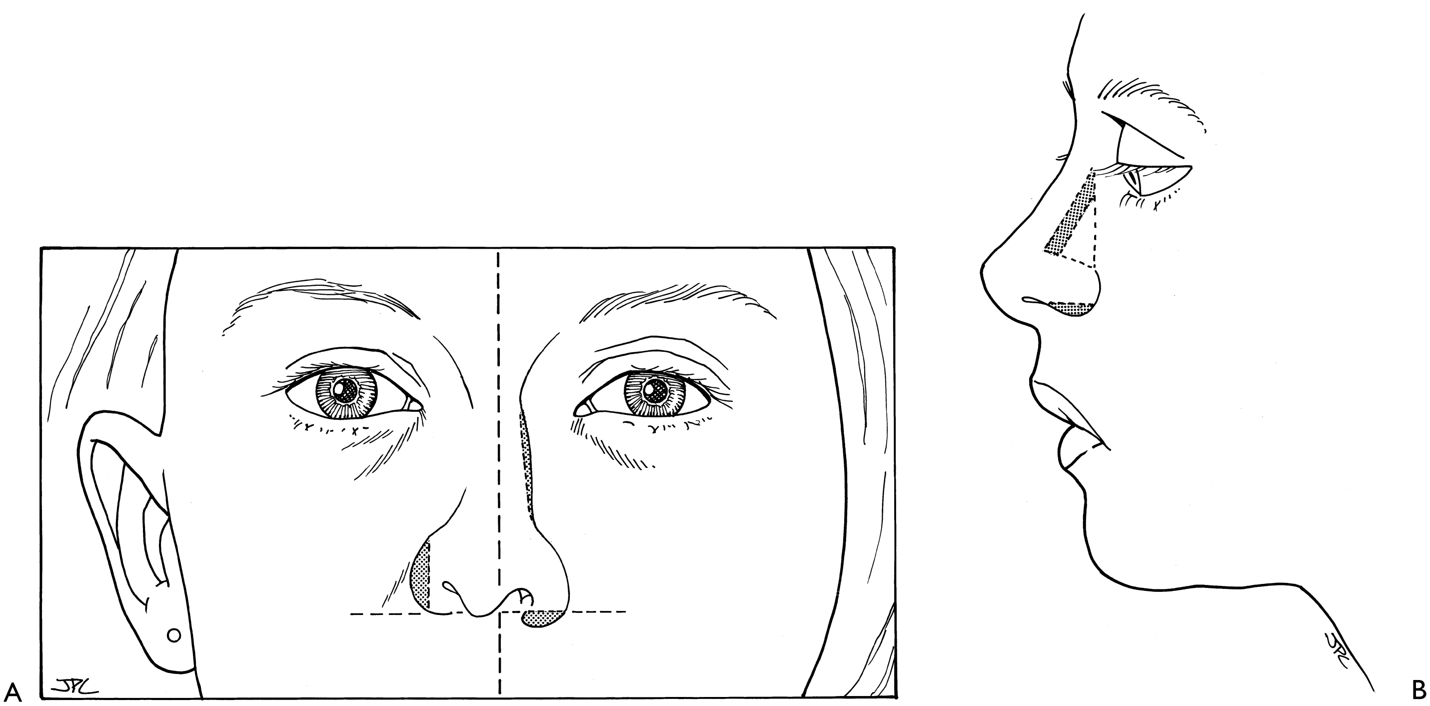


Figure 9–8. **A**, Frontal view of nasal makeup to reduce appearance curvature and droop. **B**, Profile view of nose makeup to reduce appearance of curvature.

Figure 9–9. Disparity in eye size caused by paralysis. **A**, Patient with right-side paralysis with right eye larger from drooping palpebral muscles. **B**, Eye sizes approximated with makeup technique discussed in text. **C**, Patient with left-side paralysis postcorrection with eye spring and temporalis procedure. In this case, the nonaffected eye is the larger. **D**, Makeup designed to equalize the eye sizes.

If, as is often the case, the lips have become irregular, they may be "reshaped" with cosmetics. As in Figures 9–10 and 9–11, new contours should be drawn on the thinner side with lip liner. This outline should mirror the natural shape of the fuller side. Lipstick should then be applied to fill in the new contours.

In reconstruction a cupid's bow, near-perfect symmetry may be achieved. After pressing the open rim of the lipstick cap against the tube color, press the rim onto the upper lip on either side of the midline. Then fill in the template with color (Fig. 9–12).

Fashion

The principle behind clothing selection is the same as in hairstyling, to de-emphasize facial irregularities. This may be accomplished through the skillful use of color, value, pattern, and form.

