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Reconstructive Urethral Surgery

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F. Schreiter

G.H. Jordan

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G.H Jordan

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With 224 Figures

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F. Schreiter
University of Witten Herdecke
Stubbenberg 22
D-21077 Hamburg

G.H. Jordan
Department of Urology
Eastern Virginia Medical School
Sentara Norfolk General Hospital
Norfolk, VA

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Preface

This textbook seeks to determine the current state-of-the-art of reconstructive urethral surgery and to identify new trends in this subspecialty of reconstructive urology. To this end, internationally known experts and opinion leaders in the field were invited to Hamburg, Germany to discuss and demonstrate today's commonly used surgical techniques.

Dialogues that took place during this convention, held in the spring of 2001 at the General Hospital in Hamburg-Harburg, are presented in book chapter format in this volume. The text is rounded out by live recordings of the most important of the surgical procedures. (DVD included with this compendium.)

Our desire was to publish, in close collaboration with Springer, a surgical textbook that presents the most important basic and modern techniques in urethral surgery. These techniques are underscored with simple and instructive drawings and »live surgery« video clips. We consciously chose not to make the text an all-inclusive surgical text. Thus the techniques included reflect a deliberate subjective selection on the part of the editors. We focused on the »renaissance« of graft techniques. Much of the material is concentrated on buccal mucosal and preputial grafts Two-stage surgical techniques, particularly for complex cases or patients who have undergone multiple previous operations, are also included.

This book is written for all urologists. It is intended to be an easily understandable and useful tool for their daily work, by giving them practical, clear, and reproducible accounts of the surgical techniques shown. In doing so, we hope it becomes an important part of reconstructive urology surgeons' libraries.

Prof. F. Schreiter
G.H Jordan, M.D.

Contents

List of Contributors

D.E. Andrich, MD
Institute of Urology/Nephology
Royal Free and University College
Medical School
University College London
48 Riding House Street
London W1W 7LY, UK

K. Bandhauer, MD
Prof. of Urology
Tutilostrasse 7c
9011 St. Gallen, Switzerland

G. Barbagali, MD
Prof. of Urology
Center for Urethral and Genitalia
Reconstructive Surgery
Via fra Guittone 2
52100 Arezzo, Italy

K. J. Carney, MD
Prof. of Urology
2511 Forrest Way, NE
Atlanta, GA 30305, USA

P. Emiliozzi, MD
Center for Urethal and Genitalia
Reconstructive Surgey
Via fra Guittone 2
00165 Rome, Italy

M. Fisch, MD
Prof. of Urology
Allgemeines Krankenhaus Harburg
Urologisches Zentrum
Eißendorfer Pferdeweg 52
21075 Hamburg, Germany

E. Geist, MD
Urologische Abteilung
Klinik für Urologie und Kinderurologie
Klinikum Landkreis Neumarkt i. d. Opf.
Nürnberger Str. 12
92318 Neumarkt, Germany

M. Goepel, MD
Prof. of Urology
Klinikum Niederberg
Robert-Loch-Str. 2
42549 Velbert, Germany

R. Hartung, MD
Prof. of Urology
Urologische Klinik und Poliklinik
Klinikum rechts der Isar
Technische Universität Munich
Ismaninger Str. 22
81675 Munich, Germany

R. Hohenfeller, MD
Prof. of Urology
Urologische Klinik
Johannes Gutenberg Universität Mainz
Langenbeckstr. 1
55101 Mainz, Germany

G.H. Jordan, MD
Prof. of Urology
Eastern Virginia Medical School
The Devine Center for Genito-Urinary
Reconstruction
Sentara Norfolk General Hospital
400 W Brambleton Ave.
Norfolk, VA, 23510, USA

D. Kröpfl, MD
Prof. of Urology
Urologische Klinik
Kliniken Essen-Mitte
Ev. Huyssens-Stift/Knappschaft gGmbH
Henricistr. 92
45136 Essen, Germany

J. Latini, MD
Department of Urology
2916 Taubman Center
University of Michigan
1500 E. Medical Center Dr.
Ann Arbor, MI 48109, USA

M. Lazzeri, MD
Center for Urethral and Genitalia
Reconstructive Surgery
Via fra Guittone 2
52100 Arezzo, Italy

J. W. McAninch, MD
Prof. of Urology
Department of Urology
University of California School
of Medicine
San Francisco General Hospital
1001 Potrero Avenue
San Francisco, CA 94110, USA

E.J. McGuire, MD
Prof. of Urology
Dep. of Urology, 2916 Taubman Center
University of Michigan
1500 E. Medical Center Dr.
Ann Arbor, MI 48109, USA

A.R. Mundy, MD
Prof. of Urology
Institute of Urology/Nephology
Royal Free and University College
Medical School
University College London
48 Riding House Street
London W1W 7LY, UK

R. Olianas, MD
Allgemeines Krankenhaus Harburg
Urologisches Zentrum
Eißendorfer Pferdeweg 52
21075 Hamburg, Germany

V. Pansadoro, MD
Prof. of Urology
Vincenzo Pansadoro Foundation
Casa di Cra Pio XI
Via Aurelia 559
00165 Rome, Italy

J. K.M. Quartey, MD
Prof. of Urology
University of Ghana College of Health
Sciences Medical School
PO Box 4236
Accra, Ghana

K.F. Rourke, MD
Eastern Virginia Medical School
The Devine Center for Genitourinary
Reconstruction
400 W Brambleton Ave.
Sentara Norfolk General Hospital
Norfolk, VA 23510, USA

H. Rübben, MD
Prof. of Urology
Dept. of Urology
University of Essen
Hufelandstr. 55
45122 Essen, Germany

S. M. Schlossberg, MD
Prof. of Urology
Eastern Virginia Medical School
The Devine Center for Genito-Urinary
Reconstruction
Sentara Norfolk General Hospital
400 W Brambleton Avenue
Norfolk, VA 23510, USA

B. Schönberger, MD (deceased)
Prof. of Urology
Chairman Pediatric Urology
Urological Clinic
Humboldt University, Campus Charité
Schumannstrasse 20–21
10117 Berlin, Germany

F. Schreiter, MD
Prof. of Urology
University of Witten/Herdecke
Stubbenberg 22
21077 Hamburg, Germany

K.-D. Sievert, MD
Prof. of Urology
Klinik und Poliklinik für Urologie
Universitätsklinikum Münster
Albert Schweitzer-Straße 33
48129 Münster, Germany

H. Sperling, MD
Associate Prof. of Urology
Dept. of Urology
University of Essen
Hufelandstr. 55
45122 Essen, Germany

J. T. Stoffel, MD
22 Indian Springs Wy
Wellesley, MA 02451, USA

D. Streit, MD
Prof. of Urology
Centro Clinico Da Puc
Av. Ipiranga 6690 Cj. 601
Porto Alegre, RS 90610000, Brazil

Andrea Verweyen, MD
Urologische Klinik
Kliniken Essen-Mitte
Ev. Huyssens-Stift/Knappschaft gGmbH
Henricistr. 92
45136 Essen, Germany

L. Zinman, MD
Prof. of Urology
Lahey Clinic Medical Center
41 Mall Rd.
Burlington, MA 01805, USA

Introduction

F. Schreiter, G.H. Jordan

The treatment of urethral stricture is among one of the oldest medical activities practiced by humankind. In approximately 600 BC, Egyptians and Indians used bougies made of wood, papyrus, feathers, and metal to widen constricted urethras. Early attempts at external urethrotomy (Aretheus, 80 AD) and internal urethral incision (Heliodorus, 90 AD, Opera chirurgica) are also described in the literature. In 1561, Ambroise Paré developed a lead bougie with a file-like tip for internal urethrotomy. The popularity of internal urethrotomy rose exponentially in 1971 with Sachse's description of visual internal urethrotomy. His work paralleled the development of the modern optical urethrotome. However, Riba in 1936, Fischer in 1937, and Ravasisni had already applied the technique of visual internal urethrotomy. Nonetheless, the status of optics at the time of their work did not favor wide application of the procedure.

Open single-stage surgical reconstructive procedures for urethral stricture, regardless of etiology, date back to the latter part of the 19th century. Heusner (1883), Guyon (1892), Rochet (1899), and Hamilton Russell (1914) described results of stricture resection with either partial or in some cases true end-to-end anastomosis. The results, however, were unsatisfactory because of the lack of understanding concerning the need for spatulated anastomosis and the need for efficient mobilization of the urethra so that the anastomosis was sutured tension-free. Likewise, their work was hindered by the poor availability of quality absorbable suture material. Additionally, they were unable to protect the repair by diversion because only hard rubber-based catheters existed at the time. Consequently, procedures were fraught with problems of infection due to lack of antibiotics, and thus single-stage primary reconstructive techniques were abandoned in favor of two-stage surgical techniques. The two-stage operations, as described by Bengt-Johanson, became the commonly applied technique. However, this operation, truly the first one suitable for all strictures regardless of etiology, was encumbered by poor long-term results. Much of the urethra was reconstructed with hair-bearing scrotal skin, giving rise to pseudo-diverticula, infections, abscess, urethral bezoar, and ultimately long-term failure. In 1970, Schreiter described a two-stage mesh graft operation. Many of the disadvantages of the Johanson technique were eliminated when this procedure was adopted. This procedure was also used for long and complex recurrent strictures.

In 1957, the full-thickness skin graft patch urethroplasty technique was described by Pressman and Greenberg. Devine later published a large series and improved and expanded the technique. From the time of its description to the early 1980s, full-thickness skin patch graft urethral reconstruction became the standard for single-stage urethral reconstruction for stricture. However, the early results never exceeded the mid 80% range, and long-term results showed deterioration and left much to be desired. Other surgeons such as Memmelar (bladder mucosa), Bürger and Hohenfellner (buccal mucosa), and Quartey (genital skin island flap techniques) explored new approaches in reconstructive surgery for urethral stricture. Today there has been a resurgence of interest in graft techniques, particularly with the advent of the use of the buccal mucosal graft. Island flap techniques are still applicable, but their use has drastically diminished.

Currently, the buccal mucosal graft prevails in the treatment of stricture associated with lichen sclerosus and is considered the method of choice. Whether the graft techniques employing buccal grafts will enjoy better success than flap techniques or skin graft techniques remains to be seen. The staged mesh graft operation remains for very complex situations in which there is a shortage of penile skin, the buccal mucosa donor site is not sufficient for the degree of stricture, etc. One chapter of this textbook is devoted to tissue engineering, and certainly while those techniques are in their infancy, the insights gained from today's work are felt to be the future of urethral reconstruction.

As already mentioned, this textbook is not intended to cover the entire spectrum of urethral reconstructive procedures. However, those techniques considered applicable to most surgeons' practices have been covered in this book.

We, as the editors, along with the publishers, thank the international forum of authors who have contributed to both the meeting and this volume. Without their cooperation, this textbook could not have come to press. We thank Springer for designing and publishing the book and for their assistance in its preparation.

Hamburg/Norfolk, August 2005
Prof. Dr. med. F. Schreiter
G. H. Jordan, M.D.

Fundamentals

Historical Highlights in the Development of Urethral Surgery

K. Bandhauer

»On the shoulders of the giants«: this should be the motto for the following short and of course incomplete survey of the historical highlights of urethral surgery as well as the topic of this meeting on reconstructive urethral surgery.

Speaking about the historical development of the surgical treatment of different urethral diseases, whether urethral strictures, hypospadias, or epispadias, it should always be kept in mind that most of the surgical techniques we discuss in our meetings have already been performed by excellent and creative surgeons and urologists over a certain period of time, some even for decades.

With this in mind, the question can be asked why the results of urethral surgery, with some exceptions, were rather unsuccessful until about 50 years ago. The answer is simple: not only the surgical technique is crucial for the success of urethral surgery, but also perioperative measures such as correct temporary urinary diversion using the best catheters, the use of reabsorbable sutures without the risk of calcification caused by urine, and the use of antibiotics to prevent postoperative infections. Urethral surgery had a real chance to be successful irrespective of the operative technique used only after these tools became available. Besides these important achievements of modern medicine, a better understanding of the anatomy and the function of the urethra with its adjacent glands contributes to the immense success of urethral surgery, something our urological generation can rightfully be proud of. It was the knowledge of the different functions of the corpora cavernosa and the corpus spongiosum urethrae in erection, the practical experience showing that the urethra is flexible enough to replace at least 2–3 cm of resected urethra just by stretching the remaining parts, and finally the recognition of the enormous elasticity of the penile and preputial skin, which enabled creative urologists to conceive different methods for successful surgical treatment of urethral disorders.

Despite the indication of the importance of different perioperative measures for the outcome of urethral surgery, the following historical remarks are limited only to the development of urethral reconstruction. It was the German surgeon K. Thiersch in 1869 who designed an operation for epispadias using longitudinal flaps raised on either side of the urethral furrow, one for the floor of the urethra with the other used to cover it, overlapping it in double layer fashion. With this operative technique, he recorded the first use of buried skin to create a new urethra. Five years later in 1874, this procedure was used by the Frenchman Th. Anger to reconstruct the urethra in the hypospadias. But it was the Frenchman S. Duplay who published the first important paper on the subject of hypospadias in the *Archives Générales de Médecine* in 1874. He gave credit to Anger for presenting the first successful case of hypospadias repair to the Société de Chirurgie in 1874. S. Duplay himself converted ventral penile skin into a tube using a catheter as a splint to create a new urethra. His first successful operation required five stages and in 1880 he reported further successful operations. In the same year (1880), he declared in the description of his modified operation that it is not necessary to cover the splint completely by the inner edges of the skin flaps to develop a tube by itself: »Although the catheter is not actually covered entirely by skin, I am convinced that this has no ill effect on the formation of the new urethra.« With this statement he already anticipated the idea of Denis Browne's buried-skin technique. But the differences in techniques between Denis Browne's repair and Duplay's are obvious. Duplay created a new urethra by wrapping a penile skin flap around a catheter, while Browne buried only a strip of penile skin. It is beyond doubt that Duplay was the most important promotor of the French School of Urology, creating useful procedures to correct different forms of hypospadia. Even numerous modifications of Duplay's original methods are still in use, with reasonable results.

The next achievement was set in 1949 by the English plastic surgeon Denis Browne when he introduced his buried-skin technique using the tube forming capacity of penile skin to construct a new urethra (▫ Fig. 2.1). Although Hamilton Russell (1915) and Erich Lexer (1929) had already used buried urethral epithelium to construct a tube, it was the genius of Denis Browne to use this natural capacity of a buried skin flap to become a tube within about 10 days for creating an operation that that has been widely performed ever since, with remarkable success.

Even though Denis Browne's original method, with its numerous modifications by J. Blandy, D. Zoedler, R. Turner-Warwick, and Hans Marberger et al., are not the only methods available for creating a new urethra, it was the basis of modern urethral surgery. This is particularly so after the Swedish plastic surgeon Bengt Johanson adopted Denis Browne's idea for correction of posterior urethral strictures (▫ Fig. 2.2). Until this time, posterior urethral strictures were the fear of all urologists dealing with urethral surgery; they now became within the range of possibility for successful reconstruction. It was Johanson's idea to use the enormous elasticity of the scrotal skin to operate on posterior urethral strictures up to the membranous part. Even complex posttraumatic strictures of the posterior part of the urethra with extended scar production could be treated with this brilliant concept.

Bengt Johanson's achievement is no less important because Hans Marberger and his co-workers from Innsbruck, Austria introduced the Johanson-procedure into urology and made this method known throughout Western Europe and the United States. The Johanson procedure for the repair of posterior urethral strictures was so effective that it also gained access for the primary treatment of traumatic ruptures even when connected with pelvic fractures. This possibility was especially shown by H. Marberger and his co-workers in a long series of

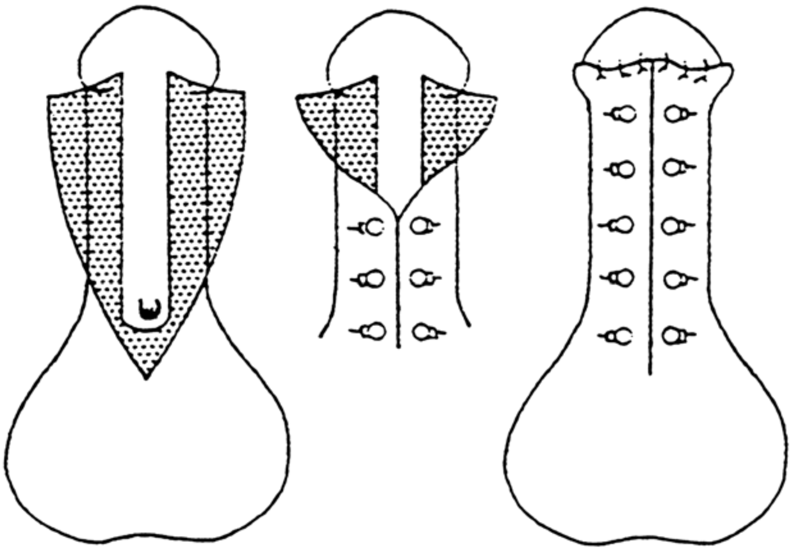

Fig. 2.1. Buried-skin technique by Denis Browne. (Courtesy of The History of Urology, by LJT Murphy, Charles C. Thomas, Springfield, IL, USA)

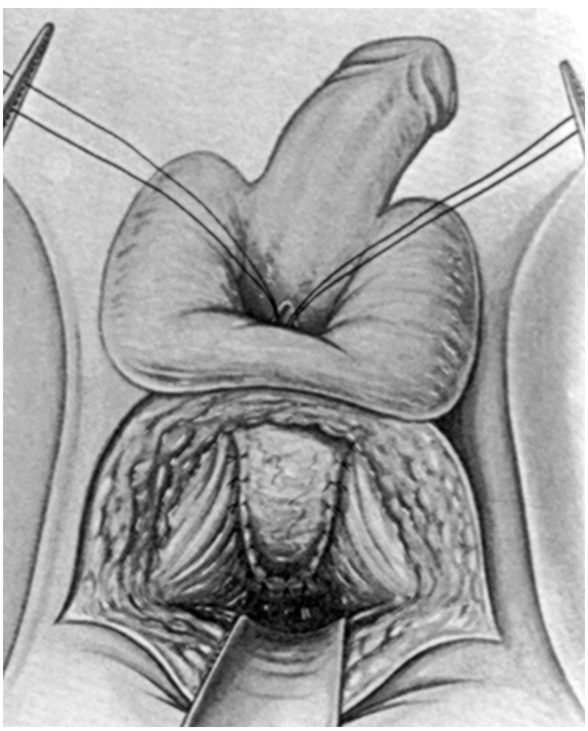

Fig. 2.2. Johanson procedure for surgical treatment of posterior urethral stricture using scrotal skin. (Courtesy of Urologische Operationen, G. Mayor and E. Zingg, 1973, Georg Thieme Verlag Stuttgart)

patients. Although the discussions on acute therapeutical measurements for traumatic ruptures of the posterior urethra continue between primary attempts to restore the continuity of the urethra or primary urinary diversion above the laceration, drainage of the intrapelvic hematoma and if necessary stabilization of the bony pelvis followed by secondary treatment of the posttraumatic strictures, the Johanson procedure provided a method that offered an excellent and safe basis for the acute treatment of urethral ruptures.

In spite of the many applications of the Johanson procedure and their numerous variations, there were some unpleasant disadvantages such as calcifications caused by remaining hair of the scrotal skin used for the reconstruction of the urethra or necrosis of the top of the skin flap used for the anastomosis with the membranous urethra. It was the idea of the German urologist Friedhelm Schreiter (1987) to eliminate this complication by using an inlay of mesh graft, which made it possible to create a wide neourethra without the risk of calcification (Fig. 2.3). The combination of Johanson's modification of Denis Browne's brilliant method with Schreiter's use of mesh graft is at the moment the safest operation for the repair of long and complex strictures in any area of the urethra.

These techniques require at least two sessions. Therefore various attempts have been made over the years to repair strictures with a one-stage operation. Probably it was the German surgeon Heusner (1883) who carried out the first excision of a stricture, restoring the urethra by sutures. Similar operations were performed by Mayo Robson (1884), Guyon (1892), and other French surgeons at the same time. The immediate outcome with one-stage operations, excising the strictured part of the urethra and re-establishing a wide urethra by anastomosis were mostly successful, but further stricture formation gave disappointing long-term results. In a review of 13 patients carried out by Watson and Cunningham (1908), only five patients showed satisfactory results more than 1 year after a one-stage operation (Fig. 2.4). In 1915, Hamilton Russel summarized the role of excision and primary anastomosis in the operative treatment of urethral strictures as follows:

»Excision of the strictures has never been very generally practised and is attempted only in a small number of cases; the reason is that the operation, as usually performed, is difficult and uncertain in its results, and surgeons are a little shy of it in the natural fear lest things should be made worse instead of better.«

An important step to improve the outcome of one-stage urethral plasties was done by Roche as early as 1895, who recommended temporary suprapubic urinary diversion after urethra surgery. But altogether the results of one-stage urethroplasties remained moderate, above all because of restrictures caused by calcification of nonreabsorbable suture material and severe local reactions produced by inappropriate catheters. For these reasons exceptional surgeons and urologists such as Marion (1929), Krois (1929), Watson (1935), and Solovov (1935) had to accept disappointing results in spite of excellent designs and operative techniques. Only when reabsorbable sutures, better catheter material, and especially effective antibiotics were available did the long-term results of one-stage urethroplasties improve. Resection of the stricture and primary end-to-end anastomosis became a routine procedure in many urological institutions all over the world. In 1975, Turner-Warwick reported excellent results of an oblique end-to-end anastomosis in the bulbous region of the urethra (Fig. 2.5). Based on these achievements, further developments were possible. Turner-Warwick (1976) made use of pediculated

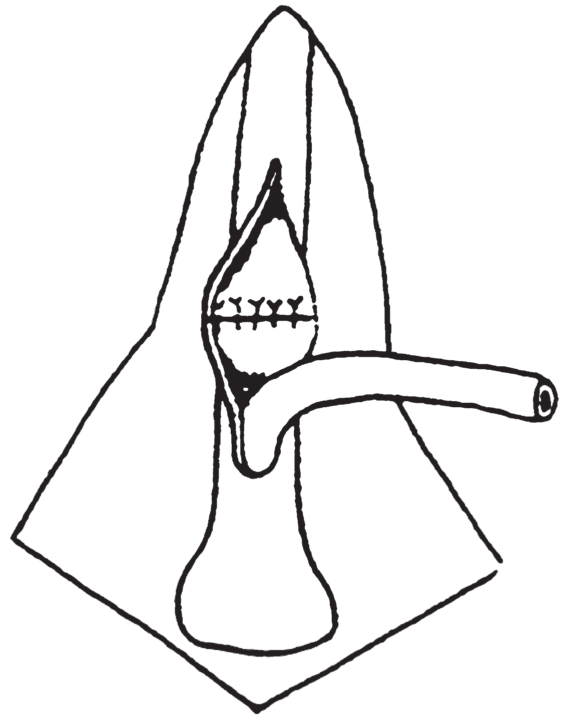

Fig. 2.4. H. Russell's technique for repair of hypospadia after excision of stricture and primary anastomosis of roof of urethra. (Courtesy of The History of Urology, by L.J.T.Murphy, Charles C. Thomas, Springfield, Illinois, USA)

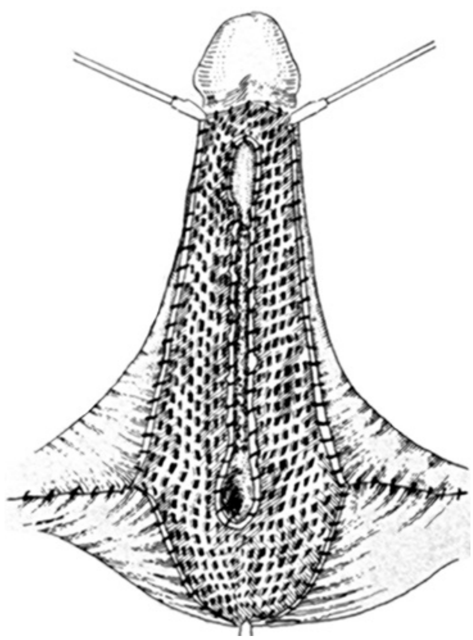

Fig. 2.3. Schreiter's method to create a new floor of urethra using an inlay of mesh graft. (Courtesy of Operative Therapie der Harnröhrenstriktur, von Klaus Bandhauer und Friedhelm Schreiter, 1991, Georg Thieme Verlag, Stuttgart, New York)

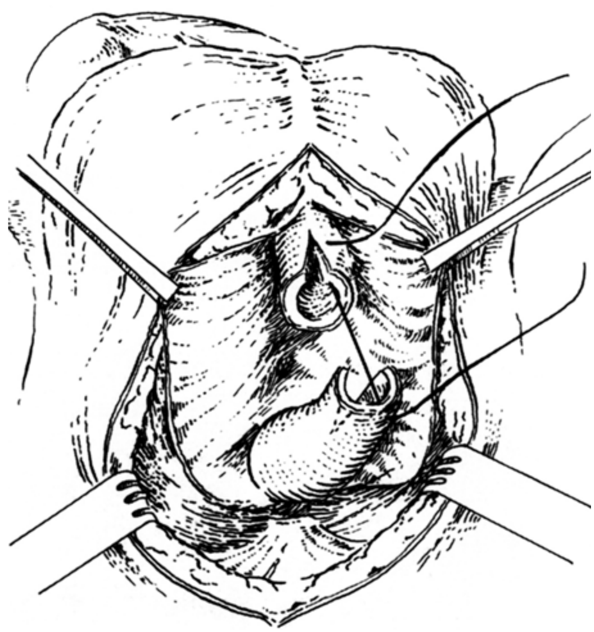

Fig. 2.5. Oblique end-to-end anastomosis in the bulbous part of urethra. (Courtesy of Operative Therapie der Harnröhrenstriktur, von Klaus Bandhauer und Friedhelm Schreiter, 1991, Georg Thieme Verlag, Stuttgart, New York)

flaps of omentum majus to cover the end-to-end anastomosis at the membranous urethra.

The elasticity of the preputial skin was already being used for pediculated grafts to make a tube to create a new urethra by Rochet in 1899 and C. H. Mayo in 1901. But it was Duckett who introduced his transverse preputial island flap technique in 1980, a method that enabled a repair of long parts of the urethra in one session (Fig. 2.6).

In contrast to pediculated flaps, the use of free grafts, pioneered already by Nové-Josserand in 1897 and again described by Devine and Horton, DeSy and others showed mostly poor results because free grafts have a strong tendency to shrink. In addition, the use of veins as reported by Tanton (1909), Tuffier (1910), Cantas (1911), and Marion (1922), and of ureters by Schmieden (1909) and McGuire (1927) to replace urethral defects, showed disappointing results. On the contrary, free grafts of bladder mucosa used by Memmelar (1947) and Marshall and Spellman (1955) to build a new urethra produced promising results, without becoming a common method in urethral surgery.

After these disappointments with different forms of free grafts, it was the utilization of oral mucosa as a free graft for reconstructive urethral surgery that seems to be an important development and can be mentioned as a highlight in the trials to replace urethral defects in one session. Oral mucosa has variously been utilized for more than 100 years in reconstructive plastic surgery, especially in ophthalmology and maxillofacial surgery. But it was to the merit of the Mainz school of Urology that Buerger et al. reported in 1992 the first results of animal experiments, using oral mucosa for reconstruction of the urethra. Based on these findings, they applied oral mucosa grafts to replace the urethra in cases of hypospadia injuries. In the same year (1992), Dessant et al. reported eight patients in whom a combination of oral mucosa and bladder mucosa was successfully employed for urethral replacement. These encouraging findings led to increased use of grafts from buccal mucosa not only for hypospadias, but also for the operative treatment of urethral strictures. Many reports on the successful use of free oral mucosa grafts for complex hypospadias have been published since and today the use of buccal mucosa onlays is widely used in urethral reconstructive surgery.

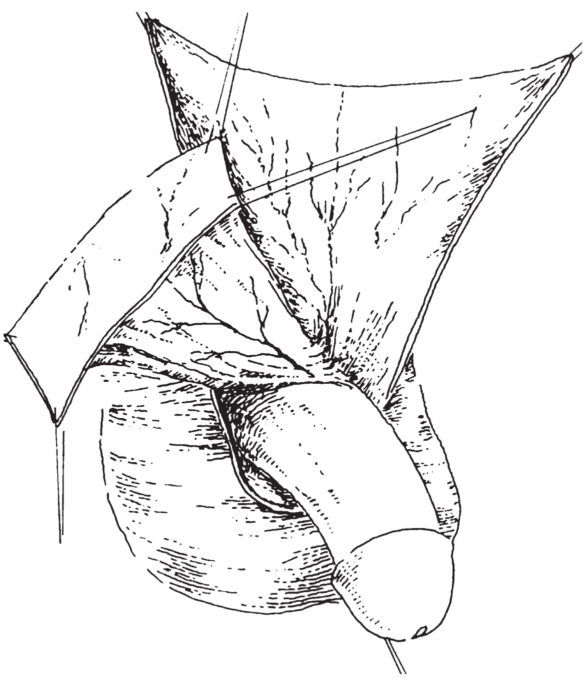

Fig. 2.6. Duckett's pediculated transversal preputial island flap to repair long parts of urethra. (Courtesy of Operative Therapie der Harnröhrenstriktur, von Klaus Bandhauer und Friedhelm Schreiter, 1991, Georg Thieme Verlag, Stuttgart, New York)

In conclusion, the historical development of reconstructive surgical treatment of urethral disorders, whether these are posttraumatic or postinflammatory strictures, hypospadias or epispadias, and even the primary treatment of urethral strictures, has known continuous improvement over the last decades. Different skillful techniques are used today as routine operations and the results of surgically treated complex urethral disorders are excellent compared to the results still 20–30 years ago. But with this short and of course incomplete historical review, I wanted to emphasize that our urological generation must remember, that we still depend on the ideas and the skill of surgeons and urologists who performed outstanding operations on the urethra already in the end of the nineteenth and the beginning of the twentieth century. Only a few of these historical highlights of urethral surgery could be presented. We were able to build on these ideas and although our operative results are much better, we must always keep in mind that this improvement stems more from the much better perioperative measures such as antibiotics, suture material, and catheters than from spectacular new operative ideas. We urethral surgeons can only remain very modest.

References

Anger T (1875) Hypospadias péno-scrotal, compliqué de cordure de verge; redressement du pénis et urétroplastie par inclusion cutanée, guérison. Rap Guyon Bull Soc Chir Paris 1:179–182

Badenoch AW (1950) A pull-through operation for impassable traumatic stricture of the urethra. 22:414–418

Bandhauer K, Senn E (1985) Die Hypospadie und ihre Korrektur- möglichkeiten. Therap Umschau 2:133–138

Bandhauer K, Alioth HR (1987) One-stage urethroplasty for bulbomembranous urethral strictures. World J Urol 5:25–29

Blandy JP, Singh M (1975) The technique and results of one-stage island patch urethroplasty. Brit J Urol 47:83–87

Browne D (1949) An operation for hypospadias. Proc Roy Soc Med 42:466–471

Browne D (1953) A comparison of the Duplay and Denis Browne techniques for hypospadias operations. Surgery 34:787–791
Bucknall RTH (1907) A new operation for penile hypospadias. Lancet ii:887–892
Bürger R, Müller SC, Hohenfellner R (1992) Buccal mucosa graft: a preliminary report. J Urol 147:662664
Cantas M (1911) Contribution à l'étude du traitement de L'hypospadias. Sur un nouveau procédé autoplastique. Lyon Chir 5:250–254
Cecil AB (1932) Surgery of hypospadias and epispadias in the male. J Urol 27:507–511
Culp OS (1958) Surgical correction of hypospadias. J Urol 79:279–283
Davis DM (1955) Results of pedicle tube-flap method in hypospadias. J Urol 73:343–346
Devine CJ, Horton CE (1961) A one-stage hypospadias repair. J Urol 85:166–172
De Sy W, Oosterlinck W (1978) One-stage urethroplasty with free skin graft. Eur Urol 4:411–413
Duckett JW (1981) The island flap technique for hypospadias repair. Urol Clin N Am 3:152–159
Duckett JW, Coplen D, Ewalt D, Baskin LS (1995) Buccal mucosal urethral replacement. J Urol 153:1660–1663
Duplay S (1874) De l'hypospadias perinéo-scrotal et de son traitement chirurgical. Arch Gen Méd 223:513–518
Duplay S (1880) Sur le traitement chirurgical de l`hypospadias et de l'épispadias. Arch Gen Méd 145:257–262
Fichtner J, Fisch M, Filipas D, Thüroff JW, Hohenfellner R (1998) Refinements in buccal mucosal graft urethroplasty for hypospadias repair. World J Urol 16:192–194
Fichtner J, Filipas D, Thüroff JW (2000) Follow-up der Hypospadie- korrektur mit Mundschleimhaut. Urol (B) 40:131–132
Filipas D, Wahlmann U, Hohenfellner R (1998) History of oral mucosa. Eur Urol 34:165–168
Guyon F (1892) De la résection partielle de l'urètre. Rev Chir 12:435–439
Heusner K (1883) Ueber die Resektion der Urethra bei Strikturen. Deutsch Med Wschr 9:415–416
Jakse G, Marberger H (1986) Excisional repair of urethral stricture. Urology 27:233–236
Johanson B (1953) Reconstruction of male urethra in strictures: application of the buried intact epithelium technique. Acta Chir Scand (Suppl) 176:100–103
Johanson B (1953) Reconstruction of the male urethra in strictures. In: Riches EW (ed) Modern trends in urology. Butterworth, London
Kroiss F (1929) Zur operativen Behandlung der undurchgängigen Harnröhrenverengung. Z Utol 23:499–502
Lexer E (1929) Zur Operation der Hypospadie. Zbl Chir 56:414–418
Marberger H, Bandhauer K (1965) Ergebnisse der Hypospadiekorrektur nach der Methode von Denis Browne. Urol 5:185–191
Marberger H, Bandhauer K (1976) Operations for urethral strictures. In: Mayor G, Zingg E (eds) Urologic surgery. G Thieme, Stuttgart, pp 363–383
Marberger H, Bandtlow KH (1976) Ergebnisse der Harnröhrenplastik nach Johanson. Urol A 15:269–272
Marion G (1912) De la reconstitution de l`urètre par urétrorrhaphie circulaire avec dérivation de l'urine. J Urol Med Chir 1:523–528
Marion G, Heitz-Boyer M (1911) Réparation de l`urètre par suture bout à bout avec dérivation immédiate et temporaire des urines par urétrostomie. Ass Franc Urol 14:310–314
Marshall VF, Spellman RM (1955) Reconstruction of the urethra in hypospadias using the vesicle mucosal grafts. J Urol 73:335–339
Mayo CH (1901) Hypospadias. JAMA 36:1157–1164
McGuire S (1927) Use of the vermiform appendix in the formation of a urethra in hypospadias. Ann Surg 85:391–396
Memmelaar J (1947) Use of bladder mucosa in a one-stage repair of hypospadias. J Urol 58:68–73
Moll F, Marx FJ (1999) Historische Anmerkungen zur Therapie von Harnröhrenstrikturen. 39:121–126
Nesbit R (1941) Plastic procedure for the correction of hypospadias. J Urol 45:699–704
Nove-Josserand G (1897) Traitement de l`hypospadias, nouvelle méthode. Lyon Med 85:198–203
Robson A W, Mayo C H (1885) Traumatic urethral stricture cured by excision. BMJ i:481–484
Rochet V (1899) Nouveau procédé pour refaire le canal pénien dans l`hypopadias. Gaz Hebd Med Chir 4:673–678
Russell RH (1900) Operation for severe hypospadias. BMJ 2:1432–1435
Russell RH (1907) Operation for hypospadias. Ann Surg 46:244–248
Russell RH (1915) The treatment of urethral stricture by excision. Brit J Surg 2:375–379
Rutherford H (1904) On ruptured urethra: is treatment by combined drainage. (suprapubic and per urethram). Lancet ii:751–754
Schmieden V (1909) Eine neue Methode zur Operation der männlichen Hypospadie. Arch Klin Chir 90:748–756
Schreiter F, Noll F (1987) Meshgraft urethroplasty. World J Urol 5:41–49
Schreiter F (1991) Meshgraft-Urethroplastik. In: Bandhauer K, Schreiter F (eds) Operative Therapie der Harnröhrenstriktur. Thieme Verlag, Stuttgart, pp 55–61
Schreiter F (1999) Die zweizeitige Meshgraft-Urethroplastik. In: Schreiter F (ed) Plastisch-rekonstruktive Chirurgie in der Urologie. Thieme Stuttgart, pp 355–361
Solovov PD (1935) Fracture of the pelvis with injury of bladder and urethra. Vestn K Chir 37:36–42
Tanton P (1909) La transplantation veineuse par l`autoplastie de l'urètre. Presse Méd 17:65–72
Thiersch K (1869) Ueber die Entstehungsweise und operative Behandlung der Epispadie. Arch Heilk 10:20–35
Tuffier T (1910) Greffe veineuse pour autoplastie de l'urètre périnéal. Bull Soc Chir 36:589–596
Turner-Warwick RT (1960) A technique for posterior urethroplasty. J Urol 83:416–420
Turner-Warwick RT (1975) One-stage bulbar anastomoses. In: Glenn J (ed) Urological Surgury, 2nd edn. Harper & Row, New York, pp 714–721
Turner-Warwick RT (1977) Complex traumatic posterior urethral stricture. J Urol 118:564–574
Watson EM (1935) Complete rupture of the urethra: a method of repair in delayed cases. J Urol 33:64–69
Zoedler D (1968) Rekonstruktionsverfahren der proximalen Harnröhre. Z Urol 61:20–27

Anatomy and Blood Supply of the Urethra and Penis

J. K.M. Quartey

3.1 Structure of the Penis

The penis is made up of three cylindrical erectile bodies. The pendulous anterior portion hangs from the lower anterior surface of the symphysis pubis. The two dorsolateral corpora cavernosa are fused together, with an incomplete septum dividing them. The third and smaller corpus spongiosum lies in the ventral groove between the corpora cavernosa, and is traversed by the centrally placed urethra. Its distal end is expanded into a conical glans, which is folded dorsally and proximally to cover the ends of the corpora cavernosa and ends in a prominent ridge, the corona. The corona passes laterally and then curves distally to meet in a V ventrally and anterior to the frenulum, a fold of skin just proximal to the external urethral meatus.

The erectile tissue of the corpora cavernosa is made up of blood spaces lined by endothelium enclosed in a tough fibroelastic covering, the tunica albuginea. The corpus spongiosum is smaller with a much thinner tunica albuginea, and its erectile tissue surrounds the urethra.

Proximally, at the base of the pendulous penis, the corpora cavernosa separate to become the crura, which are attached to the inferomedial margins of the pubic arch and adjoining inferior surface of the urogenital diaphragm. The corpus spongiosum becomes expanded into the bulb, which is adherent in the midline to the inferior surface of the urogenital diaphragm. This is the fixed part of the penis, and is known as the root of the penis. The urethra runs in the dorsal part of the bulb and makes an almost right-angled bend to pass superiorly through the urogenital diaphragm to become the membranous urethra.

3.2 Deep Fascia (Buck's)

The deep fascia penis (Buck's) binds the three bodies together in the pendulous portion of the penis, splitting ventrally to ensheathe the corpus spongiosum, and is closely adherent to the tunica albuginea. Distally, it is attached to the coronal groove. Proximally, it covers the crura and bulb with their overlying corpora cavernosus and corpus spongiosus muscles. At the junction of the pendulous and fixed parts of the penis, the suspensory ligament, a thickened sling of the deep fascia from the lower anterior and inferior margin of the symphysis pubis supports the penis. In the dorsal groove between the corpora cavernosa lie the deep dorsal median vein(s) and its tributaries, and on either side the dorsal artery and its branches and the dorsal nerve in that order mediolaterally between the tunica albuginea and Buck's fascia, although in cross-section they appear to be embedded in the deeper layers of Buck's fascia (Fig. 3.1).

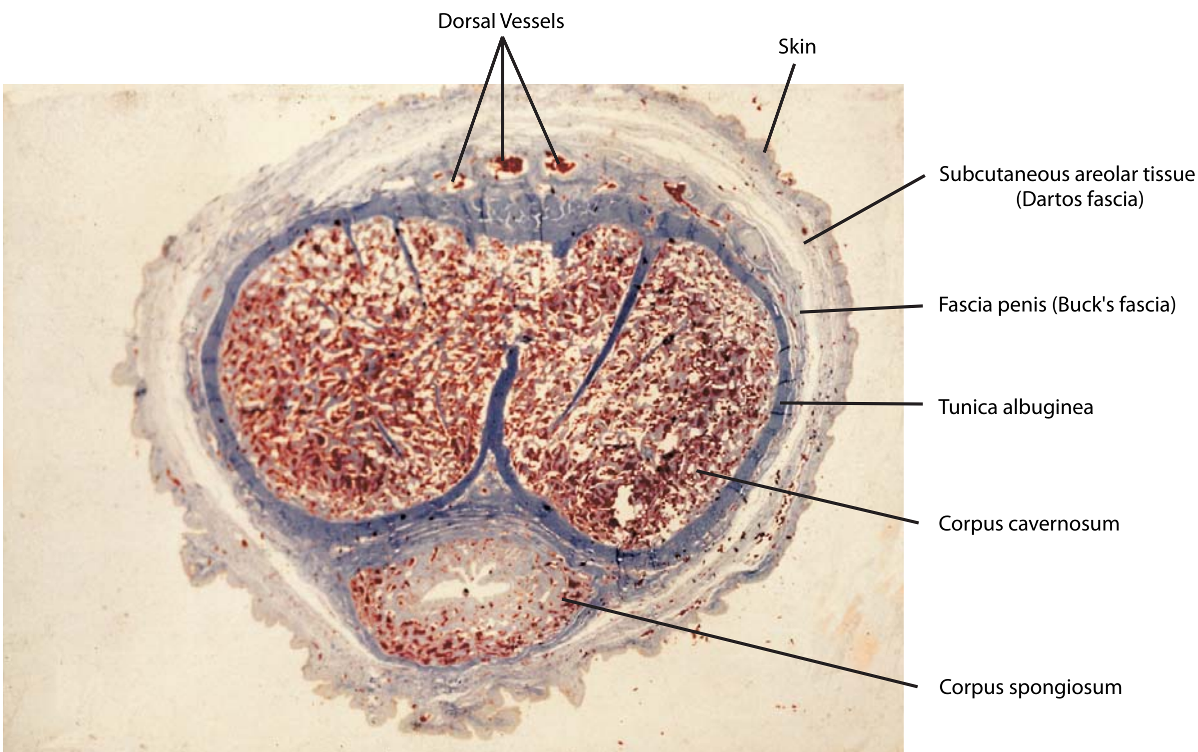

Fig. 3.1. Cross-section of the penis showing the layers

3.3 Subcutaneous Tissue (Dartos Fascia)

A loose areolar subcutaneous tissue, devoid of fat (dartos fascia) surrounds the deep fascia penis and contains the superficial blood vessels, nerves, and lymphatics. It is continuous with the membranous layer of the superficial fascia of the lower abdomen, femoral triangles and scrotum.

3.4 Skin

The skin is the outer covering of the penis and scrotum. It is thin, and the dermis contains smooth muscle fibers, the dartos muscle, to accommodate the wide variation in size between the flaccid and erect penis, and between the shrunken and relaxed state of the scrotum [1, 2]. The dartos muscle is more prominent in the scrotum than in the penis. Distally, the skin is folded inwardly on itself as the prepuce to cover the glans; the inner layer passes proximally to be attached to the coronal groove and to become continuous with the skin of the glans, which is closely adherent directly to the spongy tissue. The loose areolar subcutaneous tissue extends in between the two skin layers of the prepuce. Proximally, at the base of the penis, the inferior part of the skin is expanded into a loose bag, the scrotum, which hangs down from the urogenital diaphragm, contains the testes, epididymes and spermatic cords, and covers the structures in the root of the penis.

3.5 Urethra

The urethra in the male can be divided into penile, bulbous, membranous, and prostatic.

The penile urethra runs through the center of the corpus spongiosum in the pendulous penis. It lies ventrally in the glans to open as a vertical slit just ventral to the tip of the glans.

At the base of the penis, the urethra bends posteriorly and inferiorly as the bulbous urethra, and the erectile tissue is expanded around it to form the bulb with the urethra running in the dorsal aspect. Posteriorly, it pierces the urogenital diaphragm at a right angle to become the membranous urethra.

The membranous urethra is 2–3 cm long, and extends from the upper surface of the urogenital diaphragm to the apex of the prostate. This can be appreciated in urethrograms, at urethroscopy, and at urethroplasty as the distance from the bend at the proximal end of the bulbous urethra to the apex of the prostate. It is surrounded by areolar tissue only. The external urethral sphincter is made up of voluntary muscle fibers, which descend from the outer layers of the bladder and prostate to blend with the outer longitudinal muscle layer of the membranous urethral wall [3] (Fig. 3.2).

The prostatic urethra runs through the prostate and its walls are intimately attached to the prostatic lobes.

3.6 Superficial Arterial Supply

The superficial (superior) and deep (inferior) external pudendal arteries, branches of the first part of the femoral, supply the skin and subcutaneous tissues of the penis and anterior scrotal wall. In most bodies, the deep external pudendal is the dominant artery, but in a small proportion the superficial external pudendal is dominant. They pierce the deep fascia to run in the membranous layer of the superficial fascia across the femoral triangle to the base of the penis. Here they divide into dorsolateral and ventrolateral axial penile branches, which run distally in the subcutaneous tissue to the glans. The axial arteries

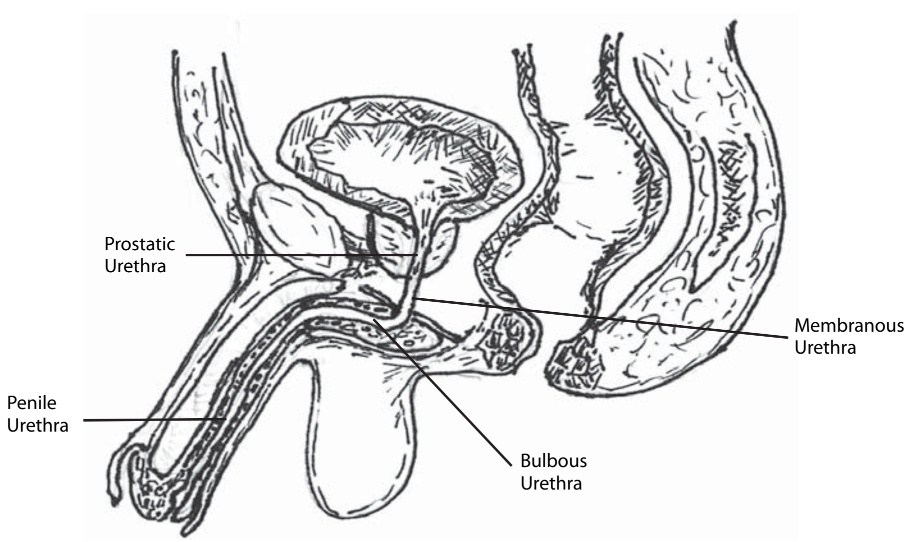

Fig. 3.2. Parts of the urethra

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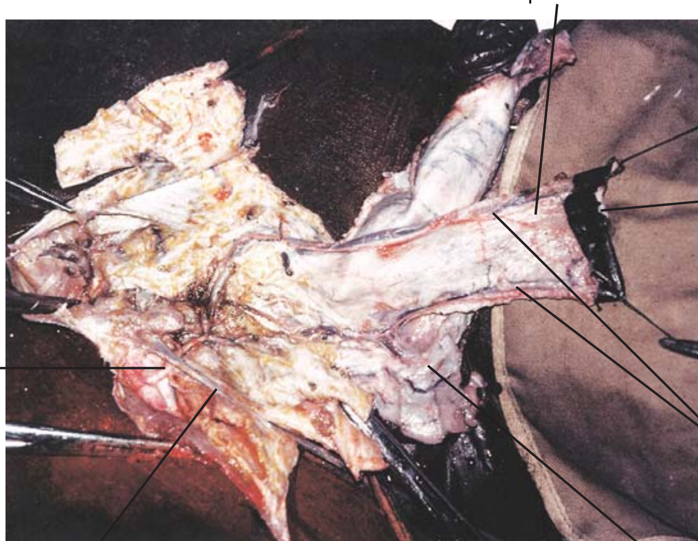


Fig. 3.3. Superficial arterial supply of the penis

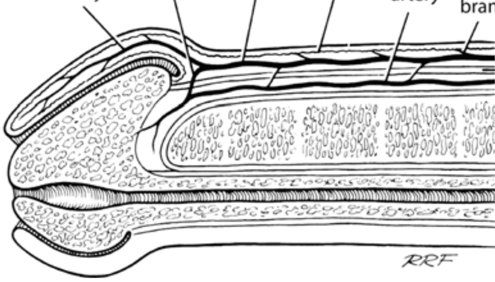


Fig. 3.4. Relationships of subdermal, subcutaneous, and dorsal arterial plexus. (From [7])

give off cutaneous branches at the base of the penis to form a subdermal arterial plexus, which extends distally to the prepuce. The axial arteries together with interconnecting branches form a rich subcutaneous arterial network, which passes distally to the prepuce (Fig. 3.3).

Behind the corona, the axial arteries send perforating branches through Buck's fascia to anastomose with the terminal branches of the dorsal arteries before they end in the glans. The attenuated continuation of the arteries pass into the prepuce. Connections between the subcutaneous arterial plexus and the subdermal arterial plexus are very fine, so that the skin can be dissected off the subcutaneous tissue with little bleeding. Occasional large connections need to be ligated and divided to raise the skin [4, 5] (Fig. 3.4).

3.7 Superficial Venous Drainage

The axial penile arteries are usually accompanied by venae comitantes.

Large communicating veins may originate from within the prepuce or from the retrobalanic venous plexus and then pierce the fascia penis to run in the subcutaneous tissues. They sometimes arise directly from the circumflex or deep dorsal median veins. They may be dorsal, dorsolateral, lateral, or ventrolateral, but converge to end in one or two dorsal median or dorsolateral trunks at the base of the penis.

A subdermal venous plexus extends from the prepuce to the base of the penis, where small venous trunks emerge to join either the communicating veins or the venae comitantes.

The communicating veins end in a variable manner. They may end in one saphenous vein, usually the left just before it enters the femoral, or they may divide and the branches join the corresponding long saphenous vein. The communicating veins or the venae comitantes may end directly in the femoral vein (Fig. 3.5).

3.8 Planes of Cleavage

There are definite planes of cleavage between the skin and loose areolar subcutaneous tissue, and between the subcutaneous tissue and fascia penis (Buck's). This makes it possible to easily dissect the skin off the subcutaneous tissue, and the subcutaneous tissue off Buck's fascia to form

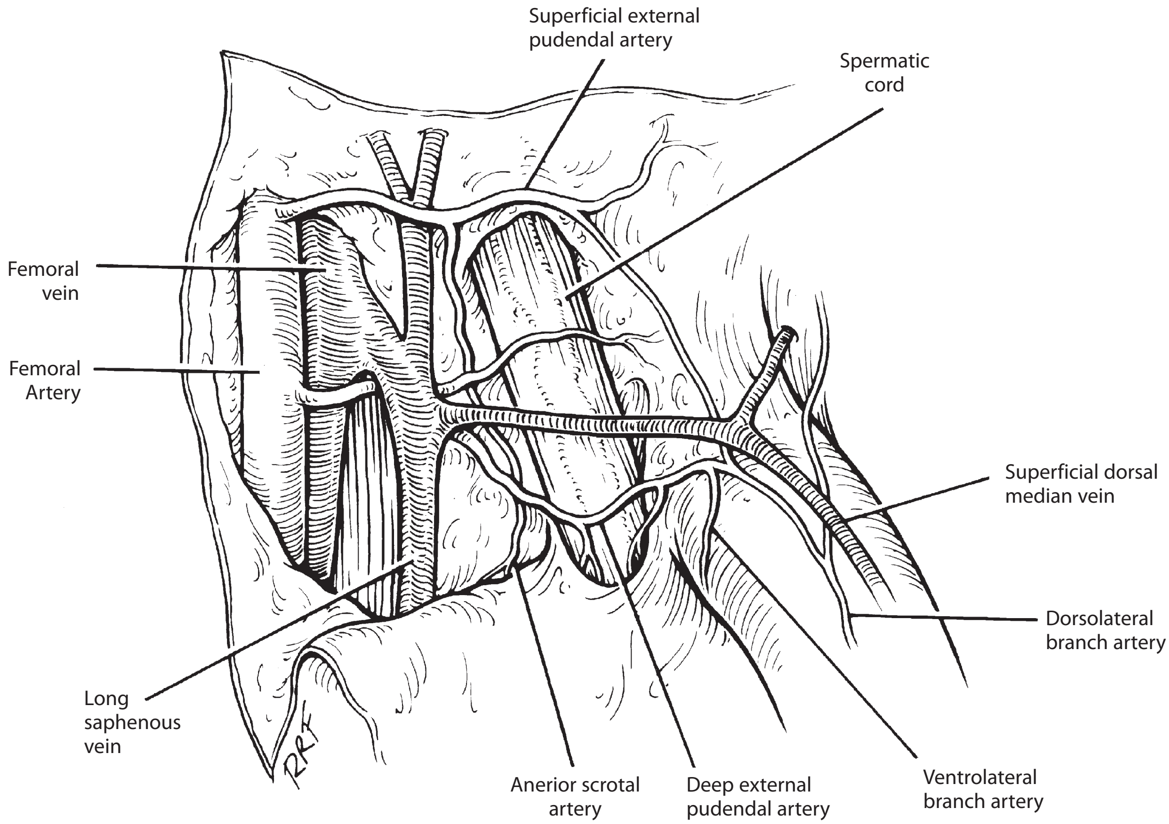


Fig. 3.5. Termination of the superficial dorsal median vein. (From [8])

a rich vascular subcutaneous pedicle nourishing a distal penile or preputial island of skin for urethral reconstruction [4, 5] (Figs. 3.1, 3.3).

There is no easy plane of cleavage between Buck's fascia and the tunica albuginea. Careful dissection is required to raise Buck's fascia off the tunica albuginea to avoid damage to the dorsal neurovascular bundle in operations for Peyronie's disease, venogenic impotence, and curvatures of the penis.

3.9 Deep Arterial System

The deeper structures of the penis and perineum get their arterial blood supply from the internal pudendal arteries. On each side, after exiting from Alcock's canal, the internal pudendal passes forward to the posterolateral corner of the urogenital diaphragm. Here it gives off the perineal artery, which pierces the urogenital diaphragm and deep fascia (Buck's), runs forward in the superficial fascia between the ischiocavernosus and bulbospongiosus muscles, and ends as the posterior scrotal artery (Fig. 3.6).

The internal pudendal next gives off the bulbar artery, which pierces the urogenital diaphragm and bulbospon-

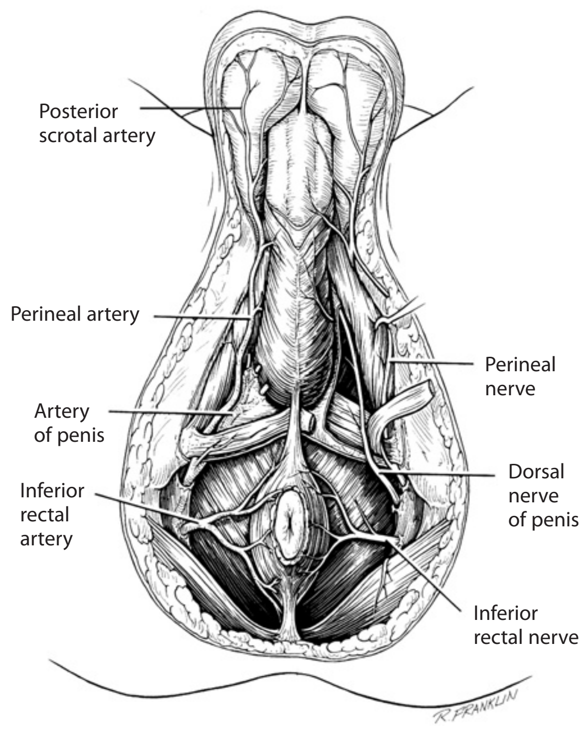


Fig. 3.6. Diagram of perineum illustrating on the left the arterial branches-perineal and posterior scrotal. (From [9])

giosus muscle to enter the base of the bulb, and slightly more distally the urethral artery to enter the bulb close to the bulbar. These two arteries anastomose or may share a common trunk, and continue along the side of the penile urethra to end by anastomosing in the glans with the branches of the dorsal artery (Fig. 3.7).

The internal pudendal artery finally divides into two terminal branches, the cavernosal and dorsal arteries. The cavernosal artery runs along the superomedial aspect of the crus, pierces the tunica albuginea in the hilum of the penis just before the two crura unite, and runs distally in the center of the corpus cavernosum. The dorsal artery continues dorsally in the hilum to gain the dorsum of the corpus cavernosum and runs distally lateral to the deep dorsal median vein and medial to the dorsal nerve. At intervals along the distal two-thirds of the penile shaft, it gives off four to eight circumflex branches, which pass coronally and ventrally round the sides of the penis, giving perforating branches to the tunica albuginea and terminal branches to anastomose with the urethral artery in the corpus spongiosum. The dorsal artery terminates in the glans.

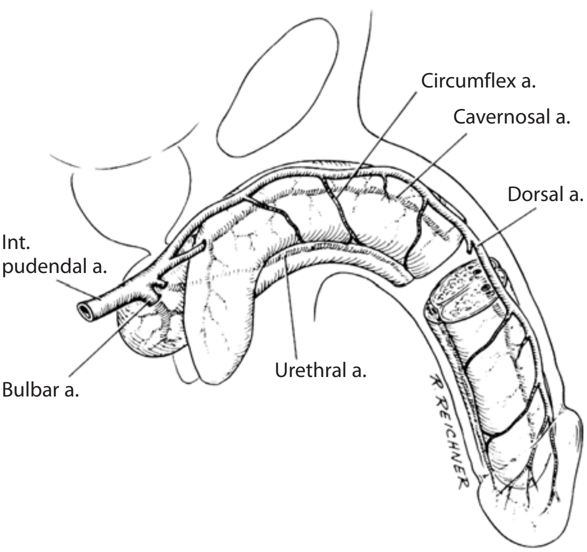


Fig. 3.7. A longitudinal view of the penis showing the deep arterial blood supply. (From [10])

3.10 Intermediate Venous System

Tributaries from the glans penis coalesce to form a retrobalanic venous plexus between the glans and the ends of the corpora cavernosa. From this plexus usually one and occasionally two or more deep dorsal median veins run proximally in the dorsal groove of the corpora cavernosa deep to Buck's fascia. At the base of the penis, where the corpora cavernosa separate into the crura, the vein(s) pass below the symphysis pubis to end in the periprostatic plexus of Santorini. Along the shaft of the penis, it receives the circumflex vein tributaries and direct emissary veins from the corpora cavernosa. Occasionally it receives tributaries from the superficial dorsal median or other superficial communicating veins, or these veins may arise de novo from it.

Emissary veins from the ventrolateral parts of the corpora cavernosa are joined by small tributary veins from the venae comitantes of the urethral arteries to form the circumflex veins, which usually accompany the circumflex arteries. The circumflex veins receive other emissary veins as they pass round the sides of the cavernosa, deep to the dorsal nerves and arteries and join the deep dorsal median vein(s) (Fig. 3.8).

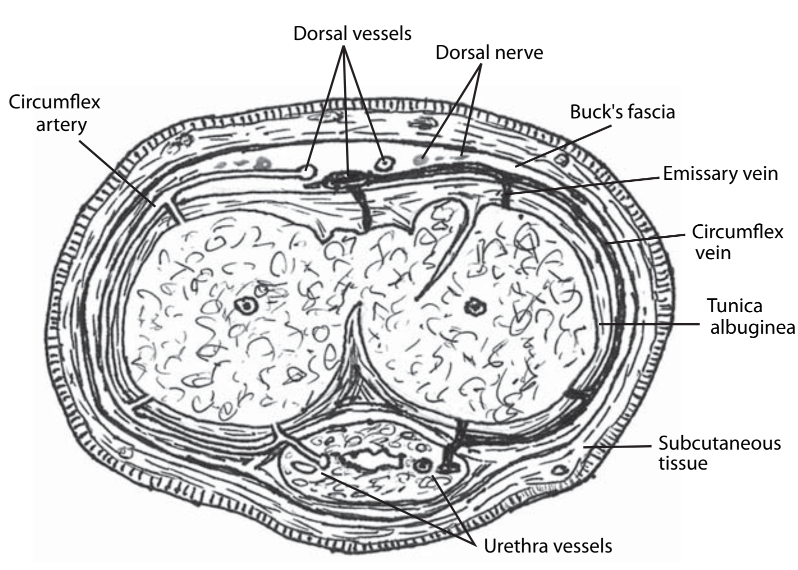


Fig. 3.8. Cross-section of penis showing the dorsal neurovascular structures and disposition of the circumflex artery and vein

Occasionally the circumflex veins receive tributaries from the communicating veins in the subcutaneous tissue, or these veins may arise de novo from the circumflex veins.

3.11 Deep Venous System

Sinusoidal veins empty into veins that run between the spongy tissue of the corpora cavernosa and the tunica albuginea, pass through the tunica as emissary veins in the proximal third of the penis and join to form two to five large, thin-walled cavernous veins on the dorsomedial surface of the cavernosa in the hilum of the penis.[6] They run posteriorly between the crus and the bulb deep to Buck's fascia and drain into the internal pudendal vein. Some cavernosal veins may drain directly into the deep dorsal median vein or the periprostatic plexus. Veins from the anterior part of the crus join the cavernosal veins. Veins from the posterior part of the crus may form crural veins, which exit from the posterolateral surface of the crus to join the internal pudendal vein (Fig. 3.9).

The urethral veins accompany the urethral arteries along the length of the urethra to the bulb to exit independently by the side of its artery, or to join the veins from the bulb to form a common urethrobulbar vein(s). These urethral and bulbar veins drain into the internal pudendal veins. The internal pudendal vein passes posteriorly and through Alcock's canal to empty into the internal iliac vein.

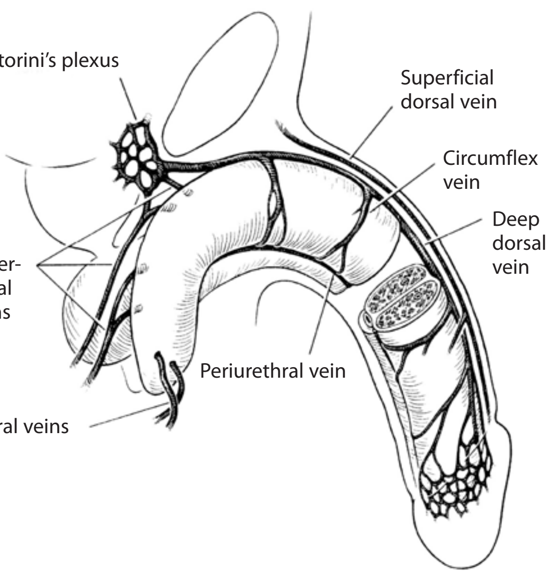


Fig. 3.9. Diagram illustrating the deep venous drainage of the penis. (From [11])

References

1. Amenta PS (1987) Elias-Pauly's histology and human micro-anatomy. Piccin, Padua. pp 473–476
2. Martini FH, Timmons MJ (1995) Human anatomy. Englewood Cliffs, NJ, Prentice Hall, pp 689–696
3. Oelrich TM (1980) The urethral sphincter in the male. Am J Anat 158:229–246
4. Quartey JKM (1983) One-stage penile/preputial cutaneous island flap urethroplasty for urethral stricture: a preliminary report. J Urol 129:284–287
5. Quartey JKM (1992) The anatomy of the blood supply of penile skin and its relevance to reconstructive surgery of the lower urinary and genital tracts. [ChM Thesis] University of Edinburgh
6. Breza J, Aboseif S, Lue T (1993) Anatomy of the penis. In Surgical treatment of erectile dysfunction. Atlas of the Urol Clin North Am (vol 1) p 4
7. Quartey JKM (1997) Microcirculation of penile and scrotal skin. In Resnick MI, Jordan GH (eds) Atlas of the Urol Clin N Am (vol 5), p 4
8. Quartey JKM (1997) Microcirculation of penile and scrotal skin. In Resnick MI, Jordan GH (eds): Atlas of the Urol Clin N Am (vol 5), p 3
9. Devine CJ Jr, Jordan GH, Schlossberg S (1992) Surgery of the penis and urethra. In Walsh PC, Retik AB, Stamey TA et al (eds) Campbell's Urology, 6th edn., vol 3, WB Saunders, Philadelphia, p 2963
10. Horton CE, Stecker JF, Jordan GH(1990) Management of erectile dysfunction, genital reconstruction following trauma, and transsexualism. In: McCarthy JG, May JW, Littler JW (eds): Plastic surgery vol 6. WB Saunders, Philadelphia, p 4215
11. Horton CE, Stecker JF, Jordan GH(1990) Management of erectile dysfunction, genital reconstruction following trauma, and transsexualism. In: McCarthy JG, May JW, Littler JW (eds): Plastic surgery vol 6. WB Saunders, Philadelphia, p 2962

Fundamentals and Principles of Tissue Transfer

G.H. Jordan, K. Rourke

Genitourinary reconstructive surgery often requires transfer of tissue from a donor to a recipient site. Techniques of tissue transfer in reconstructive urologic surgery require knowledge of donor and recipient tissue composition and physical characteristics and principles of tissue transfer – topics that are addressed in this chapter.