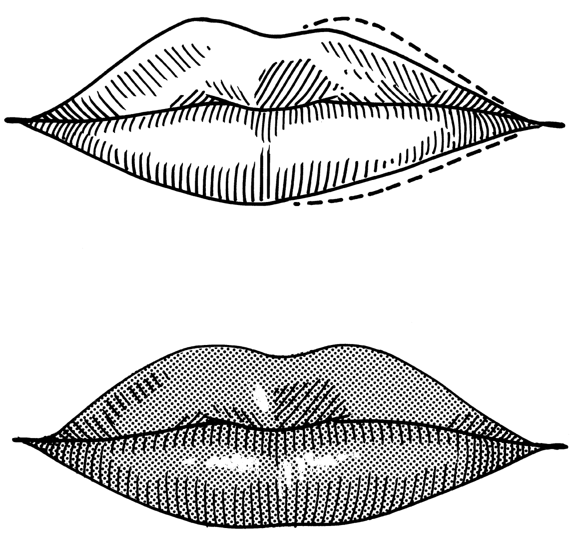


Figure 9–10. Lipstick application to equalize thickness of lips.

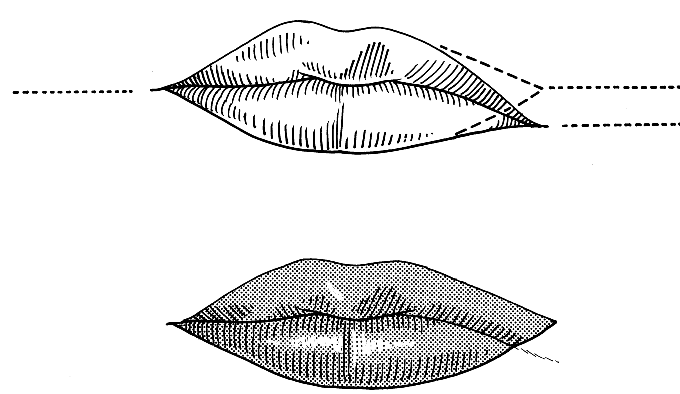


Figure 9–11. Lipstick application to modify a modestly drooping lip.

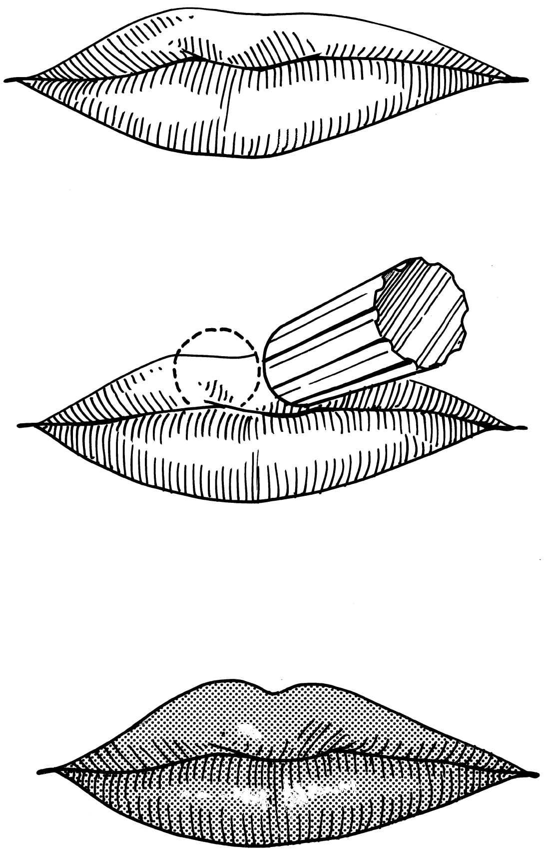


Figure 9–12. Reconstruction of a cupid's bow with lipstick cap.

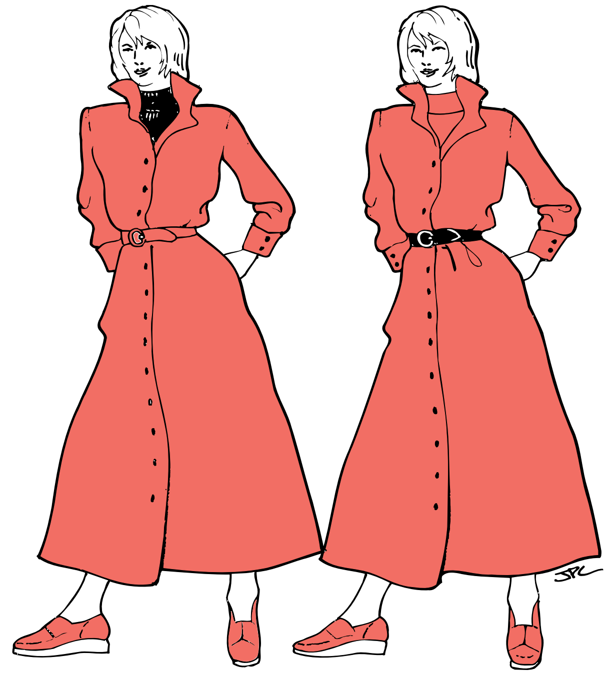


Figure 9–13. Contrasting colors will draw the viewer to the area of contrast.