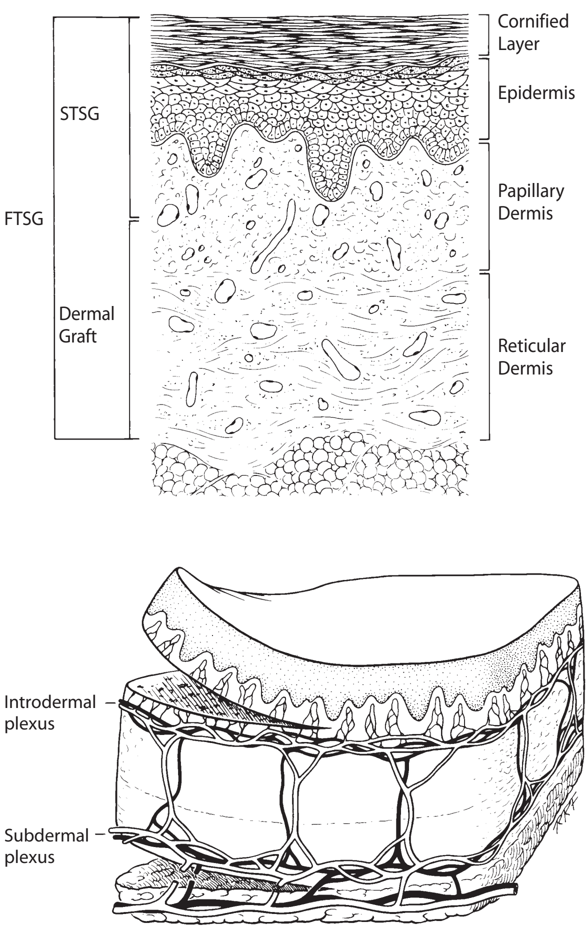
4.1 Tissue Composition and Physical Characteristics

The three types of tissue frequently used for urethral reconstruction are skin, bladder epithelium, and buccal mucosa [1]. This chapter will focus on these transferred tissues; however, the basic principles apply to all donor and transfer situations.

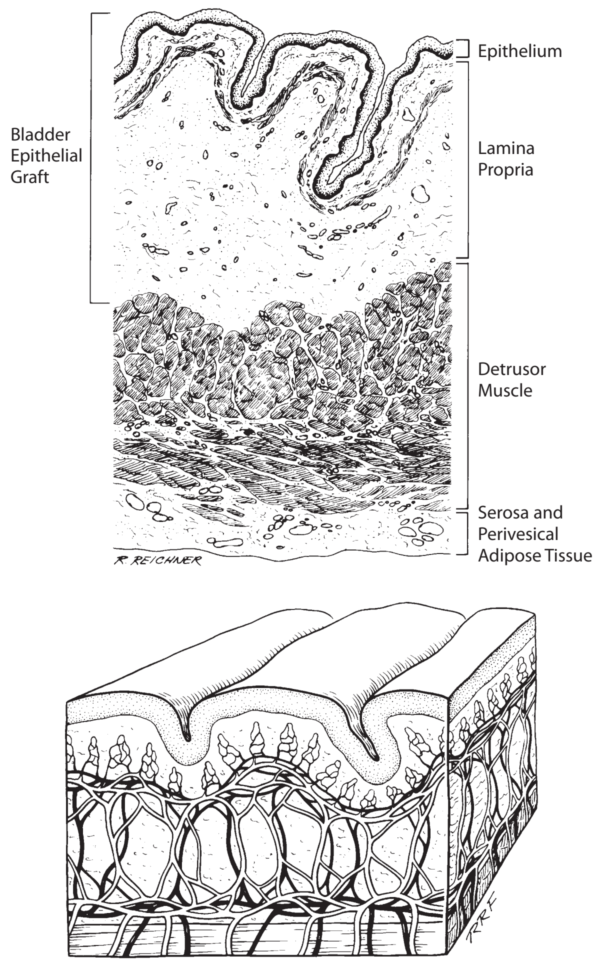
4.1.1 Tissue Composition

The superficial layer of the skin, the epidermis, is 0.8–1.0 mm deep (◘ Fig. 4.1). The deep layer of the skin, the dermis, is separated into two layers. The superficial dermal layer, the adventitial dermis, is also called the papillary dermis in areas without skin adnexal structures, and the periadnexal dermis in areas with adnexal structures. The deep dermal layer is called the reticular dermis.

The superficial layer of the bladder wall lining is the epithelial layer and the deep layer of the bladder wall lining is the lamina propria (◘ Fig. 4.2). Similar to skin, the bladder lamina propria also has a superficial and deep layer. The contraction characteristics of a bladder epithelial graft appear to be similar to those of full-thickness skin, and although formation of diverticula in bladder epithelial grafts is a concern, proper graft tailoring can prevent this complication.



◘ **Fig. 4.1.** Cross-sectional diagram of the skin (histology *above*, microvasculature *below*), illustrating graft levels and the epidermal-dermal anatomy. Note the layered microvascular plexuses (intradermal and subdermal). (From: 12, 13)



◘ **Fig. 4.2.** Cross-sectional anatomy of the bladder epithelium (histology *above*, microvascular anatomy *below*). The graft is harvested at the interface of the detrusor muscle and the lamina propria. An abundance of perforators exist between the deep and superficial laminar plexuses. (From [13, 14])

The superficial layer of the buccal tissue is the mucosal layer and the deep layer is referred to as the lamina propria (Fig. 4.3). As in the bladder, the buccal lamina propria has superficial and deep layers. Unlike split thickness skin, which contracts significantly in unsupported tissues, the contraction characteristics of the buccal mucosal graft appear to be similar to those of full-thickness skin, even with only a portion of the deep lamina included in the harvest.

4.1.2 Vascularity

The interface of the epidermal or epithelial layer with the superficial dermis or superficial lamina contains the superficial plexus (e.g., in skin, the intradermal plexus) and some lymphatics. The deep dermal layer, or lamina, contains most of the lymphatics and the majority of the collagen content, as compared with the superficial layers. The deep plexus (e.g., in skin, the subdermal plexus) is located at the interface of the deep dermal layer and underlying tissue and, in most cases, is connected via perforators to the superficial plexus (Fig. 4.1). The microvasculature of the bladder epithelium is similar to skin in that it consists of two plexuses: a deep laminar plexus and a superficial laminar plexus (Fig. 4.2). In contrast to the layered distribution found in the skin and bladder, the microvasculature of the lamina propria in the buccal mucosa is distributed uniformly, which allows it to be harvested at various levels without affecting the vascular characteristics of the graft (Fig. 4.3).

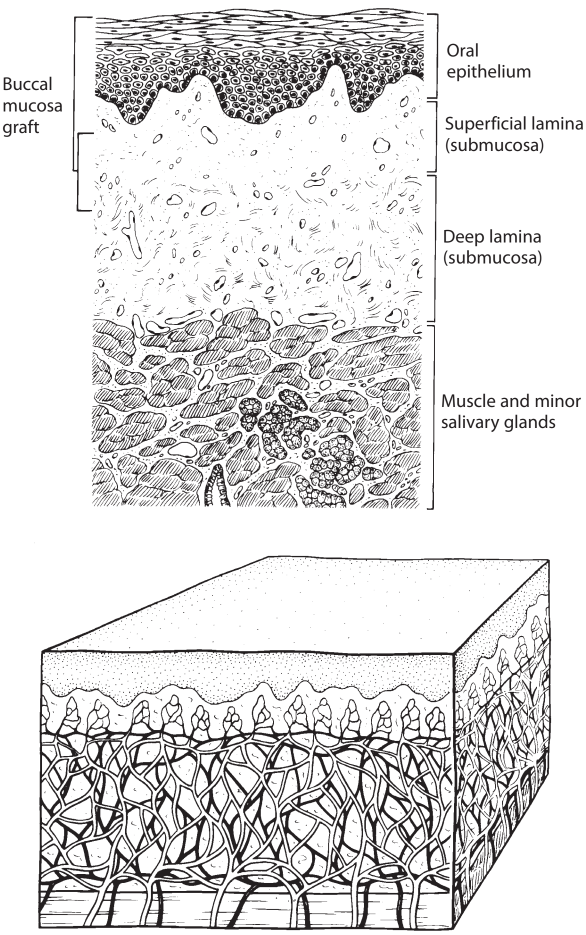


Fig. 4.3. Cross-sectional anatomy of the buccal mucosa (histology *above*, microvascular anatomy *below*). Note the panlaminar vascular plexus. (From [13, 14])

4.1.3 Tissue Characteristics

All tissue has inherent physical characteristics. Extensibility and innate tissue tension are primarily a function of the helical arrangement of collagen and elastin cross-links in the deep tissue layers. Extensibility relates to the tissue's ability to distend, while innate tissue tension relates to the static forces present in nondistended or distracted tissue. The vesicoelastic properties of stress relaxation and creep are influenced by the collagen-elastin architecture and the interaction with the mucopolysaccharide matrix in which it is suspended. The vesicoelastic property creep describes the ability of skin to gradually stretch when a constant unchanging load is applied (Fig. 4.4). Stress relaxation, in contrast, is the gradual decrease in tension occurring over time when skin is stretched at a constant distance (Fig. 4.5).

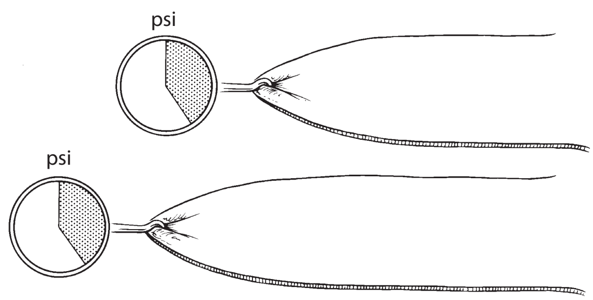


Fig. 4.4. Example of the vesicoelastic property termed creep. (From [15])

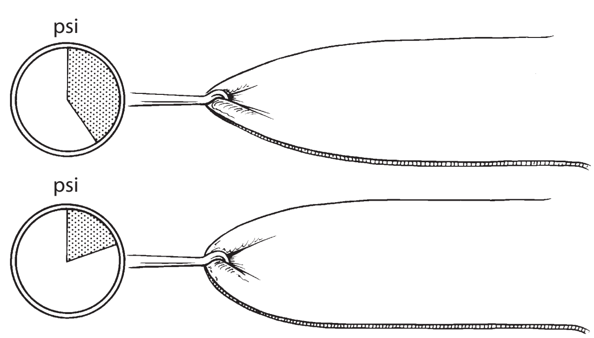


Fig. 4.5. Example of stress relaxation, another skin property. (From [15])

In cases where tissue transfer is required for urethral reconstruction, nonhirsute full-thickness skin or, recently, a buccal mucosa graft is preferred. Bladder epithelium may be used as a substitute when other tissue is unavailable.

4.2 Tissue Transfer Techniques

Tissue can be transferred as a graft or a flap. Tissue that has been excised and transferred to a recipient (graft host) bed where a new blood supply develops is termed a graft. Tissue that is excised and transferred with its blood supply either preserved or surgically reestablished at the recipient site is termed a flap.

4.2.1 Grafts

Neovascularization is the development of a new blood supply and »take« is the term applied to the process whereby graft tissue undergoes neovascularization after excision and transfer to a recipient (graft host) bed. Take occurs in two phases that together require approximately 96 h. During the initial phase, called imbibition (approximately 48 h), the graft temperature is lower than the core body temperature and the graft survives by taking up nutrients from the adjacent graft host bed. During the second phase, termed inosculation (approximately 48 h), the graft temperature rises to core body temperature and true microcirculation is reestablished in the graft. The process of take is influenced by both the nature of the grafted tissue and the conditions of the graft host bed. Processes that interfere with the graft or host bed vascularity (e.g., infection or a subgraft collection) can interfere with graft take.

4.2.1.1 Graft Classifications

Four grafts commonly used for genital reconstruction are the split thickness skin graft (STSG), full-thickness skin graft (FTSG), bladder epithelial graft, and buccal mucosal graft. A STSG carries the epidermis or covering and exposes the superficial dermal (intradermal) plexus (▪ Fig. 4.1). Because the superficial plexus has numerous small vessels, a STSG has favorable vascular characteristics; however, because it »carries« few physical characteristics of the transferred tissue, it has a tendency to be brittle and less durable. However, because the STSG does not include most of the lymphatics, it is useful in cases of reconstruction for lymphedema.

A mesh graft is a STSG with systematic slits placed in it after harvest and before application. The slits can expand the graft by various ratios, allowing subgraft collections to escape and allowing better conformation to irregular graft host beds. It has also been proposed that the slits increase growth factors, causing a mesh graft to take more readily. Although FTSGs can be meshed, they rarely are; exceptions are preputial or penile skin. Expanded buccal mucosa grafts have been evaluated in the animal model but no clinical application has been undertaken to date.

A FTSG carries the covering (epidermis), the superficial dermis and the deep dermis. Its vascular characteristics are more fastidious than that of a STSG because the deeper plexus is composed of larger, more sparsely distributed vessels (▪ Fig. 4.1). However, because a FTSG »carries« most of the physical characteristics of the transferred tissue, it is typically more durable at maturity and does not contract as much as a STSG. Because the lymphatics are usually associated with the deep layer, they are included with a FTSG. On the other hand, although these are general characteristics of FTSGs, because FTSGs carry characteristics of the transferred tissue, each graft has distinctive characteristics that are dependent on the donor site. For example, extragenital FTSGs have increased mass, which generally makes them more fastidious than genital FTSGs (i.e., penile and preputial skin grafts). However, an exception is found in the extragenital skin of the posterior auricular area, which has thin skin overlying the temporalis fascia. The full-thickness postauricular graft (Wolffe graft) is carried on numerous perforators. The subdermal plexus of the Wolfe graft therefore appears to mimic the characteristics of the intradermal plexus, while its total mass is more like that of a STSG.

A bladder epithelial graft has superficial and deep plexuses that are connected by many perforators, and therefore it tends to have favorable vascular characteristics (▪ Fig. 4.2). A buccal mucosal graft has a panlaminar plexus (▪ Fig. 4.3), which is reputed to provide optimal vascular characteristics; when sufficient deep lamina is carried with the graft to preserve the physical characteristics of the buccal mucosa, it can be thinned without seemingly adversely affecting the graft's vascular characteristics. Moreover, in recent times, the wet epithelial surface of the buccal mucosal graft is considered to be favorable for urethral reconstruction; therefore a buccal mucosal graft may often be preferred.

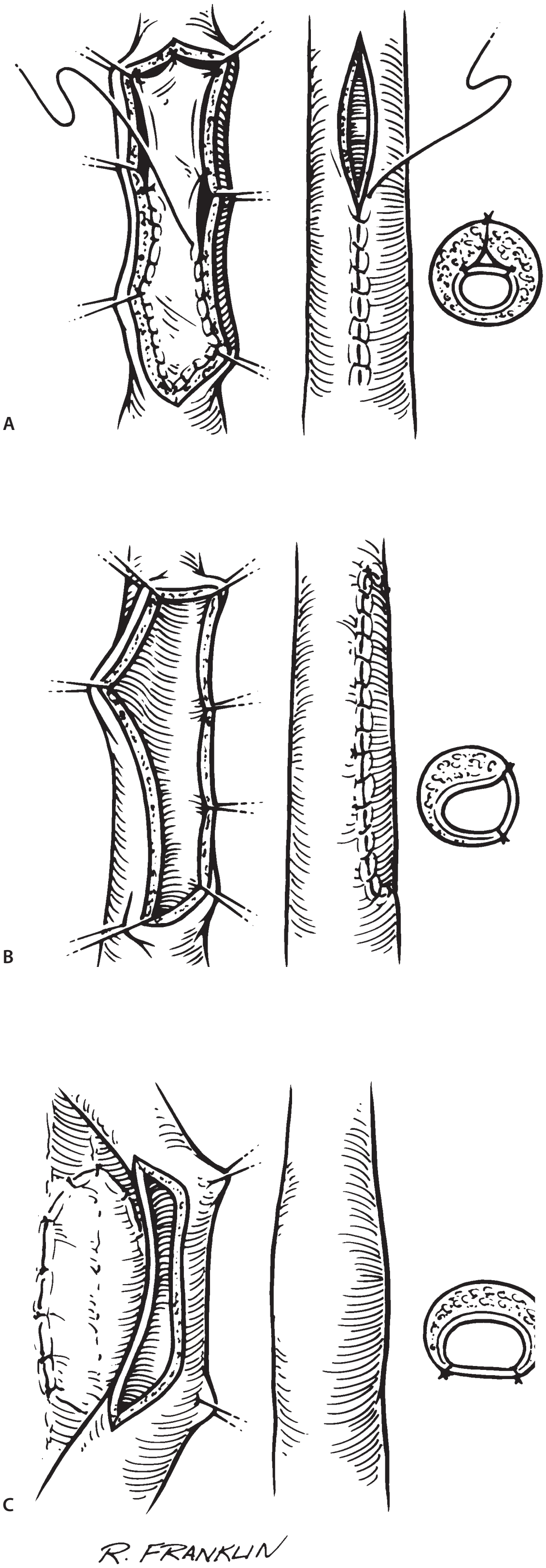
4.2.1.2 Use of Grafts for Excision and Tissue Transfer in Urethral Reconstruction

There has been a recent resurgence of interest in graft reconstruction of the urethra, especially using buccal mucosal grafts. The most successful use of grafts has been in the area of the bulbous urethra, where the urethra is invested by the ischial cavernosus musculature. Although the graft can be applied to the urethral ventrum, a ventral urethrotomy only appears to be advantageous when spongioplasty is also used (Fig. 4.6A). However, spongioplasty requires that the corpus spongiosum be relatively normal and free of fibrosis adjacent to the stricture. A lateral urethrostomy or dorsal graft onlay, in our opinion, are preferred. Placing the urethrostomy laterally allows exposure of the urethra while cutting through the corpus spongiosum where it is relatively thinner, limiting bleeding and maximizing exposure (Fig. 4.6B). This can be quite useful with flaps, but with the recent experience with dorsal graft onlay, probably provides little advantage to dorsal graft onlay.

The Monseur urethral reconstruction technique, alternately used in a few centers, creates the urethrostomy through the dorsal wall of the stricture, with the edges of the stricture sutured open to the underlying triangular ligament and/or corpora cavernosa [2]. Barbagli described a modification of this technique in which the urethrostomy is created through the stricture on the dorsal wall with a graft then applied as an onlay [3]. The graft is fixed to the area of the urethrostomy at the triangular ligament and/or corpora cavernosa and the edges of the stricture are sutured to the edges of the graft and adjacent structures (Fig. 4.6C). Series with relatively short follow-up have yielded excellent results with this modification [4–6]. The dorsal graft onlay technique can also be used in combination with partial stricture excision and floor-strip anastomosis (i.e., augmented anastomotic procedure).

Two-staged application of a mesh STSG, buccal mucosa graft, or posterior auricular FTSG is another option. A medium split thickness skin graft or other full thickness graft as indicated above are placed over the dartos fascia in the first stage of the mesh graft procedure (Fig. 4.7); however, when placed immediately onto the tunica albuginea or corpora cavernosa, the graft cannot be mobilized and second-stage tubularization is difficult. Having at least a midline strip of the graft adhered to the corpora cavernosa, though, supports the urethra. The graft is tubularized in second-stage surgery performed at a later date (Fig. 4.8). When the STSG procedure was first introduced, second-stage surgery was performed within 3–4 months of the first stage [7]; we now wait 6–12 months between first- and second-stage surgeries. It appears advantageous to wait at least 1 year with a STSG while the buccal mucosa grafts and postauricular grafts seem to mature at 6 months. This procedure has been useful for select cases in the United States and Europe; however, it has only been used for the most difficult cases in the United States, with single-stage reconstruction applied to most.

The staged buccal mucosa is a relatively new concept. The graft does very well when used in staged fashion, and the staged buccal graft technique may be the salvation for reconstruction of urethral strictures associated with



A
B
C

Fig. 4.6A–C. Diagram of various techniques of graft onlay. **A** Ventral onlay with spongioplasty. **B** Lateral onlay with quilting to the ischial cavernosus muscle. **C** Dorsal onlay with spread fixation of the graft. (From [13])

BXO. Because BXO is a skin condition, the use of skin, either as a flap, single-stage graft, or staged graft, does not preclude later BXO inflammatory involvement. It is therefore now hypothesized that staged buccal graft techniques should be used for reconstruction of strictures associated with BXO [8]. Preliminary results at our center have definitely demonstrated skin transfer techniques are less successful (i.e., 50%–60%) compared to non-BXO associated strictures. However, buccal mucosa transfer for treatment of strictures associated with BXO is a relatively new concept.

4.2.2 Flaps

4.2.2.1 Flap Classification

Flaps can be classified either by their vascularity or their elevation techniques.

Flap classification based on vascularity includes random and axial flaps [9]. A random flap (Fig. 4.9) does not have a defined cuticular vascular territory; it is carried on the dermal plexuses and its dimensions can vary greatly between individuals and body sites. An axial flap (Fig. 4.10) has a defined vessel in its base.

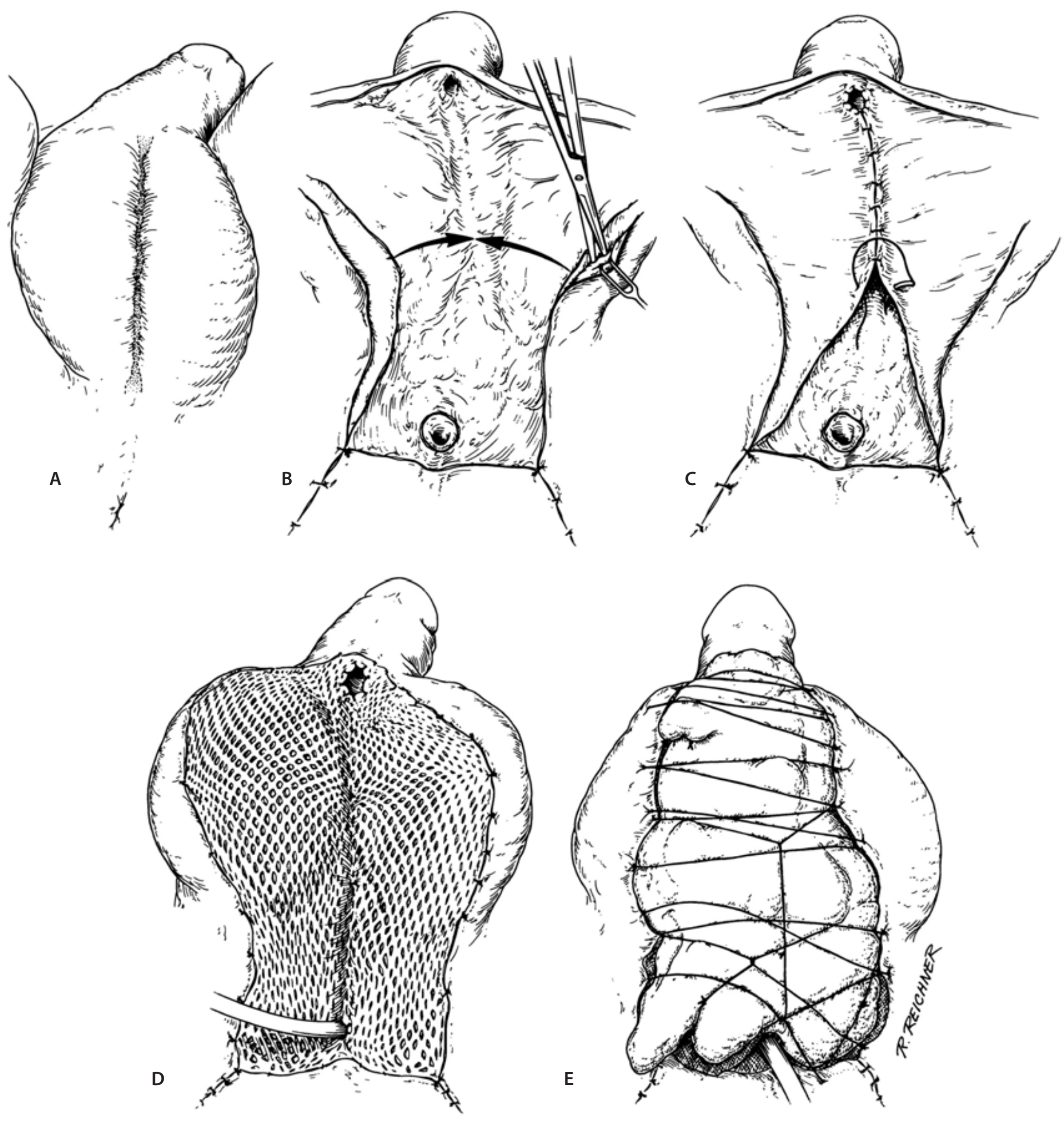


Fig. 4.7A–E. Illustration of the first-stage mesh graft urethroplasty (as described by Schreiter et al.) when all available tissue has been expended. Principles apply to all staged graft techniques. **A** Strictured urethra is either completely excised or a dorsal strip of epithelium is left. **B** Dartos fascia is mobilized to the midline. **C** Dartos fascia is used to cover tunica albuginea and scar with vascularized tissue. **D** A split-thickness skin graft is harvested, meshed with a carrier using a 1:5:1 ratio, and placed on the site of the excised urethra. If a roof strip is left, the epithelium of the urethra is sewn to the graft. **E** Graft is covered with a bolster dressing and secured in place with tie-over sutures. A Foley catheter is left in the proximal urethrostomy. (From [16])

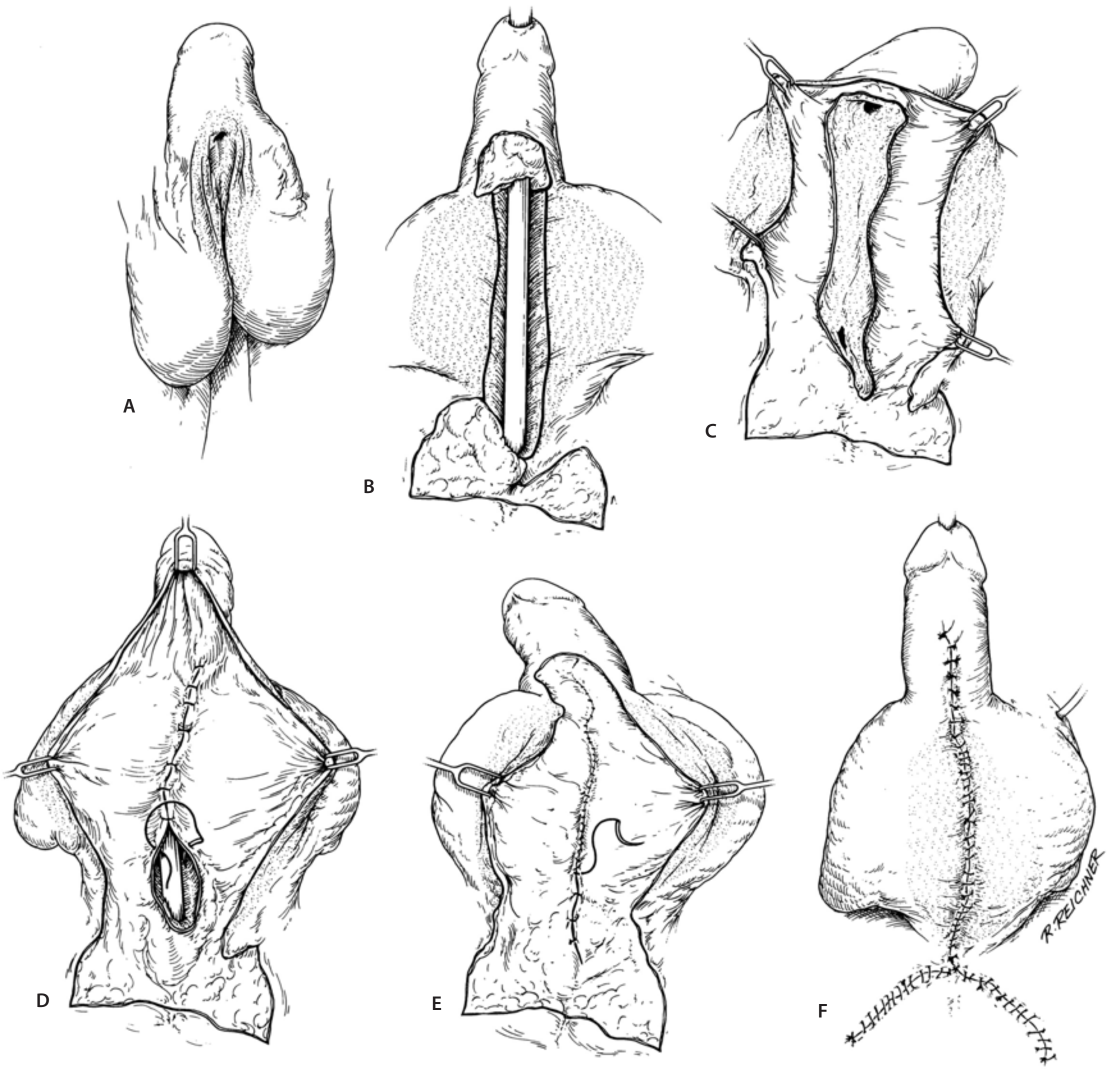


Fig. 4.8A–F. Second-stage mesh graft urethroplasty (as described by Schreiter et al.). Principles apply to all graft staged procedures. **A** New epithelial surface is smooth and elastic by 6–12 months (12 months in the case of a meshed split-thickness skin graft), and the patient is brought back to the operating room at 1 year. **B** A 2.8- to 3-cm-wide neourethra is marked to outline the new urethra. **C** Dissection is carried out laterally to mobilize the remaining skin graft and scrotal skin without undermining the strip. **D** Interrupted sutures are placed to approximate the epithelial edges. **E** Running subepithelial monofilament absorbable suture is placed to make the suture line watertight. **F** Skin is closed and urine is diverted with a suprapubic catheter. (From [16])

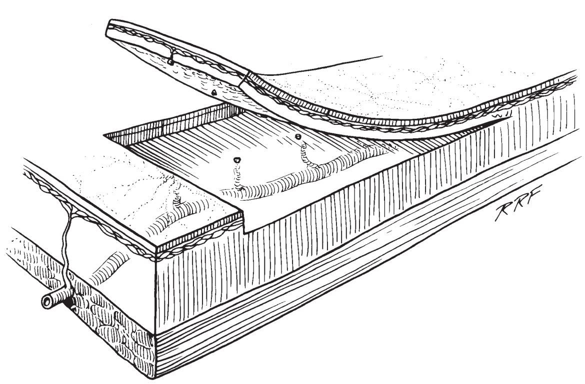


Fig. 4.9. A random cuticular flap. Note that flap survival depends solely on the dermal plexuses. (From [14])