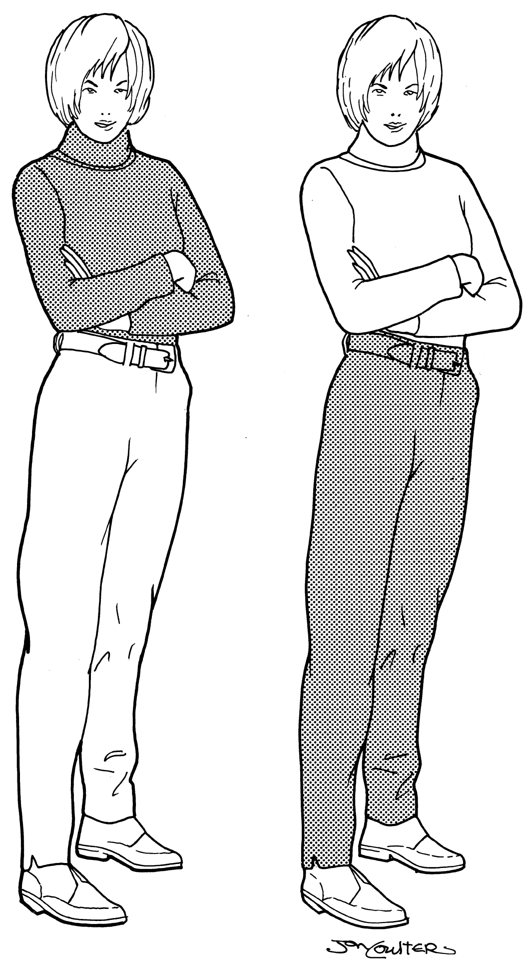


Figure 9–14. Contrasting values can influence the viewer's gaze. The eye will tend to concentrate on the area of greater (darker) value.

Colors should be chosen to compliment skin and hair color. Brighter hues will tend to attract attention to the clothes themselves. Tartans (plaids), stripes, and prints, when appropriate, will have the same tendency. One fact that must be considered is that areas of color or value contrast will draw the eye to the point of contrast. For example, a black turtleneck worn with a red dress would direct the viewer's gaze toward the neck and face. Were a red dress to be worn with a black belt, the eye would be drawn to the midsection (Fig. 9–13). Contrasting values (the lightness or darkness of a color) will have a similar effect. A dark sweater worn with light trousers would draw the view upward (and may look awkward). Dark trousers worn with a light sweater will emphasize the lower portion of the body (Fig. 9–14).

Accessories can also be effective in directing the viewer's attention. A long string of beads or pearls would be more effective than a choker. Bracelets, rings, and attractive watches worn in moderation can also be helpful in distracting from irregular facial features (Fig. 9–15).

Soft hats and scarves are practical accessories in winter. They are also useful in accentuating the better facial features in much the same way as an appropriate hairstyle (Fig. 9–16). Of course, concepts of color and contrast will still apply. The hat and/or scarf should not overwhelm the coat with which they are worn.

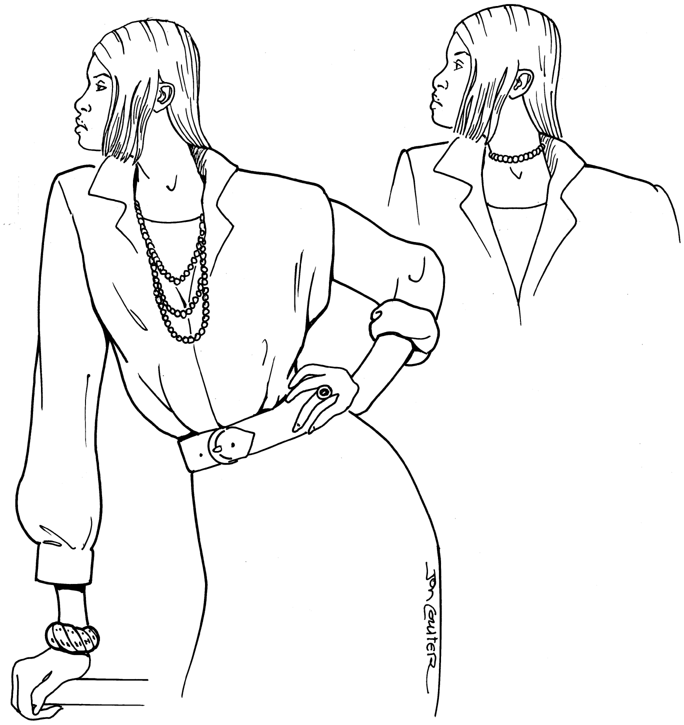


Figure 9–15. Jewelry of an appropriate length and size, with appropriate placement, can direct the view advantageously. Necklaces should be long enough to "hang." The inset shows a choker, which attracts attention to areas one may have wished to de-emphasize.

If eyeglasses are required, a few simple recommendations should be considered. Shape is a matter of personal taste and might be arrived at through consultation with an optician. The frames should be a neutral color. They should be without rhinestones or other ornamentation. The use of eyeglasses as prostheses will be discussed shortly.

Techniques for Males

Several of the makeup techniques discussed for female patients would work equally well for men. Of course, most men will resist using them. One should be aware that many professional men wear make-up as a matter of course. Every movie star, every stage actor, every television anchorman, and virtually every politician who speaks before an audience wears makeup. They should certainly embrace the cosmetic treatment of the temporalis bulge. Generally, however, most men will expect to enhance their appearance with appropriate hairstyles, facial hair, and prostheses.

Grooming

Hair can be layered and cut in a "shag" to avoid a geometric appearance, which would accentuate differences between the paralyzed and unaffected sides of the face. It can be down swept toward the larger eye to expose more forehead on the opposite side. This will optically reduce the size disparity between the eyes. If the paralyzed eye becomes smaller than the unaffected eye, this hair sweep will also mask the lack of forehead wrinkling.

The temporalis muscle procedure improves the sagging mouth but creates a bulge in the paralyzed cheek. Hair can be grown longer on each side of the face, but will tend to fall behind the bulk of the muscle. The growth of beard, carefully trimmed, can reduce the appearance of the temporal mass (Fig. 9–17). An accompanying mustache compliments the lip correction.

The loss of an ear, while it may be obscured by a long hairstyle, is best compensated for with a prosthesis. The patient in Figure 9–18 was treated for basosquamous carcinoma (see Chapter 8, Case 4, Fig. 8–4). After early attempts to achieve balance with longer hair and a beard, which was reasonably successful, the patient had a prosthetic ear fit-

Figure 9–16. Soft hats and scarves can enhance the features. A hat may be angled in the same direction as the hairstyles recommended earlier. It is important, however, that the rules of color and contrast continue to be observed. The inset shows the effect of an appropriate hat being diminished by a poor choice of scarves.

A–B

Figure 9–17. Patient with paralysis post-acoustic surgery. **A**, Postoperatively, left-sided paralysis obvious. **B**, Six weeks after eye spring, temporalis muscle, and cartilage procedures. Patient equalizes disparity and reduces temporalis bulge with neatly trimmed beard.

A–C

Figure 9–18. Patient with left facial paralysis following surgery for baso squamous carcinoma which required the removal of his left external ear. **A**, Eleven days postonset of facial palsy. **B**, Six months posttemporal muscle procedure. He has moved the part in his hair to the right. This let him comb hair into the space formerly occupied by the missing ear. He grew a beard to balance his lower face. **C**, Five years after temporalis procedure. He has added a prosthetic ear. This has permitted him to shave his beard. The mustache is retained to mask lip irregularity.

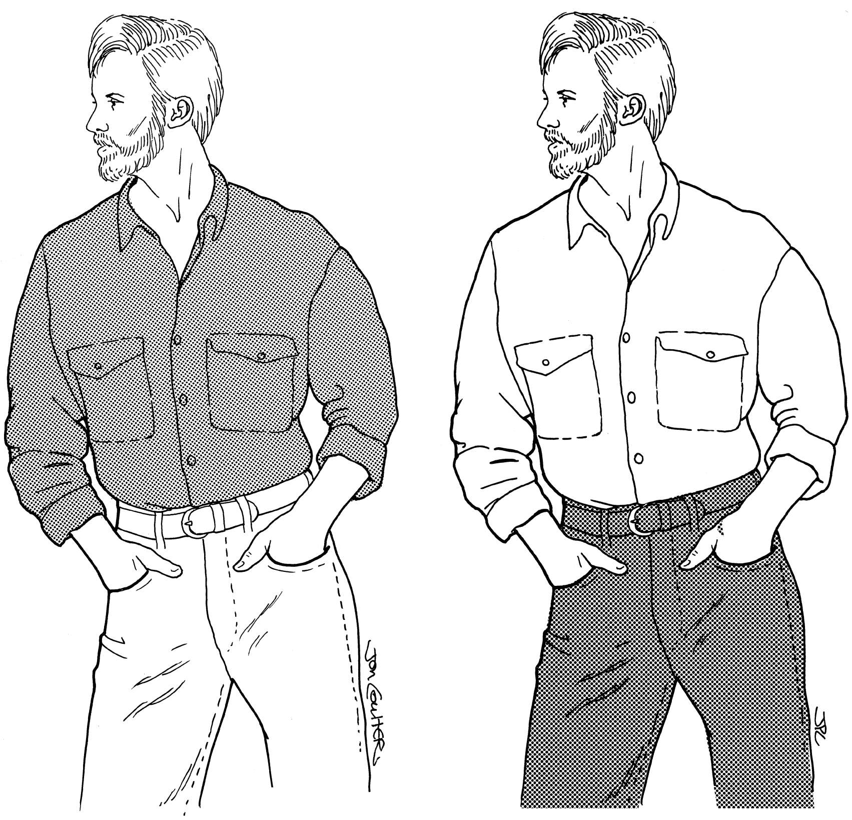
ted. With symmetry re-established, he was able to achieve an appearance of balance by again restyling his hair and shaving his beard. Note that the mustache is still useful in correcting irregularity of the lip. At rest, the temporalis bulge is not prominent.

The patient must determine which is more disconcerting, the difference in eye sizes or the temporalis bulge. Attention will be drawn to the side of the face on which the hair is parted. Lack of forehead wrinkling seems not be a major concern of males.

Wardrobe

The effects of appropriate grooming can be heightened with a carefully selected wardrobe. Although male suit designs are remarkably similar from year to year, the selection and styles of casual wear are as changeable as those of women. We will not, therefore, recommend specific designs, but will concentrate on basic principles.