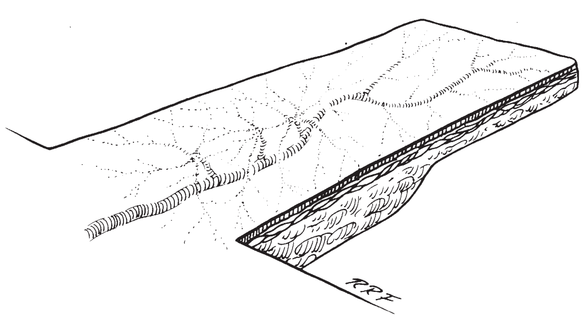
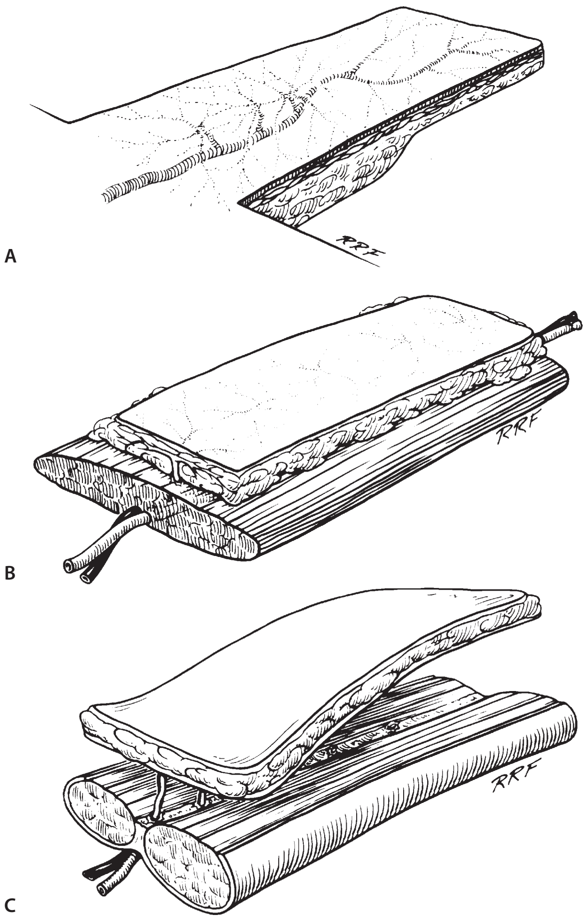


Fig. 4.10. An axial flap. Note that a defined vessel supplies a specific territory within the flap. (From [14])



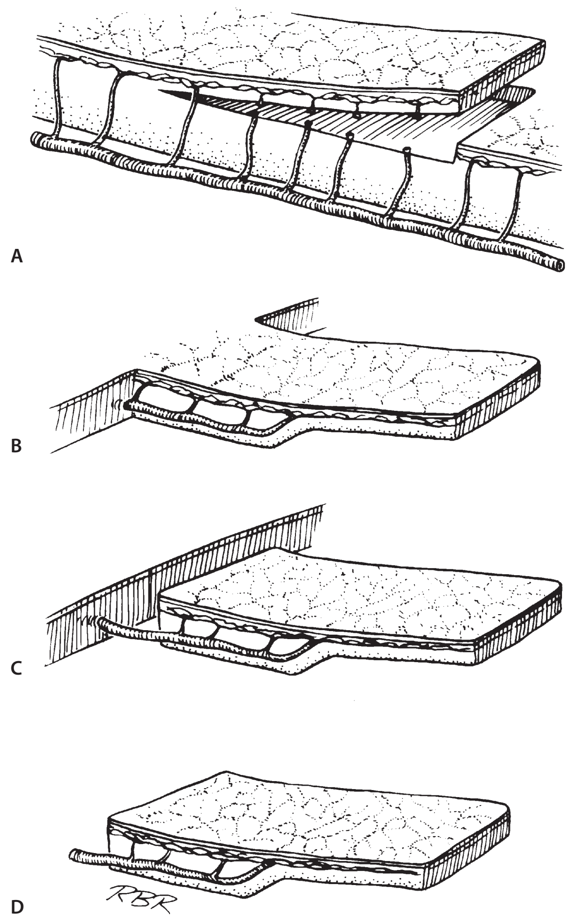


Fig. 4.11A–C. Axial flaps. **A** The direct cuticular flap. Supplied by a defined vessel superior to the superficial lamina of the deep fascia. The groin flap is such an example. **B** The musculocutaneous flap. Perforators from the artery to a muscle vascularize the skin and overlying subcutaneous fat via musculocutaneous perforators. **C** The fasciocutaneous flap. Perforating blood vessels from the superficial and deep aspects of the fascia connect to perforator vessels that communicate with the microvasculature. Examples of these flaps in urethral reconstruction are the penile cutaneous island flap based on dartos fascia and the microvascular »free« transfer flap of the forearm. (**A** from [14], **B, C** from [17])

Fig. 4.12A–D. Flaps classified by elevation techniques. **A** Random peninsula flap. **B** Axial peninsula flap. **C** Axial island flap. **D** Microvascular free transfer flap (free flap). (From [17])

Axial direct cuticular, musculocutaneous, and fasciocutaneous are the three general types of axial flaps (Fig. 4.11). A direct cuticular axial flap is based on a vessel superficial to the superficial layer of the deep body wall fascia (e.g., groin flap) (Fig. 4.11A). A musculocutaneous flap (Fig. 4.11B) is based on the vessel to the muscle, with the overlying skin paddle or island carried on perforators; the overlying skin survives as a random unit if the muscle alone is carried as a flap. The deep blood supply of a fasciocutaneous flap (Fig. 4.11C) is carried on the deep and superficial layers of the fascia. Like the musculocutaneous system, the overlying skin paddle or island is based on perforators; therefore, a fascial flap can be transferred based on the flap's deep blood supply, and if the skin overlying the fascial pedicle is not carried with the flap, it remains as a random unit.

Flap classifications based on elevation techniques are peninsula, island, or microvascular free transfer flaps. In a peninsula flap (Fig. 4.12A, B), the vascular and cutaneous continuity of the flap base are left intact. In an island flap (Fig. 4.12C), the vascular continuity is maintained while the cuticular continuity is divided; thus, the flap is elevated on dangling vessels. In a microvascular free transfer flap (i.e., free flap), the vascular and cuticular continuity are interrupted and the vascular continuity is reestablished at the recipient site (Fig. 4.12D).

In common usage, the term »island flap« is often used when referring to a skin island or paddle elevated on either a muscle (e.g., gracilis musculocutaneous flap) or fascia (e.g., local genital skin flaps). However, the true island flap described above is not synonymous with the term »skin island« or »skin paddle.« A skin paddle is skin that is carried with a fascial or muscle flap, as if the muscle or fascia is the flap and the overlying adipose and skin are passengers situated on the muscle.

4.2.2.2 Use of Flaps for Excision and Tissue Transfer in Urethral Reconstruction

Genital skin islands, based on either the dartos fascia of the penis or tunica dartos of the scrotum can successfully be used for reconstruction of anterior urethral strictures. A detailed discussion on the use of the flaps in urethral reconstructive surgery is covered elsewhere in this text. In short, three important considerations for the use of flaps in urethral reconstruction are: 1) the nature of the flap tissue, 2) the flap vascularity, and 3) the mechanics of flap transfer. Flap skin should be easily tailored, non-hirsute and are most conveniently configured from an area of natural redundancy. As with reconstruction utilizing grafts, flaps are best employed as an onlay procedure in combination with aggressive excision of select urethral segments (i.e., augmented anastomosis) [10]. When non-hirsute penile skin is unavailable, a non-hirsute or epilated midline scrotal skin island can be used as an alternative to a staged reconstruction, if care is taken to properly tailor the flap based on the underlying tunica dartos.

4.3 Conclusion

When stricture characteristics and patient anatomy precludes reconstruction via the technique of excision and primary anastomosis, tissue transfer is required. Large series utilizing modern tissue transfer techniques have demonstrated excellent outcomes [11]. However, a decline in success is demonstrated over time. The resurgence of graft techniques in urethral reconstruction, particularly the versatile buccal mucosa graft, is encouraging; but like all new concepts, long-term follow-up is required.

References

1. Jordan GH (2002) Plastic surgery for the urologist: tissue transfer, wound healing, and tissue handling. AUA Update Series 13:98–103
2. Monseur J (1980) Widening of the urethra using the supra-urethral layer (author's translation). J Urologie 86:439–449
3. Barbagli G, Selli C, di Cello V, Mottola A (1996) A one-stage dorsal free-graft urethroplasty for bulbar urethral strictures. Br J Urol 78: 929–932
4. Barbagi G, Selli C, Tosto A, Palminteri E (1996) Dorsal free graft urethroplasty. J Urol 155:123–126
5. Andrich DE, Mundy AR (2001) Substitution urethroplasty with buccal mucosal free grafts. J Urol 165:1131–1134
6. Rosenstein DI,, Jordan GH (2002) Dorsal onlay graft urethroplasty using buccal mucosa in bulbous urethral reconstruction. J Urol 167(Suppl):16
7. Schreiter F, Noll F (1989) Mesh graft urethroplasty using split thickness skin graft or foreskin. J Urol 142:1223–1226
8. Venn SN, Mundy AR (1998) Urethroplasty for balanitis xerotica obliterans. Br J Urol 81:735–737
9. Cormack GC, Lambetty BGH (1984) A classification of fascio-cutaneous flaps according to their patterns of vascularization. Br J Plast Surg 37:80–87
10. Duckett JW, Baskin L, Uedio K et al (1993) The onlay island flap hypospadias repair: extended indications. J Urol 149 (Suppl):334
11. Mundy AR (1994) A comparison of urethral reconstruction techniques. Presented at the meeting of the GURS, London, June 21, 1994
12. Jordan GH et al (1988) Tissue transfer techniques for genitourinary reconstructive surgery: AUA updates, lesson 9, vol VII,
13. Walsh PC, Retik AB, Darracott Vaugh E, Wein AJ (eds) (2002) Campbell's urology, 8th edn, Vol 4. Saunders, Philadelphia
14. Jordan GH, Schlossberg SM (1999) Using tissue transfer for urethral reconstruction. Contemp Urol 5:13–24
15. Jordan GH (1993) The applications of tissue transfer techniques in urologic surgery. In: Webster KR, King L, Goldwasser B (eds) Reconstructive Urology. Blackwell Scientific, London
16. Devine CJ, Jordan GH (1990) Stricture of the anterior urethra. Part II. AUA update series, lesson 26, vol. 9
17. Jordan GH et al (1988) Tissue transfer techniques for genitourinary reconstruction. AUA update series, 7, lesson 10

Tissue Engineering – The Future of Urethral Reconstructive Surgery?

K.D. Sievert

5.1 Introduction

The urologist remains challenged by urethral strictures, defects, and injuries. Over 200 surgical techniques have been described for the relief of urethral strictures in order to identify the ideal treatment. A more critical success factor has been the material to use after developing thinner suture materials, which improved the surgical results drastically. Even with the high success rates we have achieved thus far (e.g., good cosmetic results and function), no method guarantees freedom from complications that may occur such as fistula and restricture.

5.2 Body Material

Currently, four preferred kinds of grafts for urethral reconstruction are used: full-thickness skin, split-thickness skin, bladder epithelium, and the buccal mucosa. To harvest full- or split-thickness skin grafts, an area with no or almost no hair growth is required. The method of full- or split-thickness skin graft harvesting may even require a two-stage surgery if the mesh graft technique of is used. One of the best materials, which can provide a one-stage procedure, is the foreskin but this material is limited because many male patients are already circumcised by the time urethral surgery is required.

The bladder epithelium graft requires at least one additional abdominal incision.

Since the late1990s, the buccal mucosal graft is preferred because of its high success rate and the best long-term results reported so far. However, its success very much depends on the skill of the surgeon and the highly specialized knowledge of harvesting the tissue from the mouth.

Many patients do not like the idea of two-stage surgery, multiple incisions, or harvesting tissue from their mouth. Additional procedures can be associated with prolonged hospitalization and even donor side morbidity.

5.3 Synthetic Materials

Synthetic nondegradable materials (silicon, polytetrafluoroethylene, and polyester) have been attempted, but as yet, no full synthetic material has been developed that can meet or exceed the buccal mucosa graft success rates. Most synthetic materials manufactured thus far have caused problems such as erosion or dislodgement. In addition, these materials have not been able to get close to regenerating a normal urethra by having the required substructures such as urothelium, basal membrane, vessels, smooth muscle cell bundles, or even nerves. In addition to these criteria, any material should be biodegradable if synthetic or similar to the replaced tissue, available, and easy to store, similar to any shelf product.

5.3.1 Animal Studies

A variety of animal studies using both natural and manufactured materials have been carried out over the last 10 years. A new chapter of urethral reconstruction began with the use of biodegradable polymers, later seeded with the specific cell of the recipient (for example, urothelium and smooth muscle cells). In this same period, acellular tissues were also used for transplantation. Currently, the fusion of acellular matrices and polymers is used in the technique of tissue engineering.

5.3.2 Synthetic Materials

Olsen et al. and others used synthetic biodegradable polymers such as hydroxyacetic acid [1–3]. They used a fleece that was easy to implant and replaced by host collagen and elastin when the biodegradable fill-in material disappeared. These studies were primarily short-term in nature with limited follow-up and demonstrated re-epithelization without strictures. Olsen et al. did not mention any smooth muscle cell regeneration with a follow-up of more than 1 year [1].

5.3.3 Acellular Tissue

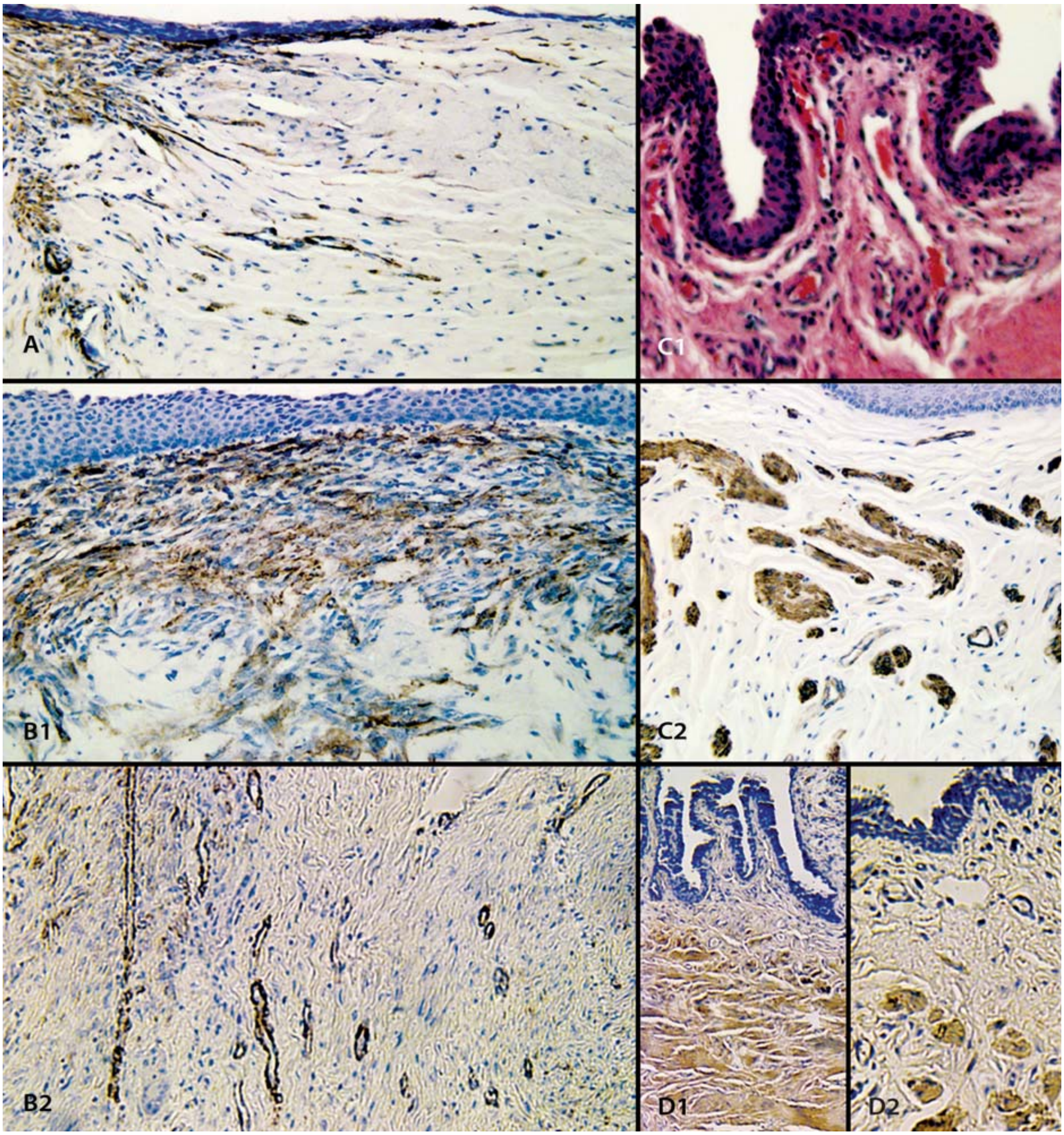
While many groups used fabrics as a synthetic biodegradable fleece sometimes produced as a tube, others started to make a piece of organ tissue acellular (small intestine submucosa [SIS]). This requires that the acellular matrix be free of any antigenicity.

Badylak grafted a vessel of an acellular matrix of SIS [4]. This harvested tissue is made completely acellular by acids and DNAse. It leaves a scaffold of the different types of collagen and elastin without any sign of antigenicity.

In 1992, they successfully replaced a small diameter artery by heterologous SIS in the dog [5] and later the superior vena cava.[6] Endothelium covered the lumen and cells were present in the complete thickness of the transplant smooth muscle [4, 6, 7].

The biocompatibility of heterologous SIS (bovine) in the lower urinary tract was demonstrated by a patch augmentation of the pig bladder with no evidence of inflammatory rejection. In the follow-up, ingrowths of capillaries and smooth muscles were demonstrated. The authors therefore suggested it could be used for bladder augmentation in the dog [8]. Encouraged by this finding and the results of others [9, 10] with an acellular matrix graft, partial urethral replacement was tried by using an acellular tissue of different origin.

The advantages of this approach are a shorter operation time with only one intervention and often a faster recovery. Several groups used unseeded acellular scaffolds of collagen and elastin of different origin such as bowel, bladder, vessel, and the urethra itself as donor tissue [11–14]. Most of them used the on-lay technique, except Sievert et al., who replaced the whole urethra circumference, following up patients for a mean of 6–7 months. In these animal studies, complete luminal multilayer epithelialization, rapid angiogenesis, and smooth muscle cell bundle growth were observed with no signs of rejection or tissue reaction (◘ Fig. 5.1). Retrograde urethrography, the clinical gold standard for surgical follow-up, documented the ongoing regenerative changes and the functional improvement over time. No strictures were noted.



◘ **Fig. 5.1A–D.** Urethral reconstruction in the rabbit with organ-specific urethral acellular matrix (AUM) with follow-up. **A** After 10 days the urothelium starts to covert the AUM and histiocytes infiltrate the matrix. $\mathbf{B_1}$ At 3 weeks, the surface of the matrix is completely covered by irregular urothelium. $\mathbf{B_2}$ At 3 weeks vascularization is seen in the middle of the AUM. $\mathbf{C_1}$ At 3 months, normal surface of the inner lining is seen with vessels and regular urothelium. $\mathbf{C_2}$ At 3 months, smooth muscle cells are detected in the matrix. $\mathbf{D_1}$ At 6 months, the area of the anastomosis is regenerated with smooth muscle; the urothelium is in multilayers. $\mathbf{D_2}$ At 6 months, as detected at month 3, now smooth muscle is seen in the middle of the AUM. (magnification 20×; the staining used is α-actin, except $\mathbf{C_1}$, which is H&E)

Most of the acellular tissues used were heterologous and from different sources. To prove the effect oft the tissue used, Sievert et al. used heterologous urethral acellular matrix (canine to rabbit) to study the differences. Comparing homologous and heterologous urethral acellular matrix, homologous tissue regenerated more completely in the same time frame than heterologous matrix [15].

Parallel to these approaches, Romagnoli et al. seeded cultured urothelium cells to acellular matrices [16]. This approach was later used by Yoo et al. for bladder augmentation [17].

Following the principles of cell transplantation, Yoo et al. used different polymers and seeded them with urothelium and smooth muscle cells to improve regeneration [18]. Today this is known as tissue engineering. Cells needed for tissue engineering are harvested from the future recipient, cultured, and finally seeded to the scaffold. After implantation, the polymer scaffold is replaced by collagen and elastin of the host [19]. The concern of this elegant technique is the cost, and currently, its FDA approval is limited to one university.

As an outlook to the future an acellular scaffold of a small intestine tissue with its vessels would be prepared by tissue engineering [20]. After re-epithelization of the vessels with endothelia, the lumen is seeded with urothelium and the scaffold with smooth muscle cells (Fig. 5.2). This combined with tissue engineered corpora cavernosa [21] might make it possible to regenerate a compete functional penis.

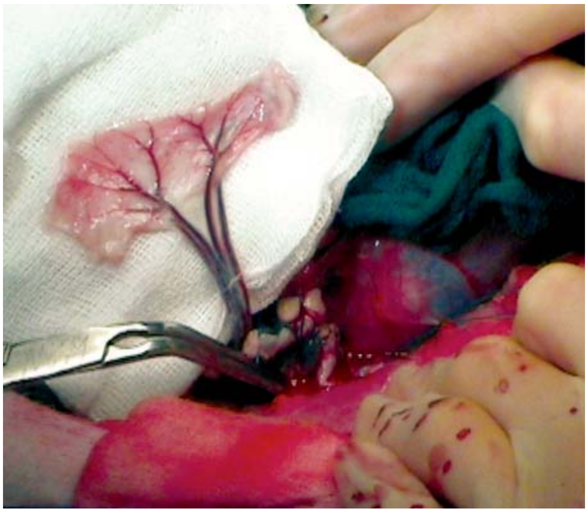


Fig. 5.2. Small intestine made completely acellular in the first step and in the second seeded with urothelium, smooth muscle cells, and epithelium for the vessels in a bioreactor with the tissue engineering technique. The picture shows in situ in the pig the vessels re-anastomosed to the blood supply for the nutrition of the prepared small intestine, to regenerate as functional tissue as required

5.4 Clinical Trials

Cardiac surgeons have used acellular tissue for some time. Trauma surgeons manage burns with acellular tissue. Recent application in the urology field for urethral reconstruction, acellular scaffolds seem to have a high success rate [22]. Synthetic nonbiodegradable materials have never been successful in clinical trials. As Chen et al. reported for 10 rabbits13, they were able to prove these results in four patients with a 3 years of follow-up [22, 23]. They created a neourethra of 5–15 cm using an on-lay technique with acellular bladder matrix. Three patients had an uneventful postoperative follow-up. One patient with a 15-cm neourethra developed a subglandular fistula. In the second clinical trial, El-Kassaby et al. included 28 patients. They reported the maximum urine flow preoperative of 9±1.29 ml/s and the satisfying flow of 19.7±3.07 ml/s after 37 months. Four patients had a slight caliber decrease at the anastomotic sites. Only one of 28 patients developed a subcoronal fistula, which closed spontaneously after 1 year [24].

In the meantime, McAninch constructed a neo-uretha in five patients using human cadaveric urethral acellular matrix with an on-lay technique. All five patients had complex anterior urethral strictures and prior surgeries. The constructed neourethra was up to 5–12 cm long. There was uniform, smooth healing without any evidence of scarring or leakage and with preservation of an adequate urethral lumen, with smooth transition between the normal and the grafted segment. The follow-up is momentarily 6–24 months (J.W. McAninch, personal communication).

Mantovanit et al. used SIS by Cook in four men and one woman. In the men, the strictures were longer than 10 cm and the tissue was placed dorsally using the on-lay technique. The urethral stricture of the woman was 3 cm. The satisfying outcome of all patients was proven by urodynamics and/or a retrograde urethrogram after a follow-up of 6 months without any reported complications [25].

This monetarily available clinical data demonstrates that a preseeding with urothelium cells or even smooth muscle cells is not necessary if the on-lay technique is used. For those cases when the entire penis needs to be reconstructed, tissue engineering is probably needed and the vascularized biological scaffold might be upcoming innovation.

5.5 Conclusion

Urethral reconstruction and the entire reconstructive surgery arena will see significant changes in the coming years. Surgery will become less invasive with an even better outcome. This will provide greater variability to react to the request immediately, ensure a higher success rate and minimize hospitalization. Because most of this data is still preliminary and in constant flow and transition, these new materials should be used in specialized centers with guaranteed close follow-up to ensure the best solution for urethral reconstruction. The best outcome for the patient requires long-term data with a 5-year follow-up [26].

Some of these new materials are already available and others will soon be on the market. Tissue transfer is probably no longer necessary for urethral reconstruction. This will improve the outcome of the common techniques in the experienced hands of the reconstructive urologist. Tissue engineering may even be a solution to organ replacement for difficult cases in the near future.

References

1. Olsen L, Bowald S, Busch C et al (1992) Urethral reconstruction with a new synthetic absorbable device. An experimental study. Scand J Urol Nephrol 26:323–326
2. Cilento BG, Retik AB et al (1995) Urethral reconstruction using a polymer mesh. J Urol 153:371A
3. Italiano G, Abatangelo G Jr, Calabro A et al (1997) Reconstructive surgery of the urethra: a pilot study in the rabbit on the use of hyaluronan benzyl ester (Hyaff-11) biodegradable grafts. Urol Res 25:137–142
4. Badylak SF, Lantz GC, Coffey A et al (1989) Small intestinal submucosa as a large diameter vascular graft in the dog. J Surg Res 47:74–80
5. Sandusky GJ, Badylak SF, Morff RJ et al (1992) Histologic findings after in vivo placement of small intestine submucosal vascular grafts and saphenous vein grafts in the carotid artery in dogs. Am J Pathol 140:317–324
6. Lantz GC, Badylak SF, Coffey AC et al (1992) Small intestinal submucosa as a superior vena cava graft in the dog. J Surg Res 53:175–181
7. Lantz GC, Badylak SF, Coffey AC et al (1990) Small intestinal submucosa as a small-diameter arterial graft in the dog. J Invest Surg 3:217–227
8. Knapp PM, Lingeman JE, Siegel YI et al (1994) Biocompatibility of small-intestinal submucosa in urinary tract as augmentation cystoplasty graft and injectable suspension. J Endourol 8:125–130
9. Probst M, Dahiya R, Carrier S et al (1996) Reproduction of functional smooth muscle tissue and partial bladder replacement. J Urol 155:336A
10. Piechota HJ, Dahms SE, Probst M et al (1998) Functional rat bladder regeneration through xenotransplantation of the bladder acellular matrix graft. Br J Urol 81:548–559
11. Kropp BP, Ludlow JK, Spicer D et al (1998) Rabbit urethral regeneration using small intestinal submucosa onlay grafts. Urology 52:138–142
12. Rotariu P, Yohannes P, Alexianu M et al (2002) Reconstruction of rabbit urethra with surgisis small intestinal submucosa. J Endourol 16:617–620
13. Chen F, Yoo JJ, Atala A (1999) Acellular collagen matrix as a possible »off the shelf« biomaterial for urethral repair. Urology 54:407–410
14. Sievert KD, Bakircioglu ME, Nunes L et al (2000) Homologous acellular matrix graft for urethral reconstruction in the rabbit: histological and functional evaluation. J Urol 163:1958–1965
15. Sievert KD, Wefer J, Bakircioglu ME et al (2001) Heterologous acellular matrix graft for reconstruction of the rabbit urethra: histological and functional evaluation. J Urol 165:2096–2102
16. Romagnoli G, De Luca M, Faranda F et al (1990) Treatment of posterior hypospadias by the autologous graft of cultured urethral epithelium. N Engl J Med 323:527–530
17. Yoo JJ, Meng J, Oberpenning F et al (1998) Bladder augmentation using allogenic bladder submucosa seeded with cells. Urology 51:221–225
18. Yoo JJ, Atala A (1997) A novel gene delivery system using urothelial tissue engineered neo-organs. J Urol 158:1066
19. Atala A (1999) Engineering tissues and organs. Curr Opin Urol 9:517–521
20. Schultheiss D, Gabouev AI, Cebotari S et al (2003) Vascularized biological scaffold for bladder tissue engineering: reseeding technique and short term implantation in a porcine model. J Urol 169:65
21. Kwon TG, Yoo JJ, Atala A (2002) Autologous penile corpora cavernosa replacement using tissue engineering techniques. J Urol 168:1754–1758
22. Chen F, Yoo JJ, Atala A (2000) Experimental and clinical experience using tissue regeneration for urethral reconstruction. World J Urol 18:67–70
23. Atala A, Guzman L, Retik AB (1999) A novel inert collagen matrix for hypospadias repair. J Urol 162:1148–1151
24. El-Kassaby AW, Retik AB, Yoo JJ et al (2003) Urethral stricture repair with an off-the-shelf collagen matrix. J Urol 169:170–173
25. Mantovani F, Trinchieri A, Mangiarotti B et al (2002) Reconstructive urethroplasty using porcine acellular matrix: preliminary results. Arch Ital Urol Androl 74:127–128
26. Fisch M (2001) Urethral reconstruction in children. Curr Opin Urol 11:253–255

Hypospadia Repair: The Past and the Present – Also the Future?

R. Hohenfellner

The lifespan of a pediatric urologist is too short to learn from late complications the errors of his therapeutic strategy and operative techniques performed on patients in early childhood.

6.1 Introduction

The following chapter is based on the experience of hypospadia repair performed in a single institution with a resident training program for pediatric urology over a period of more than 30 years. In 1989, we retrospectively analyzed the overall rate of relevant early and late complications in children with reconstructed urethras using different methods and found it as high as 35%.

This led to the question of whether the material used – nearly exclusively skin, mainly as pedicle flaps – was really the best one. In order to answer this question and although skin was used worldwide for urethral reconstruction, we started exploring beyond the limits of urology, hoping to learn from other disciplines.

What we immediately learned by consulting an experienced maxilla face surgeon (Dr. Bräutigam), was that buccal mucosa grafts were used frequently in cases of tear duct reconstruction. Furthermore, we learned about the importance of high histological homology in free tissue transfer and the basic principle that the original tissue to be replaced dictates the harvesting site. Searching for further relevant parameters, we found in laboratory investigations that the high concentration of immunoglobulin (lg-A) in the buccal mucosa – responsible for the bacterial defense mechanism – was nearly the same in the urethra, but not in the prepuce, widely used as the material of choice. The same was true for different cytoceratins found in immunohistochemistry investigations later on [10]. All this looked promising, although the only case of urethral reconstruction performed with buccal mucosa was published 50 years ago by Humby [13]. We started with the free tissue transfer by the use of buccal mucosa grafts in April 1990 and up to now – after more than 12 years – it is still the material of choice in urethral reconstruction, for hypospadias and epispadias as well as for urethral strictures.

Published first in 1992 [2], the number of articles concerning the new technique has increased every year up to 135 counted in 1996, demonstrating the worldwide interest in the new material. Within the same period of time, the enthusiasm for bladder mucosa grafts used as tubes or onlays waned due to the high number of complications and eventually disappeared from the current literature, although it was originally mentioned as »the material of choice in order to substitute urethral defects[14].« From our analysis of pitfalls in hypospadia repair, we also learned that closure of the glans wedges in order to place the meatus on the tip of the glans runs the risk of obstruction, diverticulum formation, and breakdown of the reconstructed urethra later on. Therefore, a slit-like meatus and a reconstructed frenulum became the compromise of choice, also avoiding repeated unsuccessful dilatations with metallic bougies.

6.2 Incidence and Indication

With an incidence of 1 in 300 male newborns, hypospadia is the most frequent anomaly of the male genitalia, comparable with maxillary and lip anomalies in boys. In around 70% of cases, the penis is strait, the micturition remains undisturbed, and only the meatus is not located on the tip of the glans penis (Fig. 6.1).

However, covered by the hood of the prepuce, the anomaly remains almost invisible in the standing or sitting position. Therefore at the first consultation the parents must be informed of the difference between esthetic surgery and functional reconstruction – indicated in the more severe forms of hypospadias – and also of the complications and the risk of repeated operations.

In order to underline the importance of the differential indication, the location of the meatus was investigated in 500 adult patients admitted for transurethral resection of the prostate [7] and was found in only 55% (Fig. 6.2) on the tip of the glans. A hypospadia was found in 65 (13%) of the otherwise undisturbed patients. It was also never mentioned by their wives – in the majority already multiple grandmothers – and the question concerning the psychological impact of this frequent anomaly became even more debatable (Fig. 6.3).