Contrast is of primary importance. In considering the relative value (lightness or darkness) of garments given



A–B

Figure 9–19. Relative value is important. **A**, Darker value in shirt directs the viewer toward the head. **B**, Darker value in trousers directs view toward lower limbs.

relatively equal surface areas, the darker hue will tend to attract more attention. If the darker value is close to the face (Fig. 9–19A), attention will be drawn there. If it is farther away (Fig. 9–19B), attention will be directed elsewhere. Assembling clothes with thought as to their value is helpful in guiding the viewer to the areas the patient wishes to emphasize (or away from the areas he wishes to de-emphasize).

Relatively small items of clothing can also hold the viewer's attention when contrasted with a larger mass of an opposing value. A simple belt can seize the viewer (Fig. 9–20A) when it is worn with a suit of a different value. A contrasting sweater vest worn with a sportcoat (Fig. 9–20B) will have great success in attracting the viewer's attention. Wearing trousers darker than a coat will, of course, have an even stronger effect (Fig. 9–20C).

Drawing the viewer to an area of contrast can also be accomplished by playing a smaller high value (light) garment against a large mass of lower (darker) value. This is especially important to remember with respect to the scarf or hat, which may draw the viewer's eye directly to the face unless its value is similar to the coat with which it is worn (Fig. 9–21).

Less important than value, but still profound in its effect, is color. Given equal values and surface areas, the eye will most likely be attracted to the warmer color (red, orange, yellow) than the cooler color (blue, green, violet) or the neutral color (brown, beige, grey). It would be useful to reserve the warmer colors for accents and keep them some distance from the face.

Bold patterns, such as tartans and stripes, will attract attention to themselves. They must, therefore, be positioned in accordance with the concepts of value and color. They should be placed where it is desired for the viewer to look. Ties can be quite effective in directing the eye. This is especially true if the "heaviest" part of an asymmetric design is concentrated at the tip (near the belt).

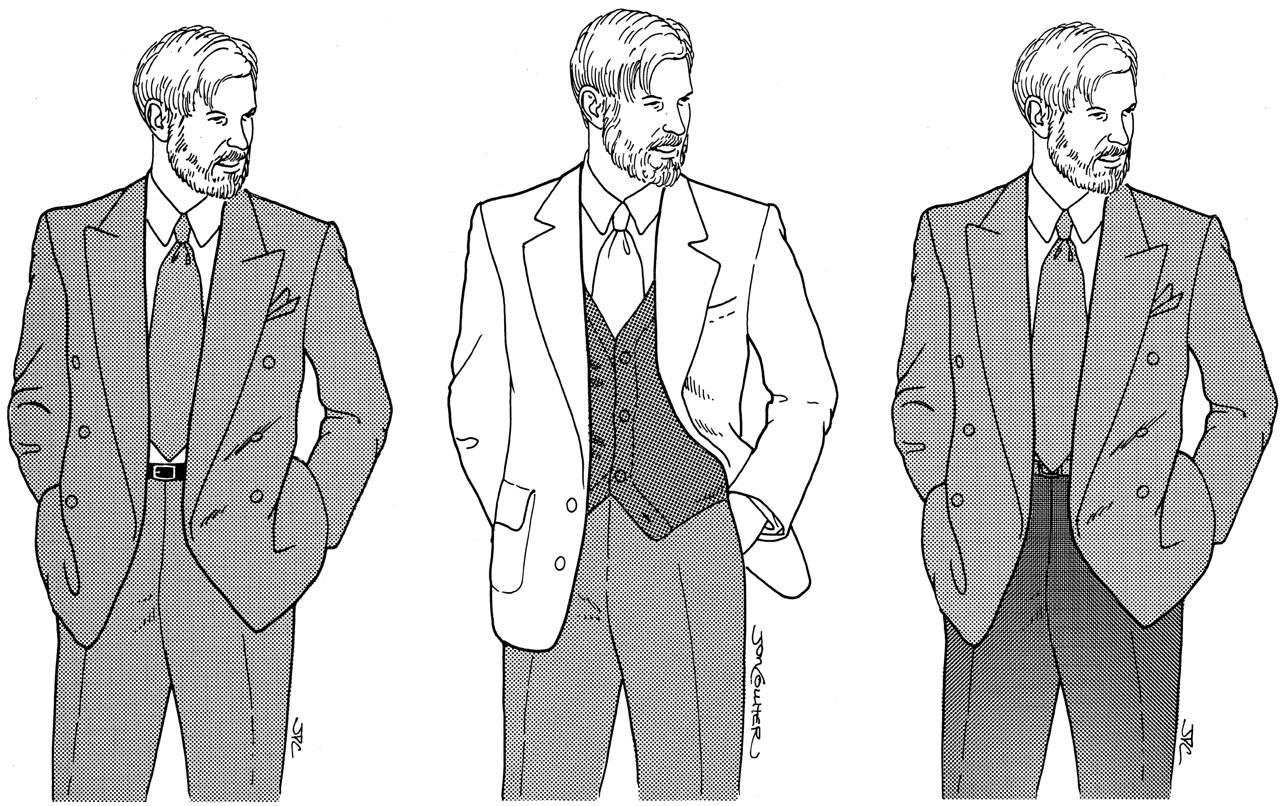
Gender-Neutral Enhancements

There are, of course, techniques which can be used by both men and women. The illustrations that follow will draw on patients of both genders.