Therefore our recommendation is to postpone the esthetic correction until the teenager or young adult can decide for himself. Following this strategy, the number of children admitted for esthetic correction decreased

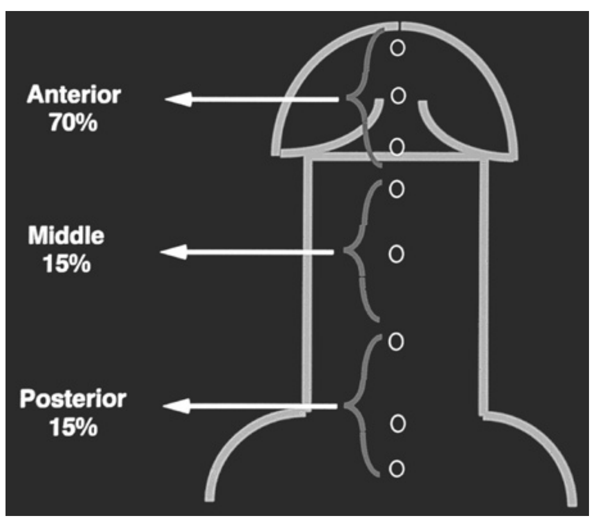


Fig. 6.1. Incidence in newborn boys: meatal position

significantly, the number of teenagers and young adults decreased to almost zero, while functional reconstructions increased in the same period of time.

In conclusion, we do not believe in the so-called psychological window, which enables the surgeon to perform unnecessary esthetic correction in early childhood. In contrast, functional repair can be performed whenever the mother feels comfortable, between the end of the 1st and 2nd year but 1 year before the child starts school.

In case of operative complications, a repeated correction should not be carried out earlier than 9 months following the first operation. Testosterone enanthate 2 mg/kg is given parenterally 5 weeks and 2 weeks before surgery has been shown to improve results. As an alternative, 1% dihydrotestosterone cream is applied on the penis every evening for 6 weeks using gloves.

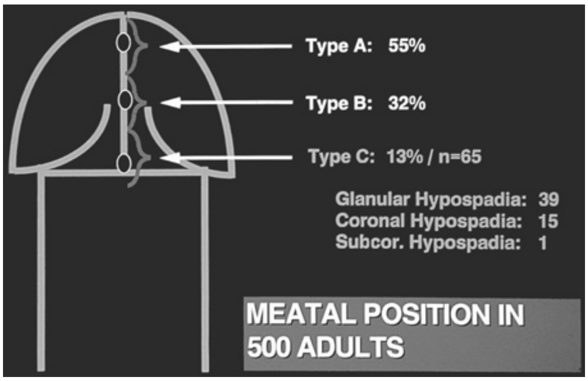


Fig. 6.2. Meatal position in 500 adults

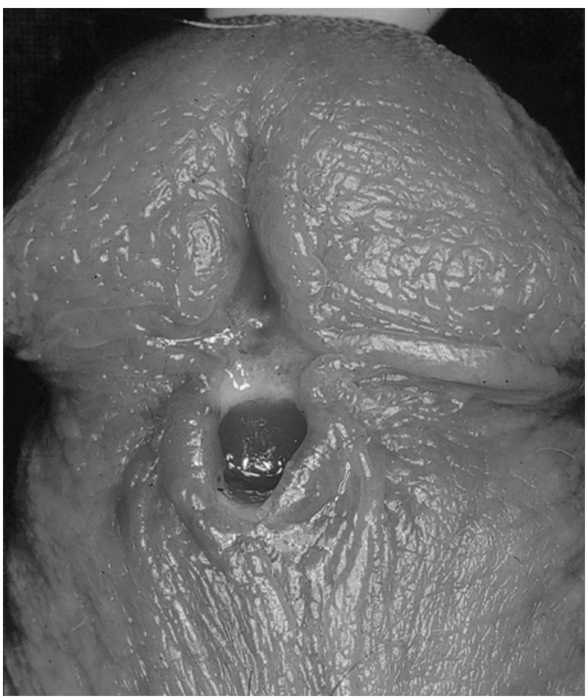


Fig. 6.3. Uncorrected hypospadia, 65-year-old patient admitted for transurethral resection of the prostate

Operative Techniques

A certain number of new techniques and modifications continue to be published every year. However, a certain number of methods are no longer presented in meetings and conferences – although they have been used for many years – and will eventually disappear from the current bibliography.

The MAGPI procedure carried out in 1,111 children [5] is only one of the numerous examples. One possible explanation is the human factor. If after an initially successful start the number of complications increases and the conceptual error becomes evident, the authors may hesitate to publish these results in the same journal as the original paper. One of the classic examples is the first successful bladder substitution using isolated ileum segments, which was published in the *Centralblatt fuer Chirurgie* in 1888 by Tizzoni and Foggi (whose name was actually Poggi). Both of them are still mentioned worldwide as pioneers in the current literature, even though their experiments carried out on healthy dog bladders were fundamentally faulty because self- regeneration of the residual bladder occurred within in the following year. The ileum segment found to be a useless diverticulum located on the dome of the bladder by Schwarz, was published later in the almost unknown *Journal of the University of Bologna* in Italian and was never mentioned in the international literature [20].

Many different techniques and modifications have been developed in order to overcome the high number of postoperative complications and the incidence of unsatisfactory outcomes. However, the true incidence of »hypospadia cripples« who started with a meatal anomaly in early childhood remains unknown. Nevertheless, within the broad spectrum of pathology found in our cohort of patients admitted for urethral reconstruction, about one-third were operated on more or less often for an originally congenital penile anomaly.

Up to 1990, one-stage urethral reconstruction was performed mainly using full-thickness skin flaps; transverse island flaps in the form of tubes [4] are onlays and two-stage repair is done with penile skin flaps.

In contrast to other institutions, the split skin grafts were used only for the two-stage mesh-graft technique – mainly for hypospadia cripples – or in order to cover penile skin defects as large as 12–10 cm. Interestingly, the thin split-skin grafts taken by a dermatome (3/10 mm) turned out to be an excellent material and the healing process was always perfect as long as the graft itself could be placed on the well-vascularized flaps of the superficial fascia (Scarpa or dartos) placed around the corpora cavernosa.

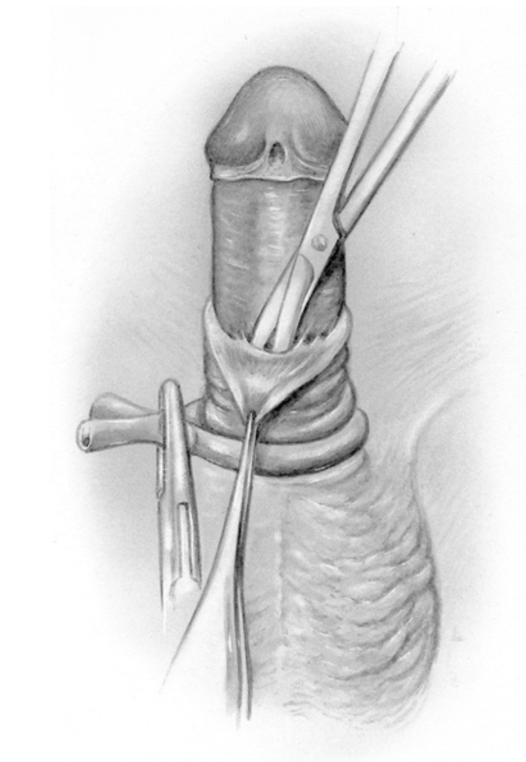


Fig. 6.4. Stripping down of the shaft skin together with Scarpa's fascia after coronal incision. Adapted from R. Hohenfellner, Ausgewählte urologische OP-Techniken, 2. Auflage Thieme-Verlag, 1997

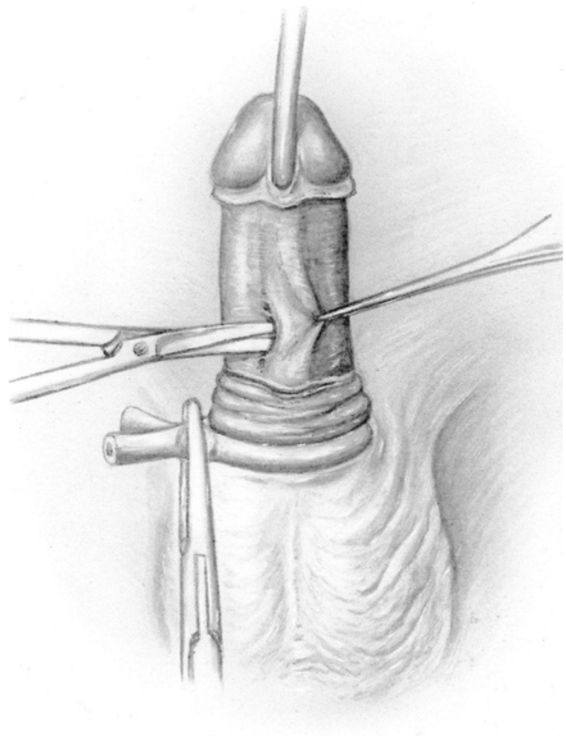


Fig. 6.6. Lifting of the urethra off the underlying tissue. Adapted from R. Hohenfellner, Ausgewählte urologische OP-Techniken, 2. Auflage Thieme-Verlag, 1997

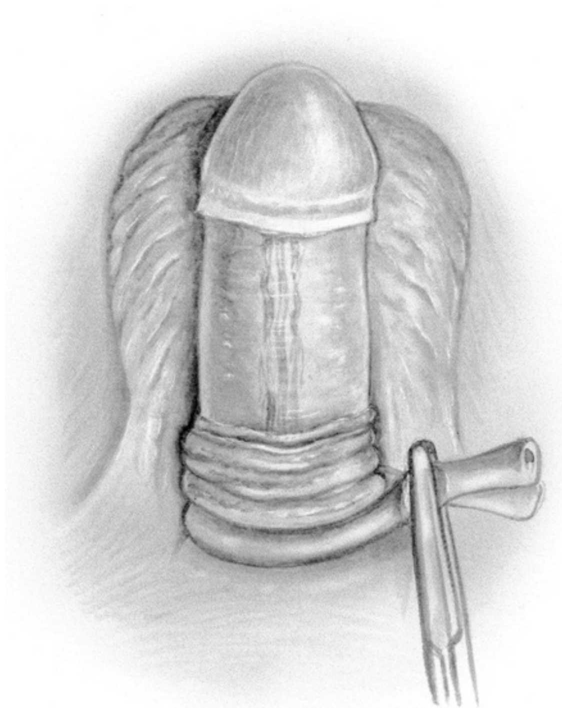


Fig. 6.5. Dorsally freed bundle. Adapted from R. Hohenfellner, Ausgewählte urologische OP-Techniken, 2. Auflage Thieme-Verlag, 1997

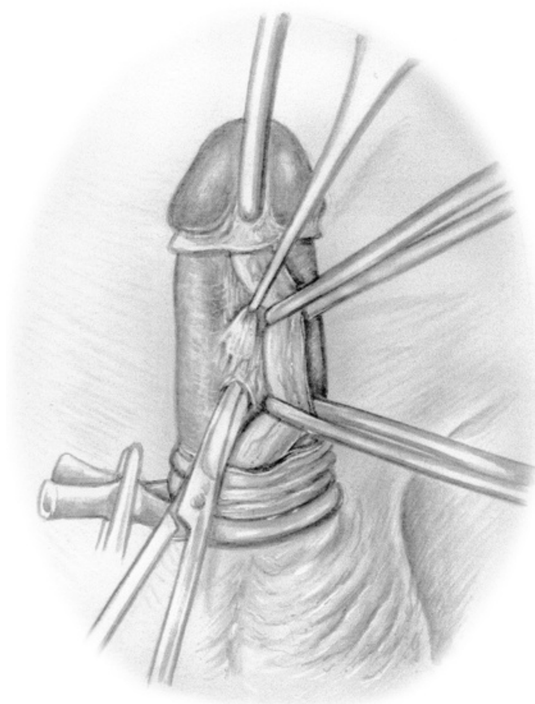
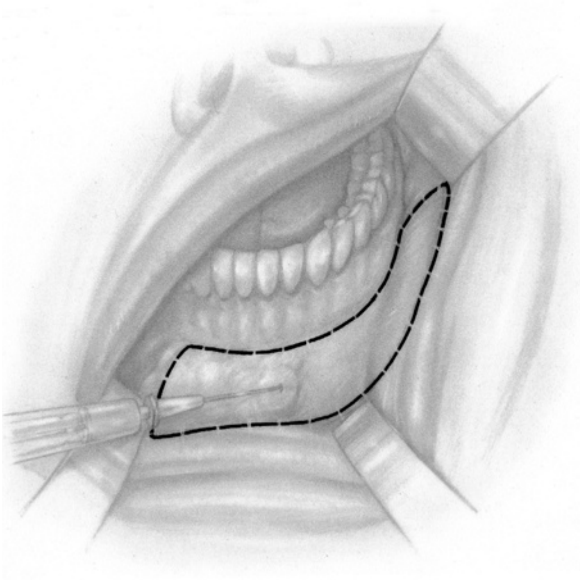
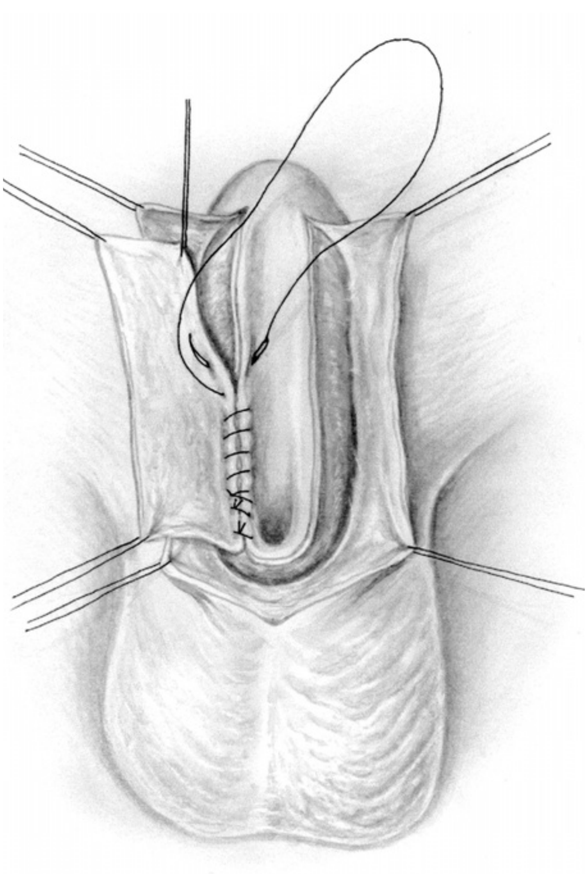


Fig. 6.7. Sharp dissection of the lateral cord bands to both sides of the urethral bed after placement of two vessel loops. Adapted from R. Hohenfellner, Ausgewählte urologische OP-Techniken, 2. Auflage Thieme-Verlag, 1997



◘ **Fig. 6.8.** Outlining of the graft from the lip and possibly the inner cheek. Submucous injection (1:100,000 adrenaline) facilitates dissection of the graft. Adapted from R. Hohenfellner, Ausgewählte urologische OP-Techniken, 2. Auflage Thieme-Verlag, 1997



◘ **Fig. 6.9.** Suturing of the onlay graft to the plate after lateral dissection of the penile shaft skin. Adapted from R. Hohenfellner, Ausgewählte urologische OP-Techniken, 2. Auflage Thieme-Verlag, 1997

This strategy also reflected the trend of the one-stage onlay repair with transverse island flaps taken from the inner preputial layer and placed ventrally on the preserved urethral plate [1]. This was in strong contrast to the former technique – introduced in 1982 and used up to 1987 – where the chordee was resected together with the urethral plate and substituted by a tube in form of a neourethra constructed also from the inner layer of the prepuce [4]. Nevertheless, it took almost 12 years until the tube was replaced by an onlay flap with no data on the high number of fistulas and obstructions found by others mainly on the side of the end-to-end anastomosis [1]. However, the main problem of a transverse island flap is how to preserve vascularization.

A wide spectrum of anatomical variations is found by intraoperative illumination of the axial vessels located within the superficial fascia [18]. Therefore a certain number of flaps may end up as a graft, which is better tolerated as an onlay, instead of a tube rotated for 90° and anastomosed end-to-end later on.

Hendren stated that »a free graft covered by two layers of well-vascularized tissue works as well, if not better, than a pedicle flap« and in accordance with our own experience with buccal mucosa grafts, we believe that he was right. In addition, secondary vascularization of a graft – mostly from vessels arriving from outside – is guaranteed if all the connective tissue is removed or if a split-skin graft is used. Therefore, thinner grafts can be larger and thereby facilitate a successful tissue defect substitution.

As stated before, in reconstructive surgery the basic principle of free tissue transfer is quite simple and logical: there must be close homology between the replaced tissue and the material used for reconstruction. Nevertheless, it took almost 100 years to raise the question of how well skin works over the long term in urethral replacement. Sir Richard Turner Warwick stated that skin hates urine, because »every year, between 1 and 2% of my former successful urethroplasties are lost mainly by secondary strictures.«

In addition to lanugo hair follicles – hard to identify in early childhood! – sebaceous and sweat glands are located in the penile and scrotal skin mainly used as onlay flap or tubes for urethral reconstruction in early childhood. Therefore, local inflammations surrounding the ducts of these glands is a common finding in urethroscopy in adults caused by recurrent infection or secondary strictures.

However, it still remains unclear why secondary urethral obstructions occur sometimes suddenly after many years following successful reconstruction, in one of our cases, as late as 18 years later.

In animal experiments, Filipas et al. [10] from our institution implanted full skin grafts and buccal mucosa grafts in the bladder of female Irish mini pigs. Perfect wound healing without tissue shrinkage was observed in the buccal mucosa grafts. In contrast, shrinkage up to 30%, severe inflammation, and stone formation occurred in the implanted full skin grafts.

In immunohistochemical investigations, expression of cytokeratin 20 (usually not expressed in the original buccal mucosa) was similar between the urothelium and all buccal mucosa grafts but not in the full skin grafts transplanted in the bladder.

Therefore, the advantages of buccal mucosa in comparison with full skin grafts were also demonstrated in animal experiments. However, today the onlay island flap taken from the inner layer of the prepuce is still used worldwide in the one-stage hypospadia repair. The same is true for the Snodgrass technique, although the final outcome remains open. As mentioned before, long-term observations are necessary. Studies to prove the usefulness of the dorsal incision through the urethral plate (comparable with the Sachse procedure) will stand [11].

One of the disadvantages of the otherwise gold standard end-to-end anastomosis in posttraumatic membranous strictures is the risk of postoperative penis shortage in the more extensive strictures. Using a buccal mucosa graft, a one- or two-stage procedure can help to overcome this problem [17], the current strategy for primary hypospadia repair in Mainz in 2002 [7]. Since 1990, our strategy has not changed. As mentioned before, esthetic corrections are not recommended and also not performed in our institution.

6.3 Results

We retrospectively analyzed 132 patients who had undergone a buccal mucosa onlay graft for hypospadia repair, including 34 salvage cases during the last 10 years in our institution and evaluated those 49 cases with an available follow-up longer than 5 years (mean 6.2 years). The overall complication rate was 24% (12/49) with all but three complications during the first postoperative year (three3 fistulas, one stricture, two graft contractures, and two scars in the oral wound healing site). The three remaining complications became evident during the 2nd and 3rd postoperative year and consisted of two anastomotic strictures at the proximal anastomosis and one meatal stenosis.

Similar results where achieved in 67 patients with urethral strictures and operated on in the same period with the same technique using buccal mucosa onlay grafts. Thirty-two patients could be followed up longer than 5 years with a complication rate of 19% (6/32): one fistula, one graft necrosis, three recurrent strictures treated successfully with one internal urethrotomy and one lower lip scar [8, 9].

6.4 Hypospadia Cripples

Therefore the buccal mucosa onlay graft technique can be recommended for hypospadia cripples with almost no material left for urethral reconstruction [6, 16]. However, in this situation the stabilization of the graft turned out to be important as well. Barbaglia was the first to fix the graft dorsally on the underlying corpora cavernous in order to increase revascularization, but also in order to prevent the graft from kinking later. The technique was repeated by several others [3]. In Mainz, we placed the graft laterally at 3 or 9 o'clock with fixation sutures on the corpus cavernous in order to avoid a curved neourethra.

Used for hypospadia cripples, the onlay technique also avoids the risk of penis shortness, which is one of the disadvantages of end-to-end anastomosis. It can be carried out in a one-stage as well as in a two-stage procedure [17].

Furthermore, the question of secondary malignancy is important and long-term follow-ups are necessary. Cultivation of buccal mucosa has been experimented for more than 10 years. In laboratory investigations, large fields of multisurface epithelial cell layers were cultivated on fibroblast cell cultures. However, no solid connection between the epithelium and the underlying tissue could be achieved, which is the indispensable prerequisite for successful tissue transfer for clinical use. Nevertheless, the investigations are promising for the future [15].

6.5 Conclusion

What can be learned from the long history of hypospadia repair?

1. Hypospadia is a frequent anomaly with a broad spectrum of different pathologies. The borderline between normal and abnormal remains unclear for the majority of distal hypospadias without functional disturbances. The statement of Sir H Gilles, »esthetic surgery is an attempt to surpass the normal« in strong contrast to functional correction »the attempt to correct the patient to normal« is important in terms of both timing and postoperative complications. Therefore, parents should be informed that in cases of esthetic correction, the operation could be postponed until the child becomes a young adult is informed about the number and severity of postoperative complications, and can decide the best course of action for himself. There is no indication for early esthetic meatus correction.
2. Experience seems to be an important factor with a long learning curve, as mentioned in the literature. A database that includes all details, which sometimes seem to be unimportant such as nonabsorbable suture material for curvature correction, may be helpful if retrospective analyses concerning the late complications are conducted later on.

3. Hypospadia may be the mildest form of ambiguous genitalia. Therefore, the early consultation with a pediatric endocrinologist is important. Not least, the question concerning heritability has to be clarified.
4. The early outcome concerning the functional and esthetic result of surgical correction does not reflect later quality of life and sexuality. In contrast to an increasing number of surgical techniques, we need modern prospective studies conducted with a psychologically accepted instrumentarium in order to clarify the late outcome. In the historical one by Heiss, no correlation was found between the esthetic outcome and later sexual life [12].
5. From time to time we should look beyond our discipline in order to benefit from the developments of other reconstructive specialties. For instance, free buccal mucosal grafts successfully used for more than 100 years in maxilla face surgery in order to cover tissue defects turned out to be the material of choice in urethral reconstruction as well.
6. Skin also used for decades in form of flaps and grafts is becoming increasingly questionable as be the ideal material for urethral substitution. The same is true for bladder mucosal grafts.
7. Innovations and creation of new reconstructive surgical techniques are important. The prerequisite however, is a full understanding of the basic principles of tissue transfer regardless of whether grafts or flaps are used in animal experiments or clinical trials later. This includes investigations in histology and immunohistochemistry.
8. Tissue engineering is a promising new technology. For daily clinical practice, however, it still may be several years until urethral mucosa becomes commercially available.

References

1. Baskin LS, Duckett JW, Ueoka K, Seibold J, Snyder HM 3rd (1994) Changing concepts of hypospadias curvature lead to more onlay island flap procedures. J Uro1 151:191–196
2. Bürger R, Müller SC, Hohenfellner R (1992) Buccal mucosa graft: a preliminary report. J Uro1 147:662–664
3. Dubey D, Kumar A, Bansal PA, Kapoor R, Mandhani A, Bhandari M (2003) Substitution urethroplasty for anterior urethral strictures: a critical appraisal of various techniques. BJU Int 91: 215–218
4. Duckett JW (1981) The island flap technique for hypospadias repair. Urol Clin North Am 8:503–511
5. Duckett JW, Snyder HM 3rd (1991) The MAGPI hypospadias repair in 1111 patients. Ann Surg 213:620–625; discussion 625–626
6. Fichtner J, Macedo A, Voges G, Fisch M, Filipas O**,** Hohenfellner R (1996) Buccal mucosa only for open urethral strictures repair clinic and histology (abstract). J Uro1 155:552
7. Fichtner J, Macedo A, Fisch M, B+rger R, Hohenfellner R (1995) Konzept der Hypospadikorrektur mittels Mundschleimhaut-Only-Flap. Akt Uro1 26:I–X
8. Fichtner J, Filipas D, Fisch M, Hohenfellner R, Thüroff JW (2004) Long-term follow-up of buccal, mucosa onlay grafts for hypospadias repair. Analysis of complications. J Urol 172:1970–1972; discussion 1972
9. Fichtner J, Filipas D, Fisch M, Hohenfellner R, Thüroff JW (2004) Long-term outcome of ventral buccal mucosa onlay grafts for urethral stricture repair. Urology 64:648–650
10. Filipas D, Fisch M, Fichtner J, Fitzpatrick J, Berg K, Starkel S (1999) The histology and immunohistochemistry of free buccal mucosa and full-skin grafts after exposure to urine. BJU Int 84:108–111
11. Guralnick ML, al-Shammari A, Williot PE, Leonard MP (2000) Outcome of hypospadias repair using the tubularized, incised plate urethroplasty. Can J Urol 7:986–991
12. Heiss WH, Helmig FJ (1975) Zur Sexualfunktion nach Hypospadiekoperationen. Akt Uro1 6:15–20
13. Humby G (1941) A one-stage operation for hypospadias. Br J Surg 29: 84
14. Keating MA, Cartwright PC, Duckett JW (1990) Bladder mucosa in urethral reconstructions. J Urol 144:827–834
15. Lauer G, Schimming B (2002) Klinische Anwendung van im Tissue engineering gewonnenen autologen Mundschleimhauttransplantaten. Mund Kiefer GesichtsChir **6**: 379–393
16. Metro MJ, Wu H-Y, Snyder HM 3rd, Zderic SA, Canning DA (2001) Buccal mucosa grafts: lessons learned from an 8-year experience. J Urol 166:1459–1461
17. Palminteri E, Lazzeri M, Guazzoni G, Turini D, Barbagli G (2002) New 2-stage buccal mucosal graft urethroplasty. J Uro1 167:130–132
18. Perovic SV, Radojicic ZI (2003) Vascularization of the hypospadiac prepuce and its impact on hypospadias repair. J Uro1 169:1098–1101
19. Powel CR, McAleer I, Alagiri M, Kaplan GW (2000) Comparison of flaps versus grafts in proximal hypospadias surgery. J Uro1 163:1286–1289
20. Tizzoni G, Foggi A (1888) Die Wiederherstellung der Harnblase. Zbl Chir 50:921

Urethral Reconstruction in Women

E.J. McGuire

7.1 Urethral Function

There are two modes of urethral function: closed for continence and open as a conduit during voiding. Loss of either function can occur. The most complicated situations are associated with loss of both continence and conduit function. Although not always linked, bladder dysfunction frequently accompanies urethral dysfunction.

7.2 Etiology of Urethral dysfunction

7.2.1 Neural Causes

Although traditionally sacral cord and root lesions are thought to cause loss of proximal or smooth sphincter function and stress incontinence, they actually do not. Complete S1 through S4 root transection eliminates striated sphincter function, but not internal sphincter function, and thus stress competence is preserved [1, 2]. In this context, stress competence refers to the ability of the urethra to resist abdominal pressure (Pabd) as an expulsive force (Fig. 7.1). On the other hand, T12–L1 spinal cord injuries *are* associated with loss of internal sphincter function and loss of the ability of the urethra to resist Pabd as an expulsive force (Fig. 7.2). Stress leakage occurs at low to very low abdominal pressures despite preservation of some striated sphincter function. An identical loss of internal sphincter function related to pelvic neural injury can occur after abdominal-perineal resection for rectal carcinoma. In these cases, the pudendal nerve completely escapes injury. As there is no central neural deficit there is completely normal reflex and volitional function of the striated sphincter [3, 4] Nonetheless, these patients have very severe stress incontinence produced by minimal effort or activity. Despite the incontinence, these patients void by straining and void incompletely. Intermittent catheterization can solve the retention problem, but does nothing for the stress incontinence. Thus, very specific neural deficits are associated with equally specific urethral functional loss.

7.2.2 Loss of Both Continence and Conduit Function Related to Neural Dysfunction

Most neural lesions that result in loss of proximal urethral sphincter function are associated with decentralization of the bladder. That means there is no neural mechanism to drive urethral responses to either bladder filling or reflex detrusor contractile activity [4, 5] This is a situation identical to that encountered in most patients with myelodys-

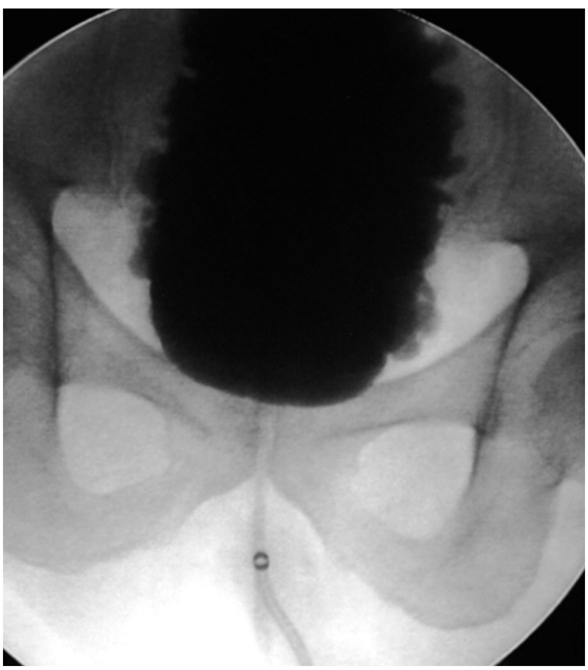


Fig. 7.1. Upright cystography at a bladder volume of 300 ml as part of a video study from a patient with S1–S4 sacral root loss. Note the closed bladder neck. This patient does not have stress incontinence despite a decentralized bladder

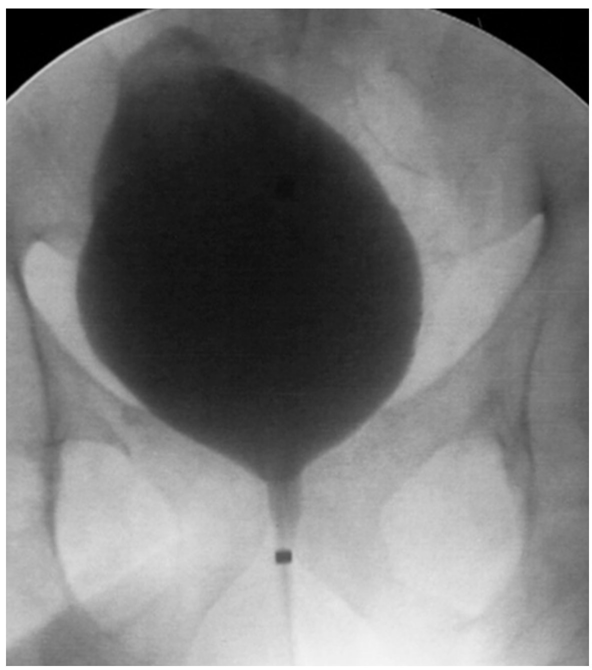
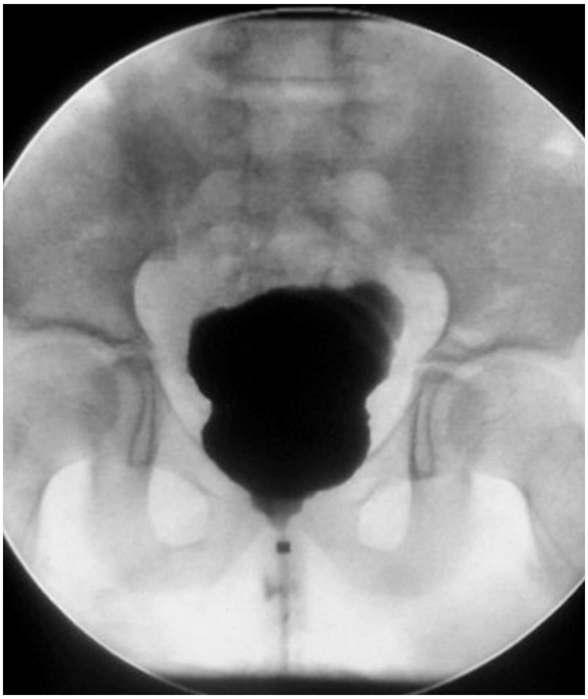
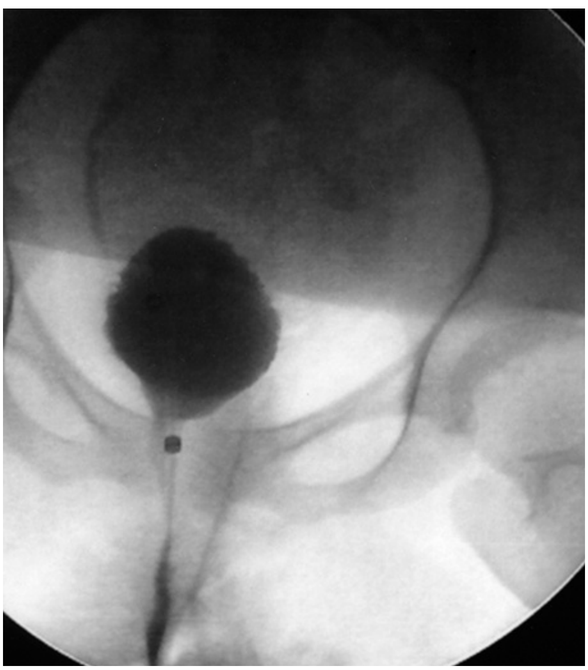


Fig. 7.2. Upright cystography as part of a video study in a patient with a T 12–L 1 spinal cord injury. The proximal urethra from the bladder neck to the striated sphincter is not functional. The patient has severe stress incontinence with transfers, straining, and coughing

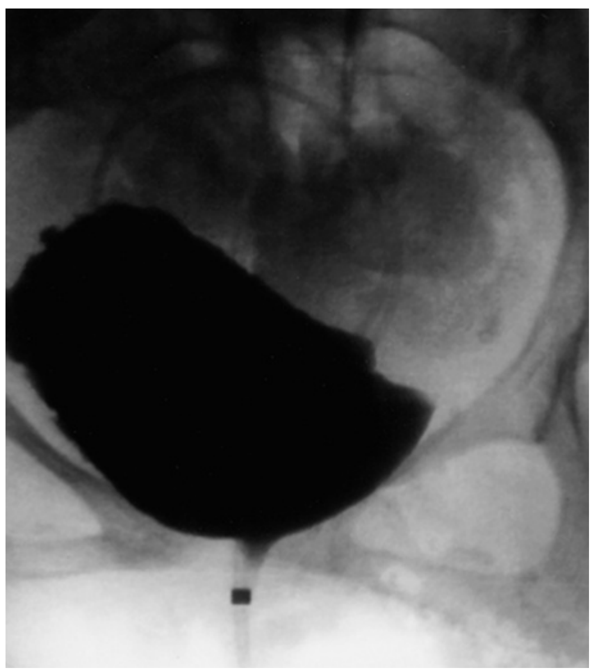


◘ **Fig. 7.3.** Upright cystography incident to a video urodynamic study in a 16-year-old with myelodysplasia. At all bladder volumes, the proximal urethra is open. The patient has severe stress leakage despite an augmentation cystoplasty

plasia where a nonfunctional internal sphincter mechanism coexists with a decentralized bladder (◘ Fig. 7.3). There is some function of the external striated sphincter but this is fixed, i.e., not reflexly active. This situation is relatively complex in that there is abdominal pressure-driven leakage due to loss of proximal urethral sphincter function. There is also a degree of obstructive uropathy as the detrusor faces a fixed outlet resistance offered by the striated sphincter. The degree of risk is determined by the detrusor pressure required to drive urine out the urethra, or the detrusor leak point pressure. (◘ Figs. 7.4, 7.5) If this is 40 cm or more, a 100% risk of upper tract damage exists in an untreated situation. These patients may have gross stress incontinence and at the same time obstructive uropathy, which risks upper tract integrity. About 39% of myelodysplastic children are in this category [6]. Reconstructive surgery to obtain a stress-competent urethra is complicated. Any procedure that increases urethral resistance may also elevate the detrusor leak point pressure and risk upper tract function. This was first reported in children with myelodysplasia treated with bladder neck placement of an artificial sphincter for severe stress incontinence. This resulted in continence but the detrusor leak point pressure became elevated and upper tract damage became obvious [7]. When evaluated, these children had very poor bladder compliance. This



◘ **Fig. 7.4.** A video urodynamics study in a patient with a lumbosacral meningomyelocele. The bladder is poorly compliant. The Pdet at the instant of leakage is 54, and at the same time there is right vesicoureteral reflux. This is a dangerous situation and the detrusor pressure must be reduced



◘ **Fig.7.5.** Video study in a myelodysplastic girl. The proximal sphincter is open with some midurethral closure. The bladder is compliant and the detrusor leak point pressure is low (22). While incontinence is a problem here with transfers and straining, the situation is not dangerous. Depending on the method chosen to close the urethra, the detrusor leak point pressure could rise to dangerous levels was attributed to a detrusor muscle response to the increased resistance associated with the artificial sphincter. That was the correct explanation but it took some time to prove it.