Eye size disparity can be visually reduced by the use of tinted lenses (Fig. 9–22). In this case, the patient also used his glasses to obscure a temporal defect resulting from a skull fracture. These images are 6 years post-eye spring and nerve graft.

Eyeglasses can also be used to alleviate a drooping brow (Fig. 9–23). A brow crutch can be affixed to the inner frame and temple piece on the paralyzed side. This crutch will support the paralyzed sagging brow and be only marginally visible from the front.

Prosthodontists can aid in restoration of lip symmetry. An edentulous patient can improve appearance with appro-



A–C

Figure 9–20. Focusing attention through the use of contrast. **A**, The darker belt set against a uniform value suit attracts attention. **B**, The dark sweater vest draws the viewer toward the midsection. **C**, Dark trousers divert attention from the lighter coat, tie, and shirt.

Figure 9–21. Tracing of patient in Figure 9–18. Beside its utilitarian value in cold or inclement weather, a hat with a brim may further the effect created by the proper hair style.

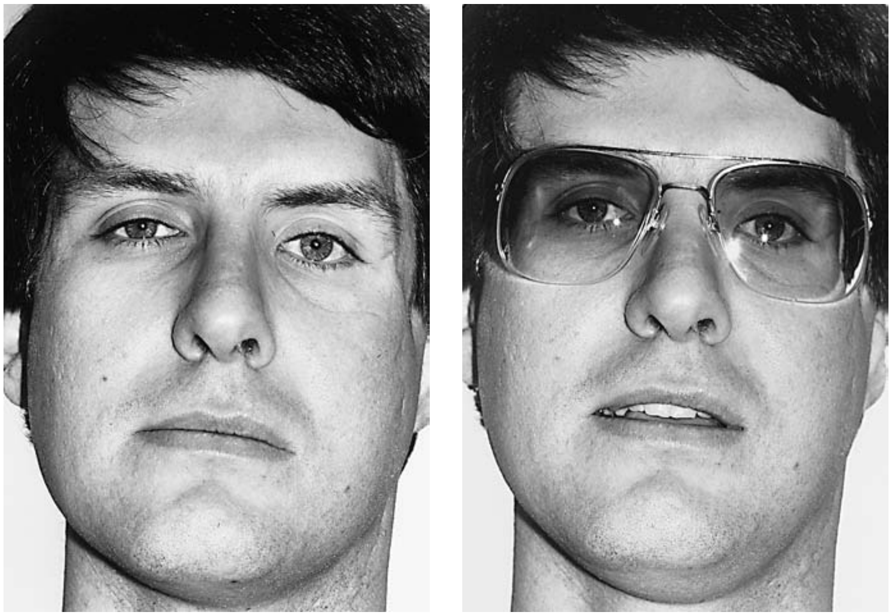
priately modified dentures. Figure 9–24 shows one such patient and the corrective affect of well-designed dentures.

Splints can be added to existing dentures. Figure 9–25 demonstrated lip deformity in a patient with marginal mandibular nerve palsy. Good results are obtained with a modified denture.

Patients who do not require dentures can likewise benefit from dental appliances. The patient in Figure 9–26 suffers from marginal mandibular branch paralysis. A splint was designed to fit between the lower lip and gum to restore balance, as well as to prevent lip biting effect.

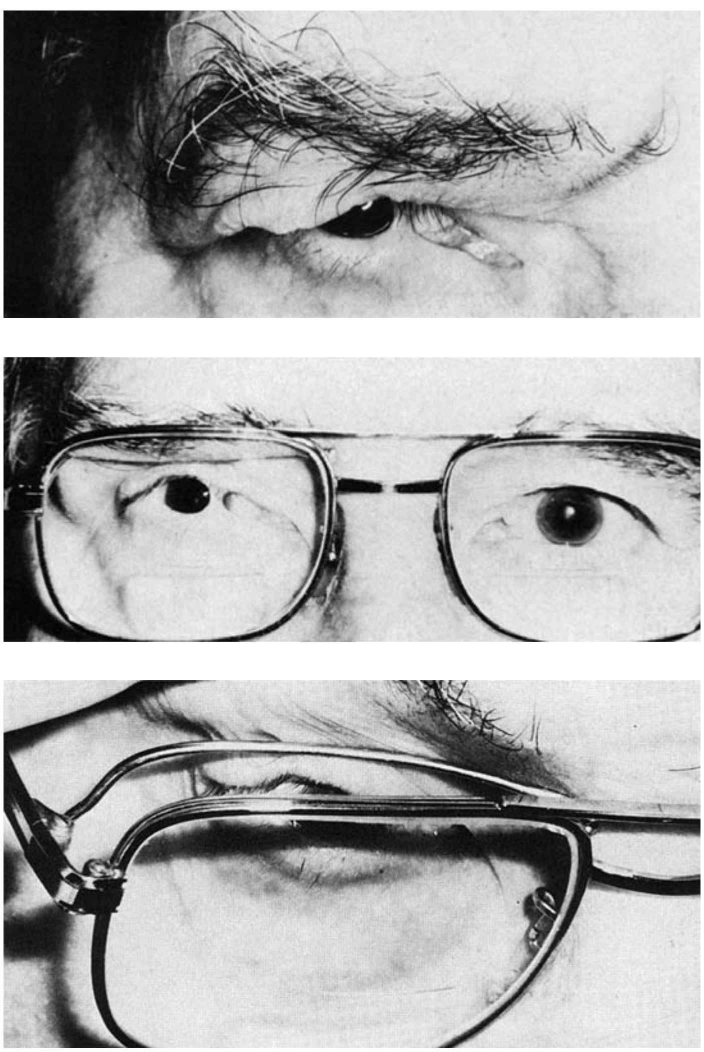
Summary

These techniques for enhancing one's appearance are neither exotic nor extraordinary. They are based on grooming and clothing decisions we all make every day. Products useful in minimizing the effect of facial paralysis are readily available and indeed are the basis of a multibillion dollar cosmetic industry. Expert opinion is easily accessible, often as close as the nearest cosmetics counter or barber shop. By modifying the styling to suit the condition, patients can do much to help themselves achieve a look with which they can be satisfied.



A–B

Figure 9–22. Patient with size disparity and depression in left temporal region following skull fracture. **A**, Patient six years post-eye spring and nerve graft. **B**, Patient with tinted glasses. This reduces disparity in eye size and obscures the temporal depression.



A

B

C

Figure 9–23. **A**, Patient with facial palsy and brow droop 3 months post-resection of acoustic schwannoma. **B**, Eyeglasses with brow crutch placed under drooping brow. **C**, Crutch supports brow.

Figure 9–24. **A**, Edentulous patient with right facial palsy. There is poor facial contour around the mouth with her denture in place. **B**, Buccal flange augmentation increased thickness of denture base on the right. Compare to the patient's original maxillary denture on the left. **C**, Mandibular denture is augmented for the same patient. **D**, Patient smiling after fitting of modified prosthesis.