7.3 The Relationship Between Upper Tract Function and Outlet Resistance

Bloom and co-workers dilated the striated sphincter in children with myelodysplasia, elevated detrusor leak point pressures, and upper tract changes. [8] They did this to decrease outlet resistance, the same change as that effected by a vesicostomy. A vesicostomy simply bypasses the urethra while dilation directly reduces urethral resistance. At the time Bloom and co workers did the dilations, it was known from othe r data that all myelodysplastic children with abnormal upper tracts had a low-compliance bladder. In follow-up of those children treated by urethral dilation, Bloom and co-workers found upper tract changes resolved but there was also a dramatic and sustained improvement in bladder compliance [9, 10]. That finding established that the outlet controls the detrusor pressure response to filling. Further, it is clear that that high, fixed outlet resistance related to a functional or structural abnormality, or that achieved surgically, can induce a destructive detrusor response, which leads to altered compliance and can cause upper tract damage. The relationship between the outlet and the bladder governs what is possible to achieve surgically where passive urinary loss is the result of a lack of proximal urethral sphincter function coupled with bladder decentralization. Where very high outlet resistance is achieved, with a procedure like the Kropp buried urethra or some variety of the Mitrofanoff procedure, a method to enlarge the bladder is required to obviate high detrusor (or reservoir) pressures [11, 12]. It is important to emphasize that passive urinary loss related to poor proximal urethral sphincter function can coexist with high detrusor leak point pressures and a risk to upper tract function.

7

7.4 Diagnosis of Proximal Urethral Failure

Upright cystography at a moderate bladder volume demonstrates an open bladder neck and proximal urethra (Fig. 7.5). A cystometrogram, preferably with iodinated contrast material under fluoroscopic monitoring, provides information on bladder compliance, as well as on capacity, which is essential to planning a reconstructive surgical procedure. In this context, bladder capacity is defined by a detrusor pressure of 40 cm, or just under that pressure. Any storage pressure above this value is associated with real risk. Compliance testing is unreliable in the presence of vesicoureteral reflux or urethral leakage, and fluoroscopy is very useful to determine if either of those variables is present (Fig. 7.6). Abdominal and detrusor leak point pressures are also useful here to demonstrate that stress incontinence is present, and to define the variable that directly determines risk: the detrusor pressure (P det) at the instant of urinary leakage.

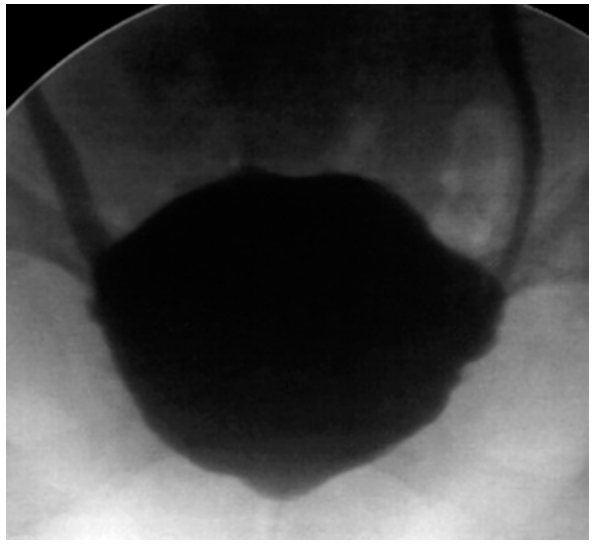


Fig. 7.6. A video study from a woman with incontinence 20 years after Cobalt 60 irradiation for a cervical carcinoma. There is bilateral reflux, and though compliance looks normal during the early stages of filling, it is not normal. Part of the bladder capacity is in fact the ureters

If poor compliance is present no urethral procedure is safe until the abnormal compliance is corrected. In such cases, part of the expulsive force driving the incontinence is Pdet, and that must be treated at the source, not by an achieved elevation in urethral resistance. Increased urethral resistance will lead to higher detrusor pressures and more incontinence, albeit at higher pressures.

While any bladder will respond to increased outlet resistance, this is an invariable and accentuated response in a decentralized or hyperreflexic bladder. Slings used to close a nonfunctional proximal urethra raise abdominal leak point pressures quite dramatically, but do not change detrusor leak point pressures very much, if at all [13]. These are thus safe procedures. That is not true for the artificial sphincter, placed at the bladder neck. That device raises both the abdominal and detrusor leak point pressure. Thus a bladder response must be anticipated, after a sphincter is implanted, and steps taken to prevent the development of abnormal compliance in the face of the change in outlet resistance. This can be done with medication and intermittent catheterization, a bladder enlargement procedure, for example an augmentation cystoplasty, or myectomy, or Botox injections, for example.

7.5 Surgical Techniques for Creation of a Competent Proximal Urethral Sphincter

The most versatile procedure to close on open proximal urethra probably is a sling. The procedure is not done to achieve urethral support but rather to close the open urethra. In this circumstance, crossing the sling ends in front of the urethra provides more circumferential closure and seems to do so at lower pressures than a conventional posterior vector force uncrossed sling (Fig. 7.7). This was first done in males with myelodysplasia where a standard sling failed to provide enough closing force to achieve continence [14]. Slings that close an open urethra are perhaps best derived from the patient's own fascia (Fig. 7.8A–C) [15, 16, 17]. There are several reasons for this but among them is the requirement for intermittent catheterization in many of these patients. While intermittent catheterization is possible after artificial sphinc-

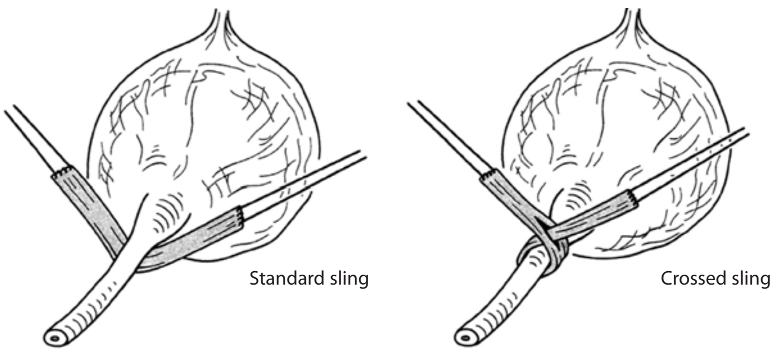


Fig. 7.7. The *left diagram* shows a conventional vector force sling, while the *right diagram* depicts a crossed sling

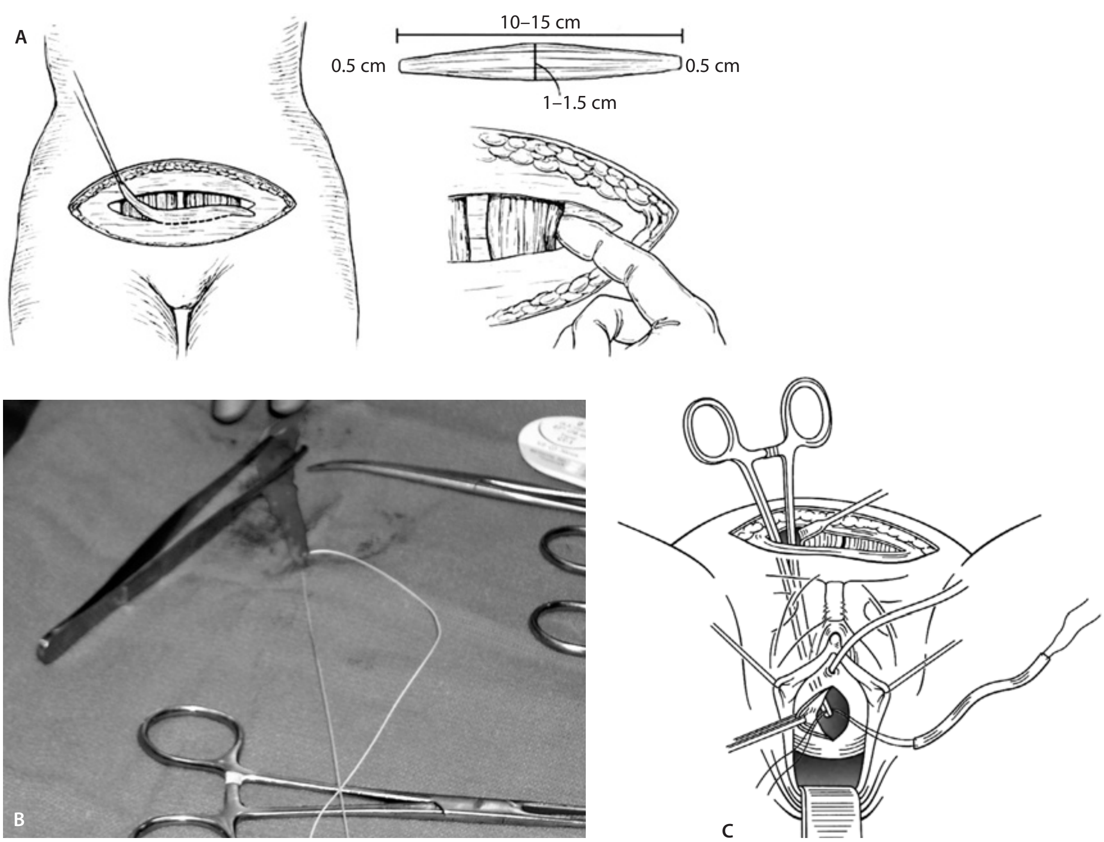


Fig. 7.8A–C. Conventional sling. **A** The sling is taken from the inferior leaf of rectus fascia. Lateral to the rectus muscles as they insert on the symphysis is an easy area to enter the retropubic space even after multiple prior operations. **B** Harvested sling with the traction sutures in place. **C** Bimanual control of the instrument used to transfer the sling sutures and sling ends into the retropubic space

ter implantation, it is more problematic and infections and erosions are more likely to occur when intermittent catheterization is required. Brantley Scott obviated the need for intermittent catheterization by doing an extensive Y-V plasty prior to sphincter implantation to ensure complete emptying when the sphincter was opened [18]. It appears that this technique avoided the compensatory bladder response to the increased resistance offered by the sphincter reported by other workers. However, in many cases bladder compliance is already compromised and bladder enlargement procedures are required in conjunction with any urethral procedure for continence. In these cases, intermittent catheterization is required and slings are probably preferable to the artificial sphincter on that basis alone. In 30 years of experience with slings, I have not seen erosion in any of my own patients other than that related to traumatic catheterization where the catheter penetrated the urethra at the sling site. These heal spontaneously with catheter drainage. On the other hand, an artificial sphincter can provide excellent continence when placed at the bladder neck, and need not obviate intermittent catheterization [19]. If the device becomes infected or erodes a sling is the only practical method to recreate a function proximal sphincter (Fig. 7.9A–C)

7.6 Urethral Injury, Tissue Loss, and Erosion

7.6.1 Etiology

Injury to the urethra can be incurred by trauma, surgical injury such as that associated with diverticulectomy, or surgery for stress incontinence. The worst urethral damage is the result of long-term Foley catheter drainage in patients with neurogenic conditions. There seems to be an impression that catheter drainage is safe in women. That is not the case. After 5 years of such treatment, serious and cumulative problems develop, including incontinence despite the catheter in as many as 75%, anterior or posterior urethral erosion, upper tract disease, chronic untreatable infection, tissue loss and skin breakdown, osteomyelitis, and not uncommonly death from uncontrollable sepsis.

Diagnosis is usually easy on examination. The patulous urethra is simply open. Erosion anteriorly into the symphysis is difficult to deal with because the superior extent of the erosion is the bladder neck. Posterior erosions are often reconstructable. A cystometrogram helps to define bladder capacity, but this is usually very small, and leakage from the urethra complicates the measurement. Attempts to occlude the urethral opening with a large-bore large-balloon catheter are not very often helpful (Fig. 7.10). In most cases the bladder is very small

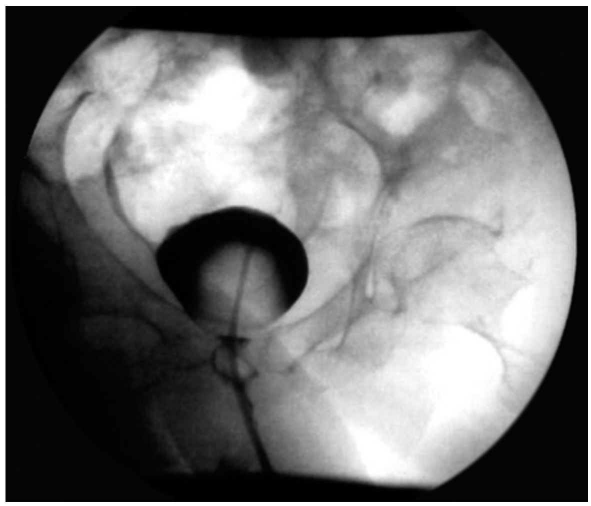


Fig. 7.10. Tiny bladder and nonfunctional urethra treated with ever larger catheters and more fluid in the balloon

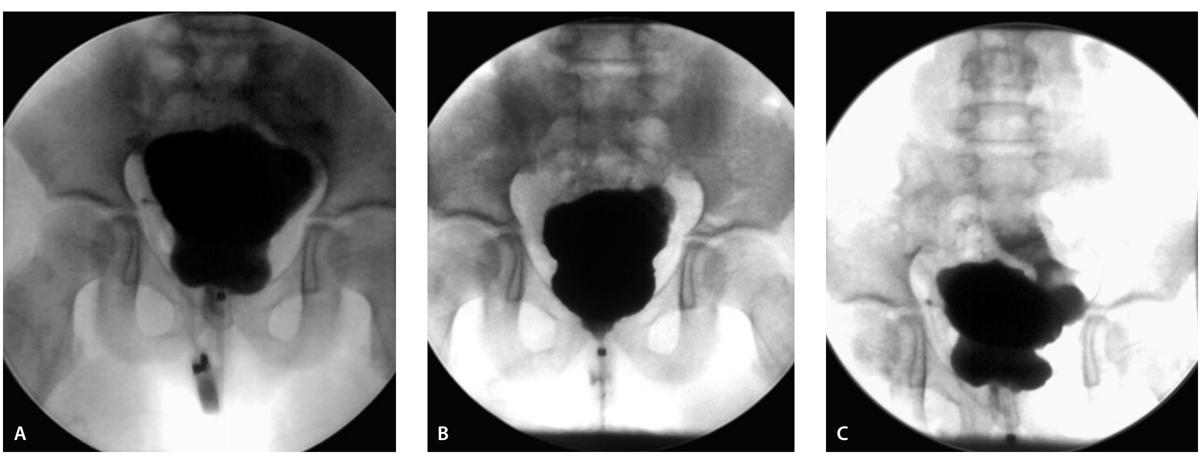


Fig. 7.9. A Video study from an 11-year-old girl with an augmentation cystoplasty and a bladder neck artificial sphincter which worked very well although it was never activated. **B** The sphincter cuff and all other components were removed because of infection. There is recurrent severe stress incontinence. **C** Closure of the bladder neck by a crossover sling with recovery of continence

and fibrotic and must be enlarged in conjunction with a procedure to close the urethra. Urethral closure of a noneroded but patulous urethra requires a crossed sling. A posterior vector force sling is generally not effective and may interfere with intermittent catheterization.

7.6.2 Inability to Catheterize per Urethra

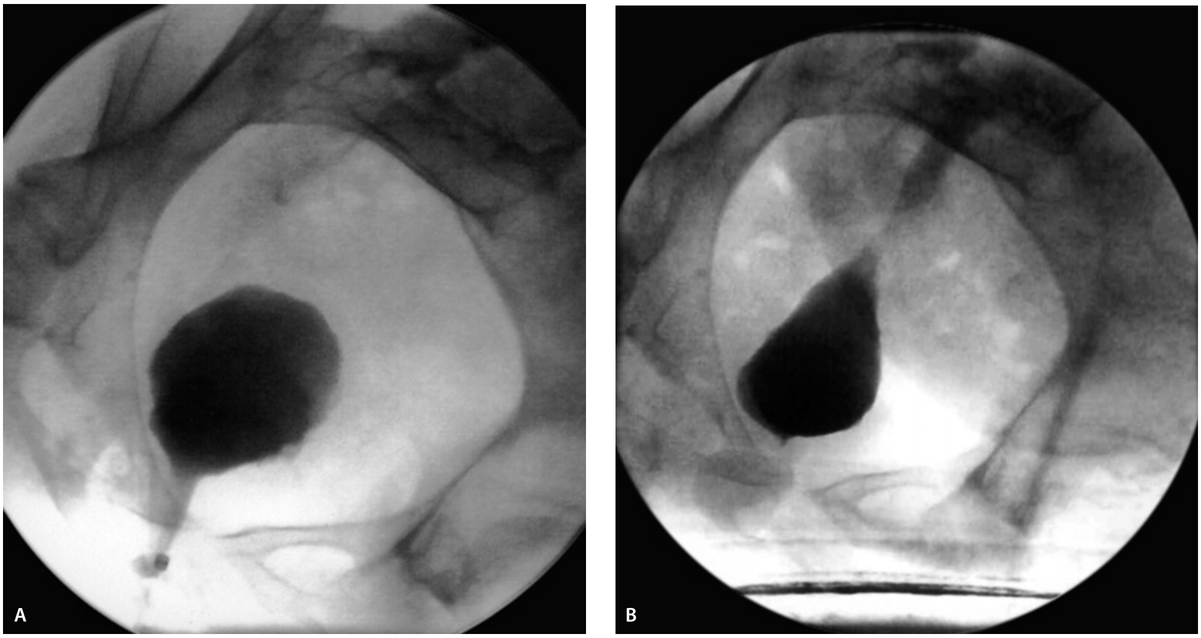
Unfortunately this happens fairly often and is the usual reason for use of a Foley catheter as a long-term method of bladder management. When there are no caregivers to do the catheterization or self-catheterization is impossible for the patient, then urethral closure must be accompanied by construction of a continent catheterizable abdominal stoma or an incontinent drainage system [20].

7.6.3 Surgical Repair

Anterior erosions are complicated conditions, as the urethra is often not salvageable and must be closed. Deliberate closure of the urethra then has to be combined with a bladder drainage procedure to allow for low-pressure urine egress, or a continent catheterizable neourethra must be constructed. The latter requires an augmentation cystoplasty to enlarge the bladder while the former does not. We usually use an ileovesicostomy to achieve low-pressure urine drainage (◘ Fig. 7.11A, B). If the bladder is large enough (500-ml capacity) one can construct a neourethra from a bladder flap identical to that which would be used to do a Boari flap ureteral reimplantation. If the bladder is smaller one can use the unmodified appendix as a catheterizable neourethra [21]. In the latter case, if the appendix looks suitable a small window in its mesentery is made immediately adjacent to the cecum. A single Allen clamp is then placed across the bottom of the cecum. A small segment of the cecum is taken on the outside of the Allen clamp. The cecum is closed inside the Allen clamp before it is removed. After the clamp comes off, cecal closure is reinforced with imbrication sutures. The segment of cecum attached to the proximal appendix is rolled and sutured into a tube over a 12-Fr catheter. This adds extra length to the appendix. The appendix is then opened at its distal end and instrumented with Hagar dilators. At a minimum, the appendix should easily accept a 10-Fr catheter. An end-to-end anastomosis is then made to the bladder at the cecal end of the tube. The distal open appendix is anastomosed to the skin. Both of these neourethral constructions are designed to leak if detrusor pressure gets much above 30 cm. As such these are safe conduits with acceptable detrusor leak point pressures. Abdominal pressure does not cause leakage in either of these two varieties of a catheterizable neourethra.

7.6.4 Urethral Closure

In those cases where the proximal margin of the urethral erosion is the anterior bladder neck, or even more proximal bladder, secure closure depends on mobilization



◘ **Fig. 7.11.** **A** Preoperative study in a 34-year-old myelodysplastic patient incontinent around a Foley catheter placed because she could not manage intermittent catheterization. **B** Postoperative study after a crossed sling and ileovesicostomy. The bladder neck is closed and the ileovesicostomy provides for low pressure drainage of the anterior bladder deep to the endopelvic fascia (Fig. 7.12, 7.13A–D). Incisions are made anterior to the open bladder neck as close to the bone as possible, or rather as far away from the bladder neck margin as possible. Sharp dissection at 10–11 o'clock and at 1 and 2 o'clock provides a safe entry place into the retropubic space. From those vantage points, one can dissect, under vision, the anterior bladder wall off the pubis without damage to the dorsal venous complex. A generous free margin of mobile bladder is needed for effective closure. Continuing the dissection along both lateral aspects of the bladder neck allows further mobilization of the anterior bladder wall from the back of the pubis. At the 3 and 9o'clock positions lateral to the bladder neck, it is not necessary to dissect into the retropubic space, as there is sufficient tissue here to permit mobilization and closure. Across the posterior aspect of the open urethra, a vaginal incision is made to permit mobilization of a generous inverted U-shaped vaginal flap to provide coverage of the suture lines closing the bladder neck. The flap is based superiorly and enough should be raised so that there is no tension on the suture line when the flap is advanced forward to the tissue margin just under the symphysis where the operation began. The mobile open posterior margin of the urethra is then sutured to the anterior bladder mobilized and pulled down toward the center of the operative field. The bladder neck is closed with a transverse suture line, which is then imbricated with a second suture line. If possible, a Martius flap should be placed over the closed bladder neck. The vaginal flap is then advanced to cover the entire area. Catheter drainage here is a two-edged sword since reflex bladder activity, which in these neurogenic conditions is accentuated by the catheter, tends to pull open the repair. A period of 5–7 days is enough to protect the closure. Catheters are the cause of the problem to begin with and a much better operative field results if all catheters are removed, despite the obvious consequences, 2 weeks or more prior to the operative procedure.

Fig. 7.12. Typical appearance of anterior complete urethral erosion. Here the distal third of the posterior urethra is also eroded

Egress from the ileovesicostomy if that procedure is used should occur at 10 cm or less detrusor pressure (Fig. 7.14). Once the catheter is removed from the ileovesicostomy and low leak point pressures from the stoma established, these systems tend to be very stable

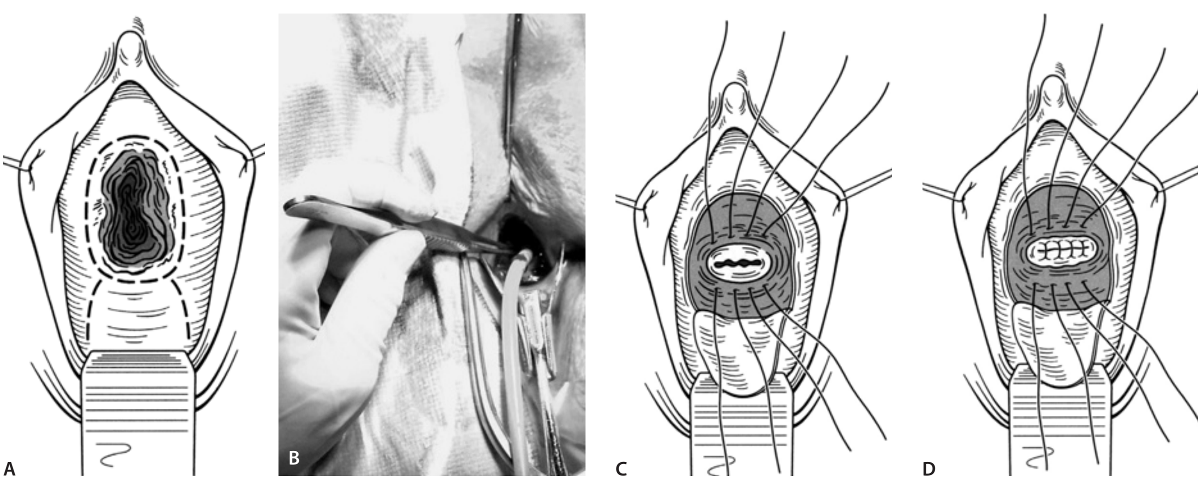


Fig. 7.13. A Incision lines to circumscribe the opening. **B** Dissection in the retropubic space to mobilize the anterior bladder wall and define the anterior margin of the defect to be closed, and posterior to the urethra to raise a vaginal flap to cover the urethral closure. **C** Initial suture line closure. **D** Second reinforcing suture line

Fig. 7.14. Postoperative study after an ileovesicostomy and crossed sling in a C4–5 spinal-injured patient. The bladder neck is shut and there is free low pressure flow from the ileal segment

Fig. 7.15. Leakage from the urethra despite a three-layer closure reinforced with a Martius flap

7.6.5 Failure of Urethral Closure

Failure of the urethral closure certainly occurs, but it does not mean that further attempts are futile. Indeed, persistence pays off here (Fig. 7.15).

7.6.6 Posterior Urethral Erosion and Tissue Loss

Posterior urethral erosion and tissue loss conditions with fistulization tend to be less extensive than anterior erosions and lend themselves to repair with salvage of urethra sphincter function. As noted above, these conditions can be associated with chronic Foley catheter drainage, but they also occur after urethral injury associated with surgical procedures on the urethra or bladder. The difference here seems to be partly related to our ability to close the urethra posteriorly with a sling. Closure of the anterior urethra so as to reconstruct a functional sphincter with any material that would be tolerated is virtually impossible, as there is no way to fix material to compress the urethra from that vantage point.

7.7 Procedure

The anterior vaginal wall is exposed and the open urethral fistula measured. The incisions are planned and marked out (Fig. 7.16A–E). The procedure is tailored to achieve enough tissue mobility to form a tubular urethra, which when closed is protected by a Martius flap and further reinforced with a broad autologous sling. The technique pictured is that of Jerry Blaivas, who devised it and explained to me how to do it [22]. The fistula is closed and the urethra formed over a catheter. The Martius flap is mobilized and brought down to cover the urethra. The final step is placement of a broad autologous sling. Unlike anterior erosions, posterior tissue loss can be reconstructed so that a functional urethral sphincter mechanism is recreated.

7.7.1 Intrinsic Sphincter Deficiency

Intrinsic sphincter deficiency (ISD) is defined by gynecologists with urethral profile data. If the maximum urethral closure pressure is less than 20 cm (sometimes 10 cm) then ISD is said to be present [23]. These profile values reflect activity of the midurethral high-pressure zone of the urethra and not closure of the proximal sphincter area. As such the condition ISD as defined by video urodynamics and leak point pressure testing is not the same condition as that defined by urethral pressure data [24, 25]. For example, by profilometry a patient with severe stress incontinence after an abdominal-perineal resection for rectal carcinoma would not have ISD as normal distal sphincter pressures, volitional and reflex activity, and normal pressures in the area are preserved.