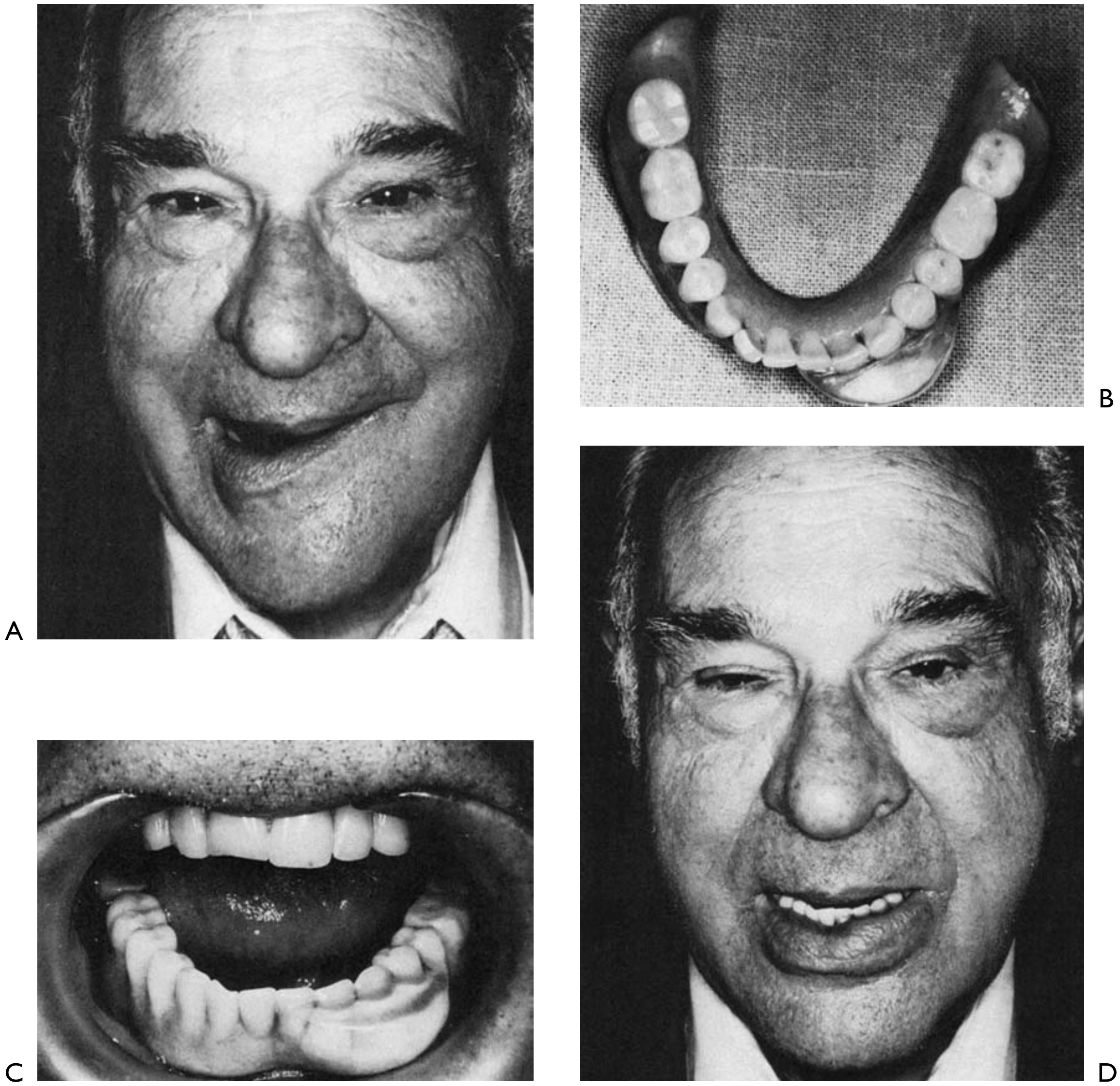


Figure 9–25. Patient 1 year following submandibular surgery and marginal mandibular nerve palsy. **A**, Smiling without denture. **B**, Denture with splint built on. **C**, Denture in place. **D**, Smiling with denture in place.

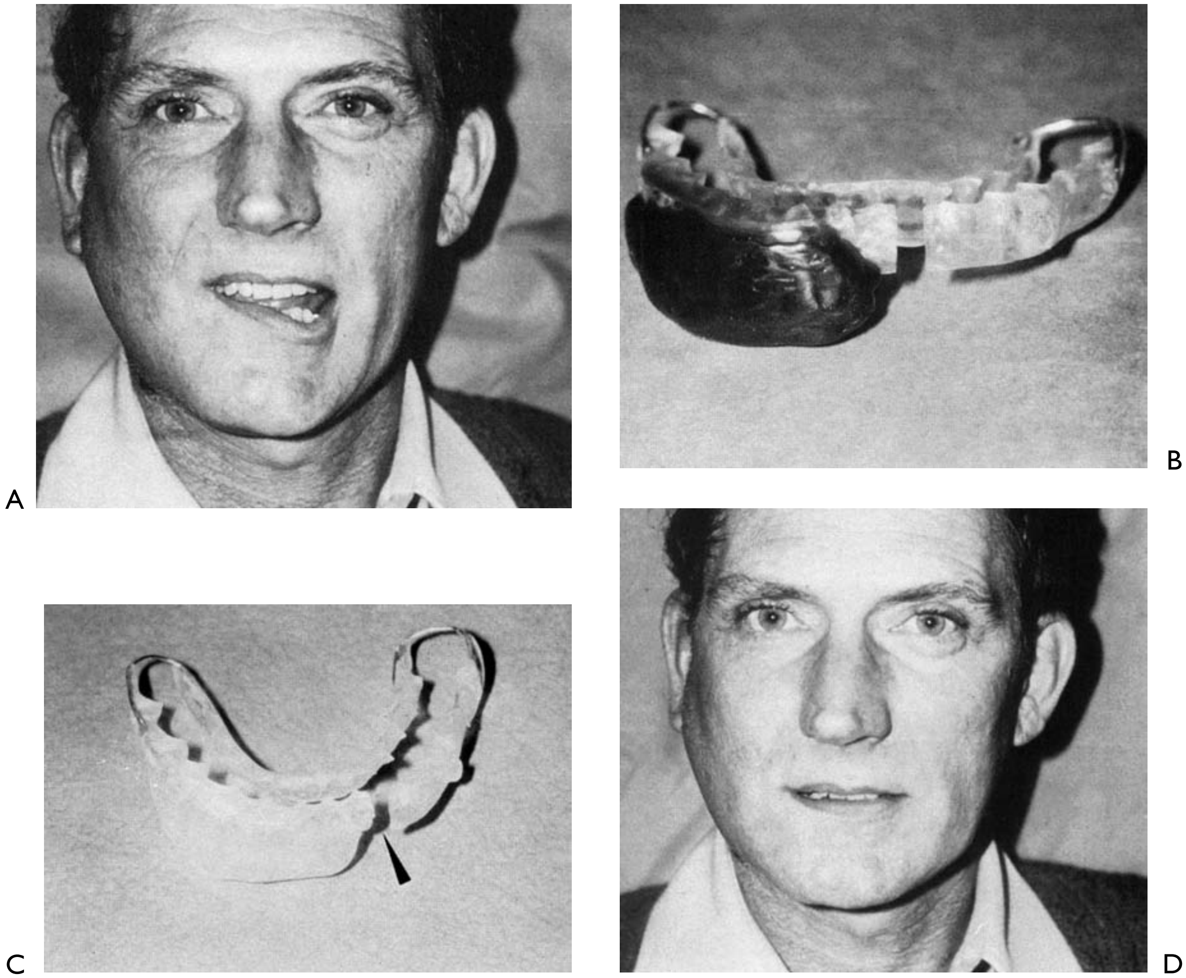


Figure 9–26. **A**, Patient at initial visit for management of marked lip distortion due to marginal mandibular branch paralysis resulting from parotid gland surgery. **B**, Labiolingual splint design. Wax is added to attain adequate lip support. **C**, Finished appliance at time of insertion. Orthodontic rubber band is applied to the button arrangement at the split area (arrow). **D**, Patient shown with the prosthesis in place. This diagnostic prosthesis will be replaced with a definitive metal framework at a later date.

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Index

Page numbers in *italics* indicate figures. Page numbers followed by "t" indicate tables.