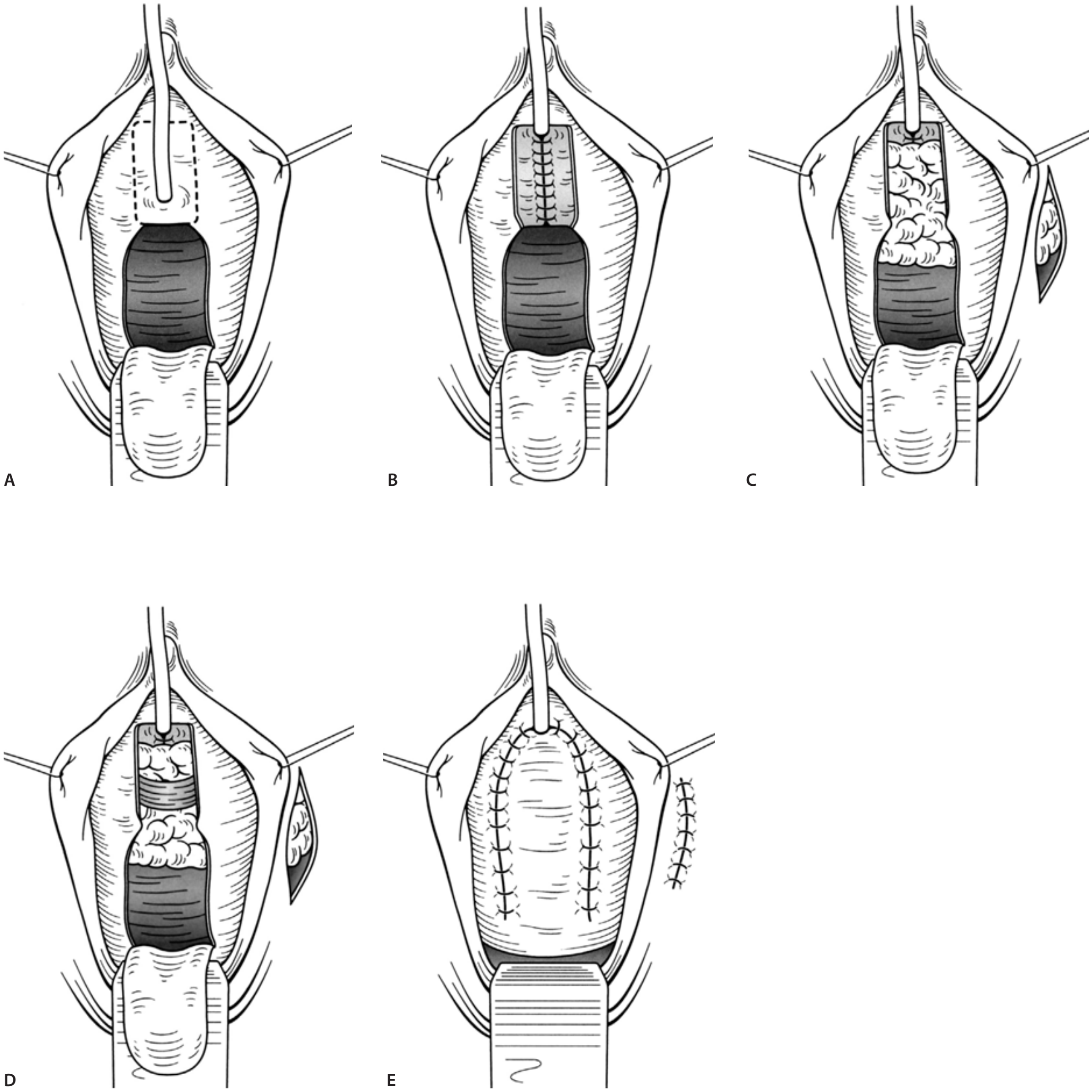


Fig. 7.16. A Posterior erosion delineation of suture lines. **B** Closed reconstituted urethral posterior wall. **C** Martius flap in place. **D** Sling in place. **E** Closed wound

By video urodynamics, ISD is found in about 9% of women with primary untreated stress incontinence [26]. Young women who develop severe stress incontinence immediately after labor and delivery usually have ISD, with variable urethral mobility but a low to very low leak point pressure (Fig. 7.17A, B) This kind of severe stress incontinence may be associated with vaginal prolapse and/or rectal sphincter incompetence as well. Where prolapse is present, MRI data may indicate loss of levator muscle bulk, and function, unilateral or bilateral [27]. That injury is independent of ISD-related stress incontinence, as either condition can exist alone without the other.

ISD is more common in women who have failed one or more operative procedures for stress incontinence (Fig. 7.18A–C); it is also moderately common in elderly women with new onset stress incontinence. In younger women with postpartum stress incontinence associated with a low abdominal leak point pressure, a crossed sling is the best method of repair. In women who have failed one or more prior operative procedures for stress incontinence, including those which incorporate synthetic material or bone anchors, autologous fascia is effective and safe. If possible, the sling should be crossed in front of the urethra.

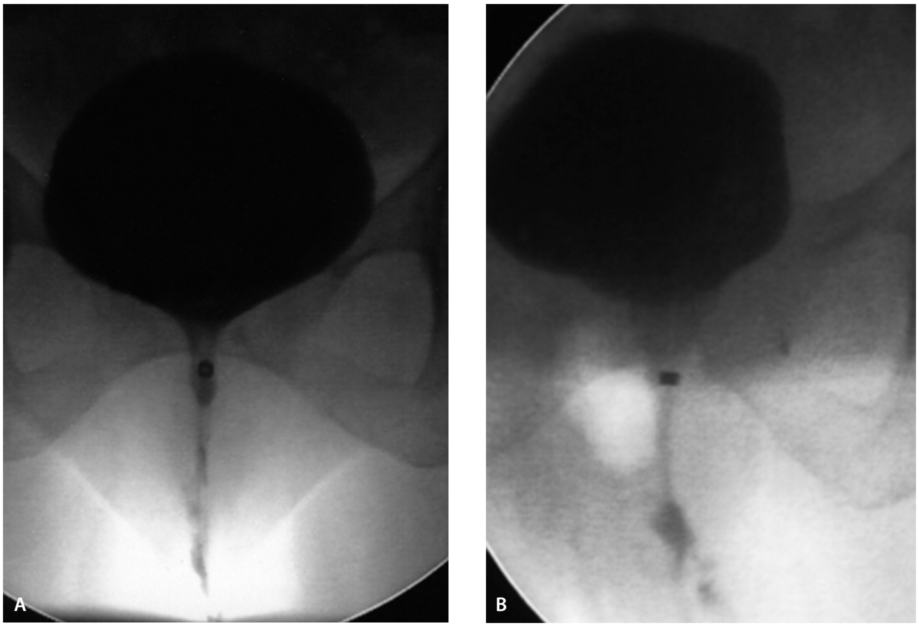


Fig. 7.17A. Video study from a 34-year-old woman with severe postpartum incontinence. Note the lack of urethral mobility. The Valsalva leak point pressure is 23. **B** Video study of a 65-year-old woman incontinent 6 months after removal of an eroded synthetic sling from the urethra

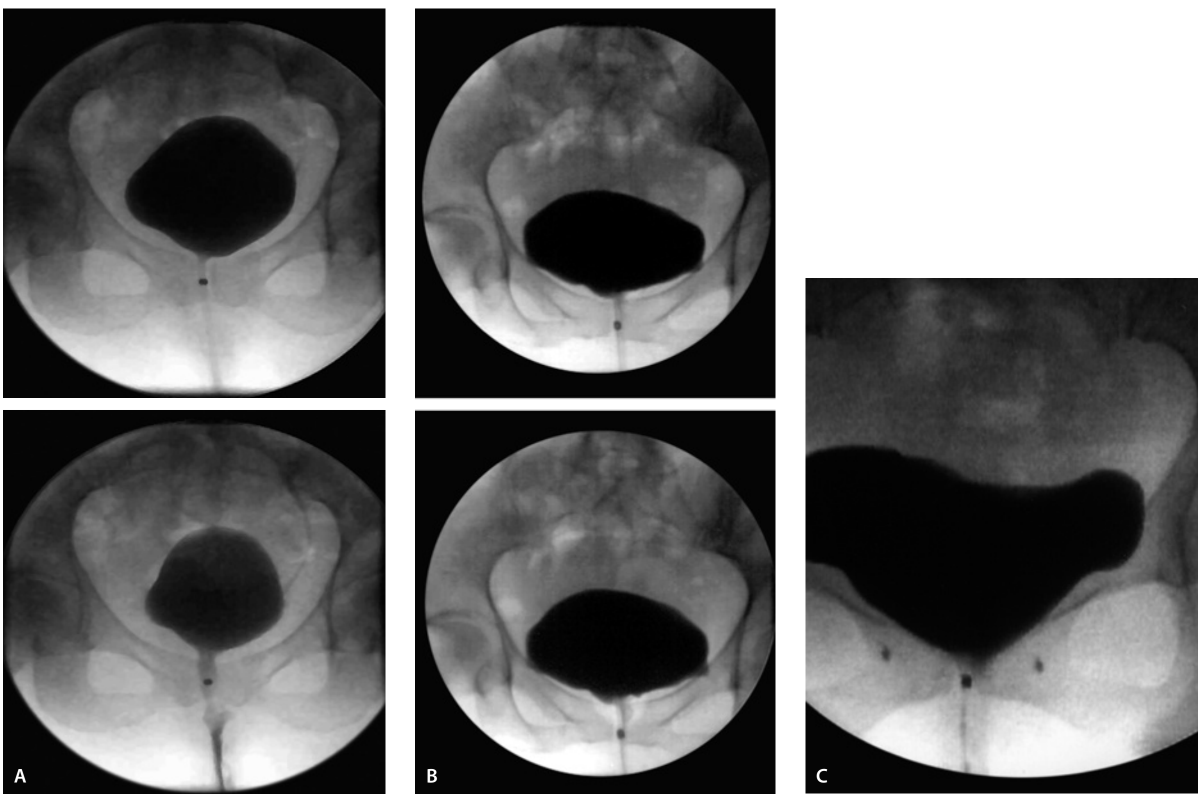


Fig. 7.18A. Recurrent stress incontinence despite a TVT. Note the tape position and partial compression of the urethra, but the urethra leaks at low pressure nevertheless. **B** Recurrent incontinence after a TVT. The tape is in good position but the urethra leaks at a relatively low abdominal pressure. **C** Recurrent stress incontinence after a bone-anchored cadaveric fascial sling. There is inadequate compression of the urethra

7.7.2 Pseudodiverticula

These are urethral mucosal outpockets formed as a result of an acquired defect in the periurethral fascia. This is the result of urethral suspension suture tearing the fascia or excision of fascia attendant to repair of a urethral diverticulum. A voiding cystourethrogram shows bilateral contrast-filled cystic structures [28] (Fig. 7.19). Endoscopy of the urethra demonstrates large mouth openings into mucosal sacculations (Fig. 7.20). Symptoms are leakage that sounds much like stress incontinence but tends to be after voiding. On the other hand, severe stress incontinence may be present quite independent of the diverticula's. In that case, the mucosal herniation is reduced and a fascial repair accomplished, or a fascial patch used to repair the defect, and the area reinforced with a broad autologous fascia sling (Figs. 7.21, 7.22).

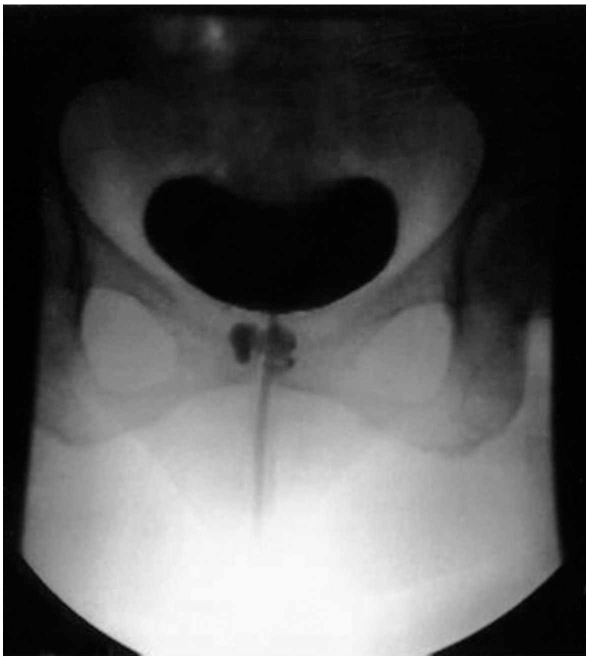


Fig. 7.19. Voiding cystourethrogram which shows bilateral pseudodiverticula

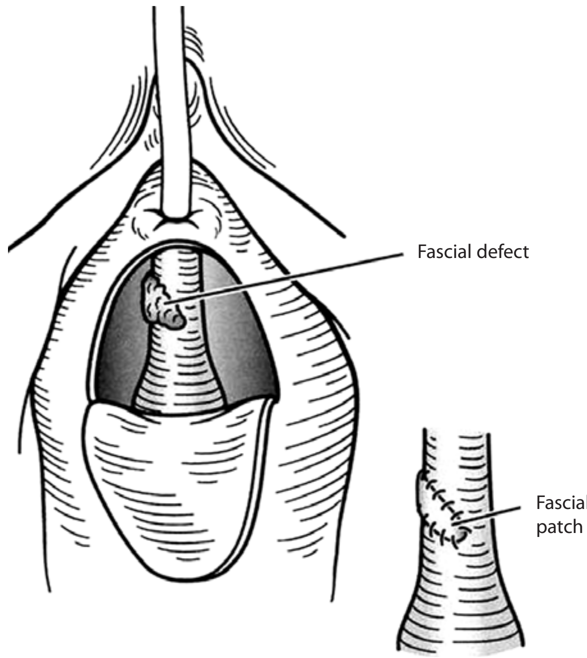


Fig. 7.21. Detail of reduction of the mucosal outpocket and applied fascia patch

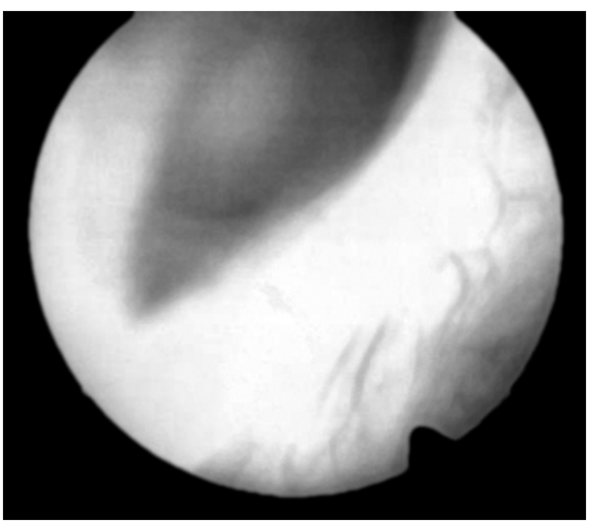


Fig. 7.20. Endoscopic view of the opening into the diverticulum on the left

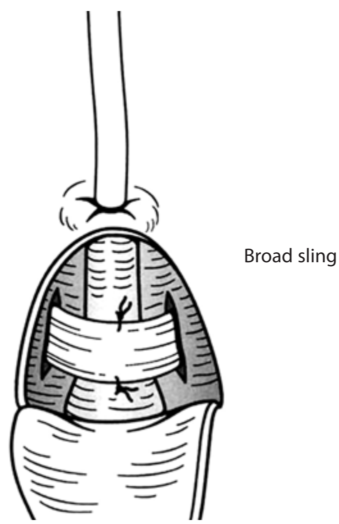


Fig. 7.22. A sling in place to support the repair

7

7.7.3 Primary Urethral Obstruction

Primary urethral obstruction is uncommon but a definite entity. The stricture process involves the distal urethra, and makes instrumentation difficult or impossible. The scar formation is circumferential, but is palpable posteriorly. The structured area impinges on the mid urethral sphincter zone but does not generally impair continence function. Often these patients have a history of repeated urethral dilations, and it is never clear whether the dilations caused the problem or were necessary because of the problem. Diagnosis is obvious. The meatus is hard to visualize and may be impossible to instrument even with a small probe. There is dense scar tissue in the plane between the urethra and vagina, which is easily palpated.

Repair involves urethra incision through the stricture area, careful removal of all scar tissue from the entire posterior surface of the urethra and advancement of a U-shaped vaginal flap into the area of the stricture (Fig. 7.23A–F).

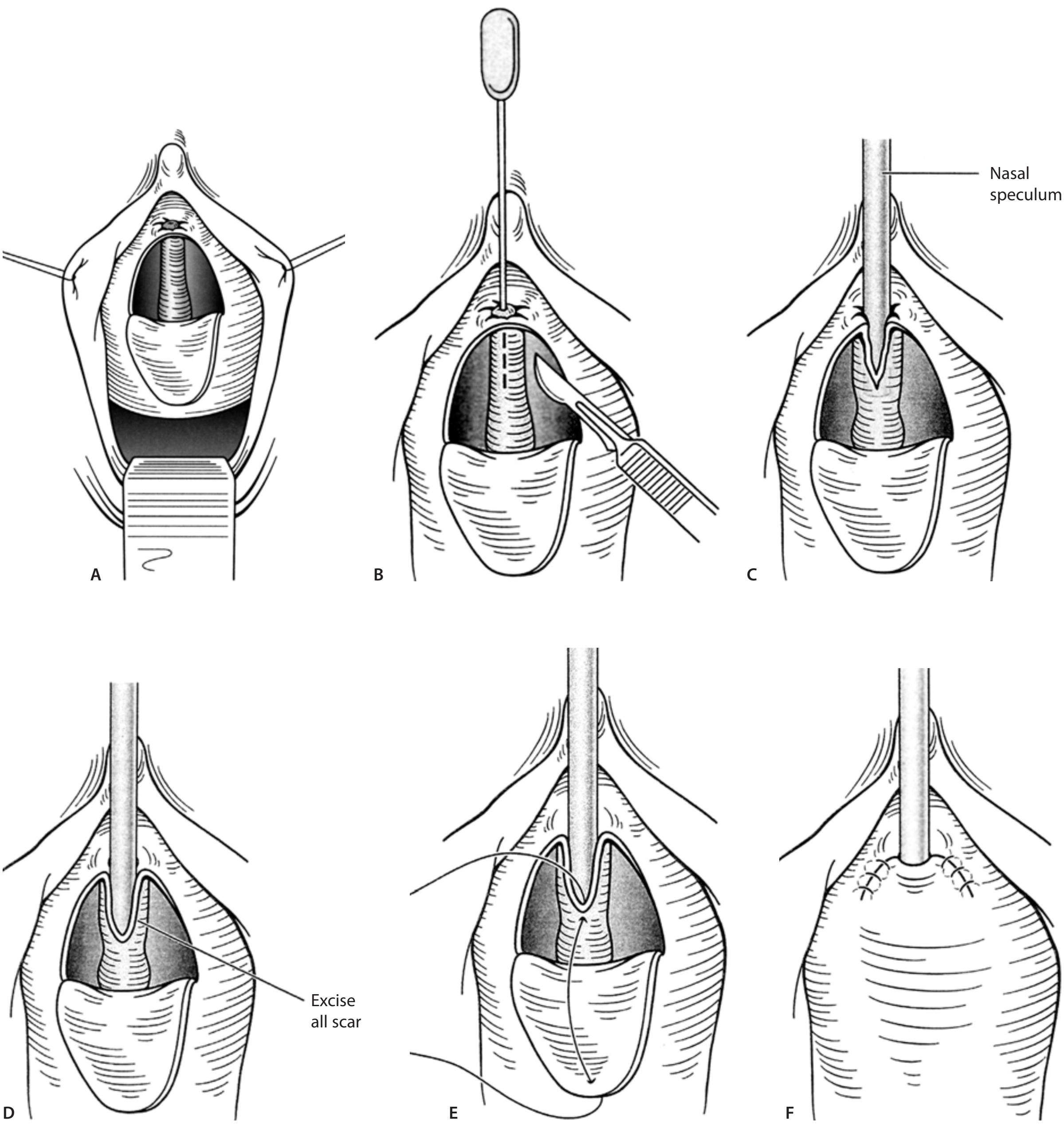


Fig. 7.23A–F. Diagrammatic representation of a flap repair of a distal urethral stricture. A vaginal flap is raised, the stricture incised completely and all scar removed from the posterior surface of the urethra. The flap is then advanced into the urethra

7.8 Urethral Problems After Stress Incontinence Surgery

Anterior colporrhaphy has a very low rate of postoperative voiding dysfunction, and almost never causes obstruction. On the other hand the procedure is rarely effective for stress incontinence.

The needle suspension procedure, or variations of the Pereyra procedure, are not done very often because of a reported high failure rate over time. These procedures are also rarely obstructive, and most of the problems related to the procedure, other than a lack of efficacy, are inflammatory or infectious reactions to materials used for the suspension.

Late erosion of suture material into the urethra or bladder can occur after needle suspension procedures with cutaneous or urethra vaginal fistulization. If this occurs a complete removal of all foreign material is required. Repair of the fistula is not required, as these heal spontaneously after the foreign body is removed.

The poor outcome with needle suspension procedures leads to efforts to combine the advantages of the needle suspension approach with the strength and durability of sling procedures. Materials used for slings vary but early attempts to use synthetic material were plagued by voiding dysfunction, obstructive uropathy, erosion into the urethra or bladder, vaginal bleeding, dyspareunia, pelvic pain, osteitis pubis, and occasionally osteomyelitis. These rather serious problems occurred with Gore-Tex slings, Vesica slings, and with various materials used for slings where bone anchor fixation of the device was utilized [29, 30, 31].

Problems specific to Gore-Tex include voiding dysfunction, obstructive uropathy, and erosion. Patients complain of vaginal bleeding, voiding dysfunction, and pain [32]. Most series reported in the literature suggest a 30%–40% removal rate after Gore-Tex slings. The nature of the material seems to encourage a dense inflammatory reaction. Removal is somewhat difficult. Palpation reveals a band-like structure deep to the vaginal tissue over the urethra. An inverted U vaginal incision is made and midline dissection over the urethra continued down to the sling, which is yellow-white in color and densely adherent to the urethra. The dissection required to identify the sling is deep into the tissue over the urethra, but injury to the urethra does not occur even though it often seems like it will. Once the material is encountered, the dissection is facilitated, and the entire strip, with the attaching sutures must be removed. This usually involves some sharp dissection together with some tugging. If a fistula is present it is not necessary to close it, as once the foreign body is gone it will heal with a few days of catheter drainage. After healing is complete and the inflammation mostly gone, one can expect severe stress incontinence to eventuate. Waiting a 12- to 15-week period before doing an autologous fascial sling, which is the only procedure to be done here, makes a very difficult procedure somewhat easier.

Problems specific to Vesica slings include pain, obstruction, voiding dysfunction, vaginal bleeding, and osteitis pubis or osteomyelitis [30]. The latter two problems are related to the bone anchors used to fix the sling to the superior surface of the pubis. Vaginal bleeding is very common and is related to granuloma formation related to infection of the sling, the sling sutures, or the bone anchors. Osteomyelitis a can be identified on a plain radiograph by the appearance of rarified bone around the anchor, or by a positive bone scan [26]. Cultures of this material when removed as well as cultures of the bone anchors grow *Staphylococcus epidermidis* almost invariably. Bone anchor removal is not easy and requires fluoroscopic localization and then persistence. The devices cannot be identified by feel; usually they are flush with the periosteum. Removal requires orthopedic instruments used for broken screw removal.

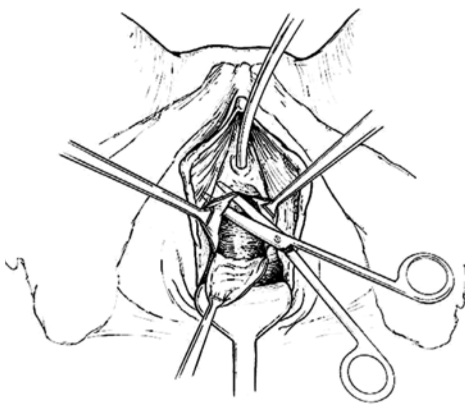
Erosion of the sling into the vaginal area is common, as is erosion into the urethra. Extraction varies in difficulty. Sometimes the device can be pulled from the urethra with a cystoscope and a grasping forceps. In other cases, a procedure like that described for the Gore-Tex sling is required. If only vaginal erosion has occurred and there is no problem with the bone anchors or the urethra, then recurrent stress incontinence is not very common. If urethral erosion has occurred, expect severe stress incontinence to redevelop.

Slings of synthetic material that are simply placed in the tissue with little or no tension, such as the TVT or SPARC, are much less likely to cause any of the problems enumerated above. Obstructive uropathy can occur, however, in which case the sling is simply cut beneath the urethra [31]. In cases of vaginal erosion, the protruding material is resected and the vagina reclosed. Erosion into the urethra and bladder can occur and if so the sling material in either area needs to be resected and removed.

Sling procedures using autologous fascia or other processed natural materials can also be associated with voiding dysfunction, obstructive uropathy, inflammatory reactions, vaginal bleeding and granuloma formation, and pain. While inflammatory reactions, pain and bleeding are not associated with autologous fascia, obstructive uropathy certainly can be. Patients with urgency frequency and incomplete emptying at 4–6 weeks should be evaluated for release of the sling. If the urethra is fixed against the posterior surface of the symphysis and immobile, in association with voiding dysfunction and/or urge incontinence, then the sling should be released. This requires that an inverted U incision be made in the vagina and the dissection carried down in the mid line until the sling is identified. A right-angle clamp is passed between the sling and the urethra and the sling transected in the mid line. Removal of the sling from the posterior surface of the urethra then completes the procedure. Sometimes free mobility of the urethra does not occur with partial sling excision, and detachment of the sling from the endopelvic fascia on either side of the urethra must be done as well. That simply requires sharp entry into the retropubic space on either side of the urethra, as is done to prepare for Raz-type needle suspension [33–35] (Fig. 7.24 A, B).

Other materials used for slings can be dealt with in exactly the same manner as described for autologous fascia. The exception is in those cases where bone anchors have been placed transvaginally into the posterior surface of the symphysis. These can become infected; vaginal granulation tissue can develop, together with severe pelvic pain. This may result from infected suture material or active osteomyelitis. Removal of the sling is relatively easy and very similar to the method used to remove any foreign body. Suture removal requires some searching and considerable tugging and dissection, but is also relatively easy. The bone anchors are a more difficult problem. These are inaccessible from a vaginal incision, not palpable, and even with fluoroscopy, they are difficult to find. A full retropubic exposure with fluoroscopy is necessary to remove these.

Retropubic suspensions are as likely to be associated with voiding dysfunction as slings, and restoration of normal voiding by an urethrolysis is more difficult than after a sling. There is often considerable scarring involved in these cases, and achievement of urethral mobility alone may not completely resolve the problem. Patients complain of incomplete voiding such that intermittent catheterization may be required. Urgency, urge incontinence, and voiding only in certain positions that take tension off the urethra are typical symptoms. The bladder neck and urethra are typically tightly adherent to the posterior aspect of the symphysis, and the vaginal wall is pulled forward as well; even when the patient in the operating room is placed in the lithotomy position with the head down visualization of the anterior vaginal wall over the urethra may be difficult. Via an inverted U incision, the urethra is mobilized laterally as if one were starting a Raz-type needle suspension (Fig. 7.24A, B). The dissecting scissors are advanced through the endopelvic fascia and entry to the retropubic space gained. Palpation in the area on both sides will reveal the suture fixation points, which need to be divided sharply one by one. Generally there are six such points. If mobility of the urethra is achieved by this method one may stop. That is not usually the case, and dissection along the later edge of the urethra to the posterior surface of the symphysis is the next step. If that does not seem to be enough a dissection plane anterior to the urethra is created, and the entire upper two-thirds of the urethra is freed from the pubis. The final step in stubborn cases is careful sharp excision of all scars from the posterior surface of the urethra (Fig. 7.25). This starts with a transverse incision in the



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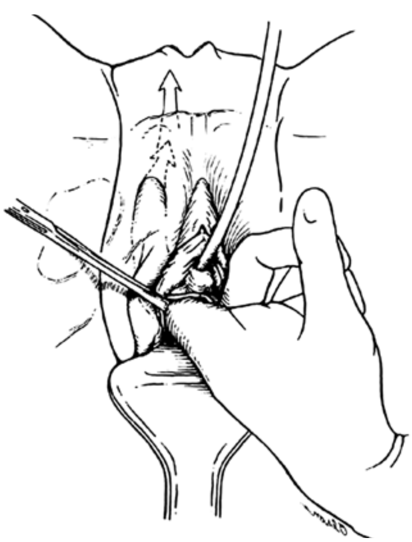


B

Fig. 7.24A, B. Detail of a urethrolysis with entry into the retropubic space and blunt dissection to free the urethra from the suspension sutures or material

Fig. 7.25. Operative photo after circumferential urethrolysis. There is thick scar over the entire posterior surface of the urethra. This should all be removed

scar just proximal to the external meatus and then sharp peeling away of the scar from the underlying soft urethral wall. If possible, one can wrap the fully mobilized urethra in a Martius flap in an effort to prevent recurrent scarring, which can occur despite full mobilization of the urethra.

References

1. Woodside JR, McGuire EJ (1979) Urethral hypotonicity after suprasacral spinal cord injury. J Urol 121:783–785
2. McGuire EJ, Wagner FC (1977) The effects of sacral denervation in bladder and urethral function. Surg Gynecol Obstet 144:343–346
3. McGuire EJ, Savastano JA (1985) Urodynamics and management of the neuropathic bladder in spinal cord injury patients. J Am Paraplegia Soc 8:28–32
4. Blaivas JG, Barbalias GA (1983) Characteristics of neural injury after abdominoperineal resection J Urol 129:84–87
5. McGuire EJ, Morrissey SG (1982) The development of neurogenic vesical dysfunction after experimental spinal cord injury or sacral rhizotomy in the nonhuman primate. J Urol 128:1390–1393
6. McGuire EJ (1988) Myelodysplasia. Semin Neurol 8:145–149
7. Light JK, Pietro TJ et al (1986) Alteration in detrusor behavior and the effect on renal function following implantation of the artificial sphincter. J Urol 136:632–635
8. Wang SC, McGuire EJ, Bloom DA (1989) Urethral dilation in the management of urological complications of myelodysplasia. J Urol 142:1054–1055
9. Bloom DA, Knechtel JM, McGuire EJ et al (1990) Urethral dilation improves bladder compliance in children with meningomyelocele and high leak point pressures. J Urol 144:430 –433
10. Park JM, McGuire EJ, Koo HP et al (2001) External urethral sphincter dilation for management of high risk meningomyelocele – 15 years experience. J Urol 165:2383–2388
11. Waters PR, Chehade NC, Kropp KA (1997) Urethral lengthening and reimplantation evaluation and management of catheterization problems. J Urol 158:1053–1056
12. Parres JA, Kropp KA (1991) Urodynamic evaluation of the continence mechanism following urethral lengthening – reimplantation and enterocystoplasty. J Urol 146:535–538
13. Gormley EA, Bloom DA, McGuire EJ et al (1994) Pubovaginal slings for the management of urinary incontinence in female adolescents. J Urol 152:822–825
14. Raz S, McGuire EJ, Ehrlich RM et al (1988) Fascial sling to correct male neurogenic sphincter incompetence. J Urol 139:528–531
15. Leng WW, McGuire EJ (1999) Reconstructive surgery for urinary incontinence. Urol Clin North Am 26:61–80
16. Gosalbez RJ, Castellan YN (1990) Urinary incontinence in myelodysplastic children. What ids the role of the bladder neck sling. Arch Espan Urol 51:595–603
17. Walker RD, Flack CE, Hawkins-Lee B et al (1995) Rectus fascial wrap: early results of a modification of the rectus fascial sling. J Urol 154:771–774
18. Scott FB, Fishman IJ, Shabsigh R (1986) The impact of the artificial urinary sphincter in the neurogenic bladder on the upper urinary tracts. J Urol 136:636–642
19. Heitz M, Olianas R, Schreiter F (1997) Therapy of female incontinence with the AMS 800 artificial urinary sphincter. Indications, outcome, complications and risk factors. Urologe (A) 36:426–431
20. Wan J, McGuire EJ (1990) Augmentation cystoplasty and closure of the urethra for the destroyed urinary tract. J Am Paraplegia Soc 13:40–45
21. English SF, Pisters LL, McGuire EJ (1998) The use of the appendix as a continent catheterizable stoma. J Urol 159:747–749
22. Blaivas JG, Heritz DM (1996) Vaginal flap reconstruction of the urethra and vesical neck in women: a report of 49 cases. J Urol 155:1014–1017
23. Pajoncini C, Constantini E, Guercini F et al (2002) Intrinsic sphincter deficiency: do the maximum urethral closure pressure and the Valsalva leak point pressure identify different pathogenic mechanisms? Int Urogyn J 13:30–35
24. Ghoniem GM, Elgamasy AN, Elsergany R et al (2002) Grades of intrinsic sphincter deficiency (ISD) associated with female stress incontinence. Int Urogyn J 13:99–105
25. Lose G, Brostrom S (2002) Low pressure urethra in women: what does it mean and what can it be used for? Int Urogyn J 13:215–217
26. McGuire EJ (1981) Urodynamic findings in patients after failure of stress incontinence operations. Prog Biolog Res 78:351–.60
27. DeLancey JO, Kearney R, Chou Q et al (2003) The appearance of the levator ani muscle abnormalities in magnetic resonance images after vaginal delivery. Obstet Gynecol 101:46–53
28. Leng WW, McGuire EJ (1998) Management of female urethral diverticula: a new classification. J Urol 160:1297–1300
29. Chin YK, Stanton SL (1995) A follow up of silastic sling for genuine stress incontinence. Brit J Urol 102:143–147
30. Clemens JQ, DeLancey JO, Faerber GJ, Westney OL, McGuire EJ (2000) Urinary tract erosions after synthetic pubovaginal slings: diagnosis and management strategy. Urology. 56:589–594
31. Klutke C, Siegel S, Carlin B, Paszkiewicz E, Kirkemo A, Klutke J (2001) Urinary retention after tension-free vaginal tape procedure: incidence and treatment. Urology 58:697–701
32. Weinberger MW, Ostergard DR (1996) Postoperative catheterization, urinary retention, and permanent voiding dysfunction after polytetrafluroethylene suburethral sling placement. Obstet Gynecol 87:50–54
33. Cespedes RD (2001) Treatment options for outlet obstruction following anti-incontinence surgery in females. [Review] [20] Tech Urol 7:118–125
34. Amundsen CL, Guralnick ML, Webster GD (2000) Variations in strategy for the treatment of urethral obstruction after a pubovaginal sling procedure. J Urol 164:434–437
35. Nitti VW, Carlson KV, Blaivas JG, Dmochowski RR (2002) Early results of pubovaginal sling lysis by midline sling incision. Urology 59:47–51

A Current Overview of the Treatment of Urethral Strictures: Etiology, Epidemiology, Pathophysiology, Classification, and Principles of Repair

S.M. Schlossberg

8.1 Urethral Strictures

Urethral stricture generally refers to anterior urethral disease, or a scarring process involving the spongy erectile tissue of the corpus spongiosum (spongiofibrosis) (Fig. 8.1). The spongy erectile tissue of the corpus spongiosum lies under the urethral epithelium and the scarring process can extend through the tissues of the corpus spongiosum into adjacent tissues, reducing the urethral lumen. Although anterior urethral stricture disease can initially be asymptomatic, it is generally associated with marked voiding symptoms, as scar contraction continues to reduce the lumen diameter.

In contrast, posterior urethral stricture – not included in the common definition of urethral stricture – results from an obliterative process in the posterior urethra that has caused fibrosis, and is generally the result of a distraction injury caused by either trauma or radical prostatectomy. This chapter discusses the pathophysiology and diagnosis and evaluation of urethral strictures and general reconstructive surgical techniques.

8.1.1 Pathophysiology

Any process that injures the urethral epithelium or the underlying corpus spongiosum to the extent that healing results in a scar can cause a urethral stricture.

8.1.2 Congenital Urethral Strictures

The term »congenital stricture« has been used to define a stricture with no identifiable etiology; however, a stricture can only be defined as congenital if it is not inflammatory in nature, is of short length, and is not associated with a history of, or potential for, urethral trauma. These limitations restrict use of the term »congenital stricture« to strictures of the anterior urethra found in infants at a natural place in embryological development where a fusion of structures occurs (i.e., the posterior and anterior urethra) before they have attempted erect ambulation. So defined, congenital strictures are rare.

8.1.3 Acquired Urethral Strictures

8.1.3.1 Infectious Strictures

Inflammatory strictures associated with gonorrhea are much less common now than in the past. With the use of prompt and effective antibiotic treatment, gonococcal urethritis now progresses less often to gonococcal urethral strictures; however, the place of chlamydia and *Ureaplasma urealyticum* (i.e., nonspecific urethritis [NSU]) in the development of anterior urethral strictures is unclear.

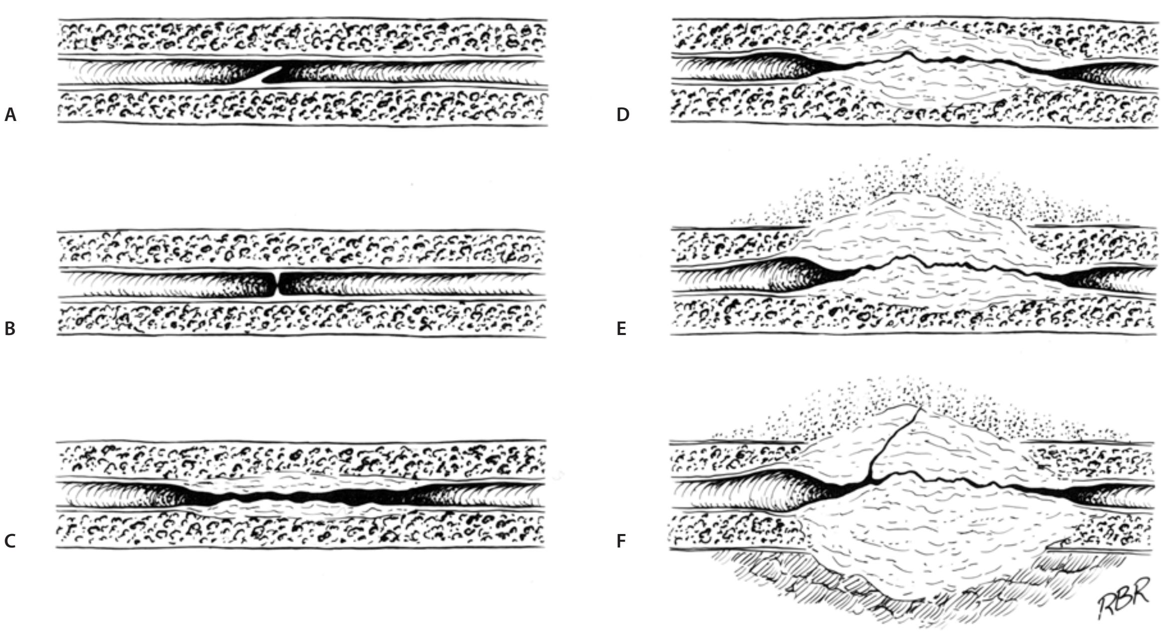


Fig. 8.1A–F. The anatomy of anterior urethral strictures. **A** Mucosal fold. **B** Iris constriction. **C** Full-thickness involvement with minimal fibrosis in the spongy tissue. **D** Full-thickness spongiofibrosis. **E** Inflammation and fibrosis involving tissues outside the corpus spongiosum. **F** Complex stricture complicated by a fistula. This can proceed to the formation of an abscess or the fistula may open to the skin or the rectum (Adapted from Jordan, Problems in Urology, Vol. 1, 1987)

8.1.3.2 Inflammatory Urethral Strictures

There has been a recent increase in strictures associated with balanitis xerotica obliterans (BXO), which are more like inflammatory strictures than isolated, traumatically induced scars. BXO usually begins with inflammation of the glans and generally leads to meatal stenosis, if not a true stricture of the fossa navicularis. Although the cause of this distal penile skin and urethral inflammation is unknown, recent literature suggests the possibility of bacterial infection with resultant skin changes. There is also some evidence that the progression of the stricture to eventually involve the entire anterior urethra may be caused by high-pressure voiding that leads to intravasation of urine into the glands of Littre, inflammation of these glands, and micro abscesses and deep spongiofibrosis (▫ Fig. 8.2). Whether the urethral changes and fibrosis are also related to bacterial injury has not been well defined.

8.1.3.3 Environmental Strictures

Thermal, chemical, and electrical burns and exposure to radiation make up the environmental sources of urethral injuries that can lead to strictures. The emergency treatment of thermal burns to the genitalia is similar to that for any burn; however, extensive debridement should be approached cautiously, with the goal of preserving as much viable tissue as possible. Thermal and chemical burns to the genitalia are treated similarly to any burn, whereas management of electrical burns to the genitalia involve suprapubic urinary diversion, followed by amputation or debridement to the proximal limit of deep tissue destruction with later reconstruction.

Radiation injury to the genitalia can occur either as a direct result of radiation exposure, or indirectly, as the result of radiation on the venous and lymphatic drainage.

▫ **Fig. 8.2.** Urethrogram in a patient with urethral stricture disease secondary to balanitis xerotica obliterans. The area of inset illustrates the intravasation of contrast during voiding into the dilated glands of Littre

Although direct radiation to the genitalia is uncommon, occasionally a patient will present with a small (2- to 3-cm), superficial, noninvasive, malignant lesion of the glans penis or coronal sulcus, who elects small-field electron beam radiotherapy vs partial penectomy. Although there are generally few problems with these patients, others who have had direct radiation exposure to the penis can present with progressive gangrene of the genitalia, requiring debridement and, in some cases, partial penectomy. In addition, radiotherapy to the pelvis can cause chronic lymphedema, with the patients often presenting with hydroceles as well. In contrast to direct radiation exposure, chronic lymphedema is considered a highly treatable condition, usually involving excision of the lymphedematous tissue and primary reconstruction.

8.1.3.4 Traumatic Urethral Strictures

Most urethral strictures are the result of trauma (usually straddle trauma) which often goes unrecognized until the patient presents with voiding symptoms resulting from a stricture. Trauma can occur in nonpenetrating, penetrating, amputation, or avulsion injuries. Although iatrogenic trauma to the urethra still occurs, with the development of small endoscopes and the limitation of indications for cystoscopy in the juvenile male, it occurs less frequently than in the past.

Nonpenetrating Injuries

Nonpenetrating injures to the genitalia can result from a crushing or sudden deforming force to the penis (i.e., blunt trauma, contusion, or fracture of the corpora or urethra) that causes severe damage to the internal structures without disrupting the skin. Whenever the penis is injured or a straddle trauma to the perineum or scrotum occurs, a urethral injury should be suspected and evaluated.

The term »fracture of the penis« implies disruption of both laminas of the tunica albuginea of the corpora cavernosa, usually with disruption of Buck's fascia. These fractures typically occur during vigorous intercourse. In some cases, a snap may be heard, with immediate onset of pain, swelling, and detumescence as the penis buckles. In other cases, the patient will notice immediate onset of pain with subsequent painful erections, but there will be minimal swelling, no immediate detumescence, and often only a small ecchymotic area of injury. In these patients, it is believed that there is either a disruption of the outer lamina of the tunica albuginea or a disruption of both lamina of the tunica albuginea, with Buck's fascia left intact. Often, these patients have a delayed presentation, with the complaint of lateral curvature and indentation or induration of the penis on erection. Patients who describe an injury descriptive of penile fracture should be examined and evaluated; it is important not to confuse this injury with Peyronie's disease.

Penetrating Urethral Injuries

Penetrating injuries to the penis frequently involve the urethra, with management depending on the source of the trauma. Injuries from a low-velocity source require exploration, irrigation, removal of foreign material and anatomical repair. With sharp laceration, or laceration via a low-velocity projectile, primary reconstruction is indicated. With a high-velocity projectile, suprapubic diversion and delayed reconstruction may be required.

Amputation Injuries

Amputation injuries to the penis are ideally treated with microreimplantation. However, in some cases of penile amputation, the distal portion of the organ has either been thrown away by an assailant or has not been found; these patients should be treated as though they have undergone partial penectomy.

Avulsion Injuries

Avulsion injuries of the genitalia occur when the loose, elastic genital skin becomes entangled. This occurs most frequently when clothing has become caught in rotation machinery or when a patient is involved in an accident in which the clothing is traumatically ripped from his body. Occasionally, avulsion injuries are caused by suction devices used for sexual arousal. The severity of avulsion injuries can vary form minimal injuries to emasculating injuries that involve the deep structures; appropriate management therefore involves a complete evaluation.

8.2 Diagnosis and Evaluation of Urethral Strictures

Patients with urethral strictures most often present with obstructive voiding symptoms or urinary tract infections, such as prostatitis or epididymitis; some will also present with urinary retention. On close inquiry, many of these patients have tolerated obstructive voiding symptoms for prolonged periods before progressing to complete obstruction.

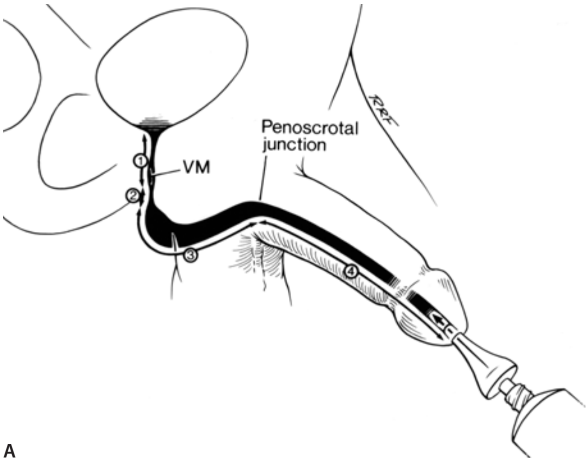
If a patient cannot void, an attempt should be made to pass a urethral catheter; if the catheter does not pass, dynamic retrograde urethrography should be performed to determine the nature of the obstruction. Most cases are managed with acute dilation; however, this is not the best treatment course in many cases. If the appropriateness of management with acute dilation is unclear, a suprapubic cystostomy catheter should be placed acutely while an appropriate treatment plan is devised. Although detailed imaging is not always available, flexible endoscopy is almost universally available in the US, and the stricture can at least be visualized and a guidewire passed through the lumen under direct vision. The practice of blind passage of filiforms and blind dilation without knowledge of the anatomy of the urethral stricture is no longer acceptable medical practice.

Knowledge of the location, length, depth, and density of the stricture (i.e., spongiofibrosis) are critical to planning appropriate treatment. Radiographs, urethroscopy, and ultrasound can be used to determine stricture location and length; physical examination and ultrasound will reveal the depth and density of the scar in the spongy tissue. The appearance of the urethra can be determined in contrast studies and the amount of elasticity noted on urethroscopy.

Contrast studies of the urethra are best carried out under the direct supervision of the treating surgeon. Radiographic studies should be dynamic vs static, best accomplished by imaging during retrograde injection of contrast material and while the patient is voiding (▣ Fig. 8.3A, B). It should be kept in mind that more than one projection may be necessary to visualize a stricture with contrast urethrography (▣ Fig. 8.4). Even using a gentle technique, extravasation during retrograde urethrography can occur in patients with a markedly inflamed urethra (▣ Fig. 8.5); therefore, only contrast material suitable for intravenous injection should be used. Contrast materials thickened with lubricating jelly can be problematic and do not significantly enhance radiographic studies; however, real-time ultrasound evaluation of the bulbous urethra filled with a lubricating jelly may allow more accurate determination of stricture length, which could be important when planning an anastomotic repair.

Endoscopic examination may be required after contrast studies. Use of a flexible cystoscope has simplified this evaluation, and minimal discomfort is associated with the procedure when local anesthesia is administered. The scope can be passed to the stricture – it is usually unnecessary to pass it beyond that level. It is generally not necessary or beneficial to dilate the stricture at the time of the initial endoscopic evaluation. Pediatric endoscopic equipment is valuable for examining the urethra proximal to a narrow-caliber area without dilation and, in a patient who cannot void and has a suprapubic tube, combined contrast studies with endoscopy can help define the stricture anatomy.

In contrast, to ensure that all the involved urethra is included in the reconstruction, it is imperative to completely evaluate the urethra proximal and distal to the stricture with endoscopy and bougienage during surgery. Although hydraulic pressure generated by voiding can keep segments proximal to the stricture patent, unless they are included in the repair, they are at risk for contraction after the narrow-caliber segment obstruction is relieved with reconstruction. Therefore, areas of the urethra proximal to a narrow-caliber segment of the stricture must be treated with suspicion. If the lumen does not appear to demonstrate evidence of diminished compliance, it is presumed to be uninvolved in active stricture disease; however, coning down of the urethra suggests scar involvement.



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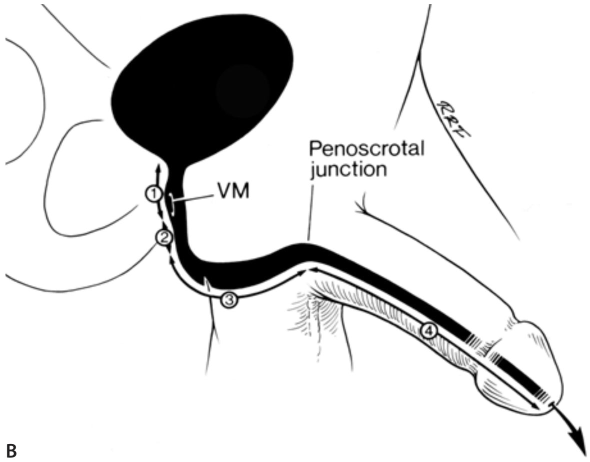

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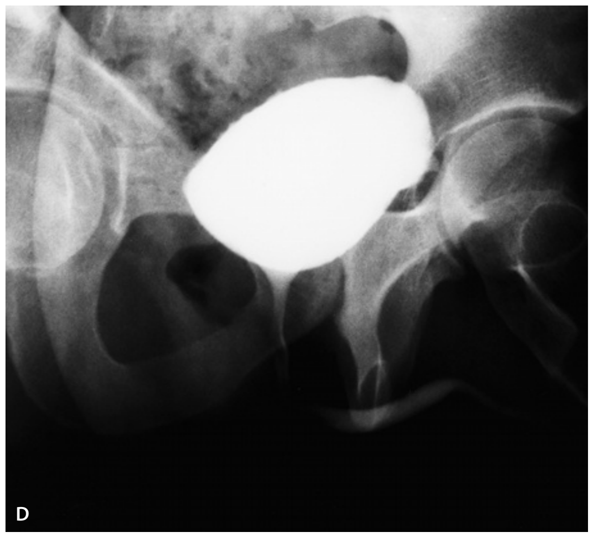

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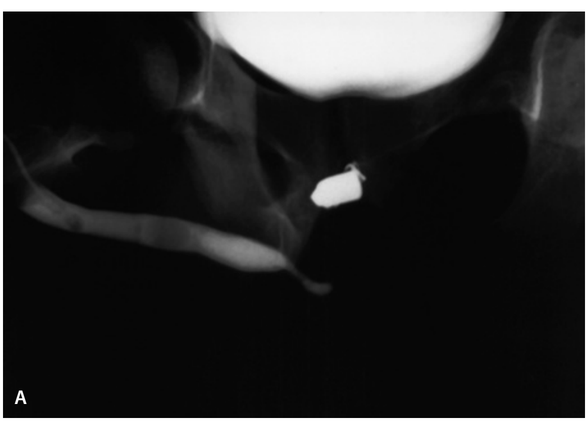
Fig. 8.3. A Diagram of dynamic retrograde urethrogram. **B** Diagram of a dynamic voiding urethrogram. (Adapted from McCallum Urol. Clinics N.A., 1979) **C** Normal retrograde urethrogram. **D** Normal voiding urethrogram.



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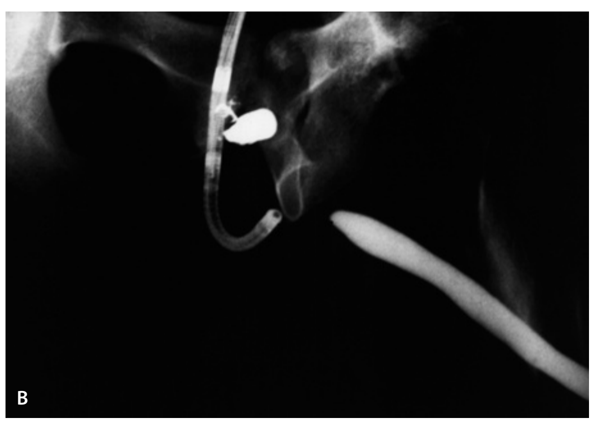

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Fig. 8.4A, B. Retrograde urethrogram. **A** A right posterior oblique dynamic retrograde urethrogram does not define the situation; contrast material flows past an irregular area in the posterior bulb and through the tonic external sphincter outlining the verumontanum. **B** A left posterior oblique dynamic retrograde urethrogram shows the stricture in the same patient with intervening diverticulum

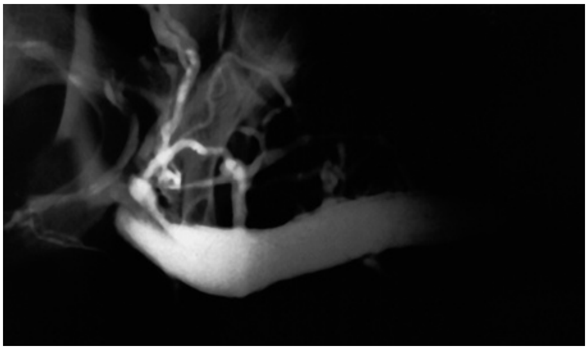


Fig. 8.5. Venogram of the penis, pelvis, and inferior vena cava following gentle retrograde urethrogram

The potential for continued constriction after reconstruction in the urethra proximal to a narrow area may be unclear in some patients. In select patients, a suprapubic tube placed to defunctionalize the urethra is useful. If an area that was hydrodilated with voiding is going to be constricted, it should be apparent after 6–8 weeks.

8.3 Reconstructive Surgical Techniques

In addition to proper diagnosis and planning, the surgical technique adds to the overall success of reconstructive surgery. Unlike extirpative surgery, the surgical results are dependent on methods that minimize tissue damage and maximize wound healing. The key ingredients are adequate visualization, appropriate choice of suture, delicate tissue handling, appropriate positioning, and adequate retraction.

8.3.1 Visualization

Adequate visualization is essential and surgical loupes are used by most adult reconstructive genital surgeons. In an adult, 2.5× magnification is generally sufficient; however, 3.5× magnification is occasionally necessary. A headlight or suction with attached light aids visualization in deep perineal surgery.

8.3.2 Cautery

Both monopolar and bipolar cautery can be appropriate depending on the procedure. Monopolar cautery can be used in superficial structures, whereas bipolar is better during dissection around the corpus spongiosum, elevation of penile and scrotal flaps, division of the perineal intracorporal space, and dissection of the dorsal neurovascular structures. Bipolar cautery is also used exclusively in penile cases such as reconstruction of the fossa navicularis or correction of penile curvature.

8.3.3 Instrumentation

To minimize tissue injury from manipulation and permit more precise dissection in genital reconstructive surgery, appropriate instruments are those typically used for plastic or peripheral vascular surgery, including fine tenotomy scissors, fine forceps, skin hooks, and delicate needle holders. In addition, bougie à boule sizers (V. Mueller) are needed to check the caliber of the urethral lumen. McCrea urethral sounds are a good addition to the typical Van Buren sounds available in the usual operating room; however, sounds do not replace the need for bougie à boule for calibration. A sound to pass through the cystostomy tract and prostate to find the proximal end for the reconstruction (e.g., Haygrove sound) is also helpful for posterior urethral reconstruction.

8.3.4 Sutures

The choice of suture material clearly evolves based on the surgeon's experience and bias; however, absorbable suture is the rule in urethral surgery. Most surgeons choose braided absorbable sutures or a monofilament absorbable suture. Chromic is rarely used now because other absorbable sutures are generally superior. Small sutures can be used for tension-free closures; however, tying the suture can be awkward in some cases and a larger suture may be necessary even for a tension-free anastomosis. The caliber of suture should be the smallest possible to line up the tissue, as there is no reason to use suture that is stronger than the tissues being sutured. Fine suture such as 6-0 chromic or polyglactic acid can be used to suture the epithelium to the adventitia of the corpus spongiosum; 4-0 to 6-0 suture is usually adequate for a flap or graft repair. For primary anastomosis of the corpus spongiosum or a posterior urethral reconstruction, 3-0 suture may be appropriate because of tying concerns. The needle should be tapered except when severe spongiofibrosis or scarring is present (e.g., urethroplasty). Commonly used taper needles include the RB-1, TF, or SH-1; cutting needles include P-3 and PC-3. The UR-6 1/2 circle taper needle (often used in radical prostatectomy) can be helpful for deep perineal anastomoses of the urethra.

8.3.5 Surgical Positions

Surgical position and retraction are important for good results. Whenever possible, the patient should be in the supine or split leg position. The time spent in the lithotomy or exaggerated lithotomy position should be minimized; however, appropriate padding for the foot and positioning without pressure on the back of the leg will reduce the incidence of complications with the low lithotomy position. Venous compression stockings can be used for the supine, split leg, or low lithotomy positions. Use of the exaggerated lithotomy position is controversial. The author prefers this position for bulbar and posterior urethral reconstructions, while other surgeons use a lower lithotomy position. However, the more exaggerated position is safe and provides unequaled access to the deep perineal structures. To minimize time in the exaggerated position, all graft harvest or flap elevation is performed with the position in the flat supine position. For penile surgery, a Scott retractor with stay hooks is often helpful and either a Denis-Browne ring retractor modified to accept Scott stay hooks or the Jordan-Bookwalter retractor set provide excellent exposure.

References

McCallum RW (1979) The adult male urethra. Urol Clinics of North Am 17:227–244

Therapy, Principles

The Acute Posterior Urethral Injury

J. Latini, J.T. Stoffel, L. Zinman

Posterior urethral disruption and distraction injuries present the most devastating and formidable challenges to the reconstructive urologic surgeon dealing with urinary tract trauma. Subprostatic pelvic fracture urethral distraction defects represent a traumatic disruption in continuity with minimal loss of urethra but with displacement of the two ends in the anteroposterior or cephalocaudal planes. Historical reports of surgical care of this injury are replete with management techniques resulting in lifelong sequelae of recurrent stricture, incontinence, and erectile dysfunction. The development and refinement of anastomotic techniques to restore continuity to the urethra, magnetic resonance imaging to identify and define the injury, duplex ultrasound to avoid and understand the vascular injuries, and a revised classification have impacted and affected the successful outcomes now achieved in resolving this injury. The long-standing controversy surrounding initial management by early intervention with primary realignment vs delayed surgical repair after preliminary cystotomy diversion remains a contentious debatable issue, with reported success with alignment over a stenting catheter varying between 15% and 94% [1]. Advocates of either approach to surgical care of this injury have traditionally focused on the development of impotence and incontinence as a potential complication of the surgical technique. However, it is increasingly evident that the length of the distraction defect and subsequent development of incontinence and impotence are related more to the severity of the injury and the extent of the anatomical disruption, both bony and soft tissue, rather than the surgical approach itself [2, 3].

9.1 Anatomy and Pathogenesis of the Urethral Injury

Pelvic fractures are the major source and etiology of posterior urethral distraction injuries, occurring at a rate of 20 per 100,000 population. Motor vehicle and motorcycle injuries are associated with the highest incidence of pelvic fractures (15.5%) followed by pedestrian injuries (13.8%), falls from heights greater than 15 ft (13%), car occupants (10.2%), and occupational crush trauma (6%). The majority of injuries occur in the first four decades, with a mean age of 33 years including an 8% pediatric occurrence (<12 years).

Pelvic fractures are a marker of severe post-traumatic injury and are associated with intra-abdominal and urogenital injuries in 15%–20% of patients. The most commonly injured organ in pelvic fractures is the posterior urethra (5.8%–14.6%), followed closely by the liver (6.1%–10.2%) and the spleen (5.2%–5.8%) [4]. The bladder and bladder neck are frequently involved, and injury to these structures needs to be identified and included in the equation of the surgical strategy. Associated perforation injury of the rectum is critical to identify but rarely seen with pelvic fracture trauma [17]. The life-threatening injuries take precedence in diagnosis and management over the urethral injury, but in those patients who survive, the urethral injury will be the source of chronic complex disability and morbidity. Urinary incontinence in the male depends on the bladder neck proximally and the external sphincter distally. The distal external sphincter mechanism may be destroyed by this posterior urethral injury or during subsequent reconstruction and continence will, therefore, be dependent on bladder neck function alone. Most men, however, are continent following repair of this injury and will reveal a closed bladder neck on preoperative cystography and cystoscopy. A few patients will be noted to have a persistently open, funneled bladder neck or a bladder neck quadrant scar seen on transvesical cystoscopy, which support the potential of a concomitant bladder neck injury.

The type of fracture correlates as a risk factor for urethral injury based on the observations of broken pelvic rami, sacroiliac diastases or posterior and anterior arch disruptions. Pelvic fractures are classified by stability and by the forces that are responsible for the fracture. These forces are noted to be 1) lateral compression injury (side-to-side force), 2) anterior-posterior compression injury (front-to-back force), and 3) vertical shear (down-to-up force). Lateral compression fractures are the most common types of pelvic injuries and are most often associated with urethral disruption. The most serious pelvic fracture is the Malgaigne with the highest morbidity and morality. This fracture is produced by a vertical shear force and usually consists of breaking of the anterior ipsilateral pubic rami as well as posterior disruption through the sacrum, sacroiliac joint, or ileum. This is usually an unstable fracture with marked bony deformity and upward displacement of the hemi-pelvis and has the highest incidence of urethral separation [11, 12].

The risk for urethral injury increases with the number of broken pubic rami and the coexistence of posterior pelvic bone disruption. However, the contributing pathogenesis of pelvic fractures and the specific urethral anatomy that is disrupted has not yet been completely and accurately defined. The traditional concept that the prostatomembranous junction is the weak point and that the shearing force of the injury produces separation at that point has been revised. Following rupture of the prostatic and bladder attachments, the compressed pelvis and its hematoma forces the prostate upward, resulting in membranous urethral cephalad retraction and displacement with rupture at the bulbomembranous junction. The fibrous gap between the prostate and the bulbous urethra involves primarily the membranous component and the proximal edge of the bulb. The proximal and distal urethral lumens may be thus mal-aligned in both an anteroposterior and a lateral displacement. Consequently, these injuries are frequently evident only by true lateral and AP position cystography.

Urethral trauma associated with a pelvic fracture in the female was previously thought to be nonexistent given the short urethral length, moderate mobility, and lack of rigid pubic ligaments [5, 9]. However, a review of more contemporary reports reveals a 4.6%–6% incidence of injury, mostly occurring in children [7, 8]. A urethral tear in the female is commonly a partial one located in the anterior or dorsal wall at the 12 o'clock position and is often accompanied by vaginal laceration. Complete urethral separation in the female has been described at all levels but most often noted at the proximal urethra and bladder neck (26 of 31 patients – 84%) [8]. The main mechanism of disruption in a female is a laceration of the urethral wall by a displaced bony fragment rather than the shearing effect seen in male urethral injuries. The diagnosis of a urethral injury in a female may be quite elusive if only the distal urethra is involved. A low threshold for this injury should be maintained when pelvic fracture, vaginal bleeding, inability to void and labial edema or hematuria is noted. This possibly then needs to be excluded by careful pelvic examination and urethroscopy.

Posterior urethral injuries in the pediatric population occur commonly with pelvic fracture, particularly with Malgaigne and straddle fractures, but are not associated with diastases of the sacroiliac joint [10]. These injuries often present with disruption of the bladder neck or mid prostatic level of the urethra since the bladder is positioned intra-abdominally and the prostate is undeveloped. Consequently, the urethra has less protection than in adults.

In addition to orthopedic injuries, many patients with urethral injuries also have associated trauma to the urinary sphincters. The overall incidence of incontinence after posterior urethral disruption is low [10]. However, Iselin noted that an open bladder neck detected on urethrogram or cystoscopy might predict incontinence after an anastomotic reconstruction [31]. Urinary incontinence in the male depends on the bladder neck proximally and the external sphincter distally. The distal external sphincter mechanism may be destroyed by this posterior urethral injury or during subsequent reconstruction and continence will, therefore, be dependent on bladder neck function alone. Most men, however, are continent following repair of this injury and will reveal a closed bladder neck on preoperative cystography and cystoscopy. A few patients will be noted to have a persistently open, funneled bladder neck or a bladder quadrant scar seen on transvesical cystoscopy, which support the potential concomitant bladder neck injury. These findings may be due to an involuntary detrusor contraction during bladder filling and may not be predictive of future incontinence, so that bladder neck revisionary surgery should only be considered following repair of the urethral disruption. Turner-Warwick proposed that incontinence could also be caused by bladder neck tethering from scar and suggested that removal of this fibrous tethering adhesion would then restore continence [32]. Iselin and Webster reported a series of 13 patients (8%) of 158 who underwent posterior urethroplasty for a urethral distraction defect and were found to have a concomitant open bladder neck on preoperative studies: six of these were continent and seven were incontinent following the repair. One patient underwent simultaneous placement of an artificial urinary sphincter at the time of urethral reconstruction. The length of the bladder neck and prostatic urethral opening prior to urethroplasty in the continent patient was 0.9 cm (range, 0.4–1.4) on cystourethrogram. In the *incontinent* patients, the average measurements were 1.68 cm (range, 0.8–2.7). If the bladder neck and urethral length was equal to or greater than 1.5 cm with a funnel shape and an anterior bladder neck scar seen on transvesical cystoscopy, urinary incontinence was likely to occur following urethroplasty. These prognostic factors will help identify the likelihood of urinary incontinence but the injured open bladder neck is only repaired with sequential surgical procedures by bladder neck reconstruction, leaving the AMS-800 artificial sphincter as a backup procedure. In general, the low incidence of urinary incontinence in men with posterior urethral disruption reflects the functional adequacy of the internal sphincter mechanism (bladder neck). Most patients will remain continent after reconstruction, but mild stress urinary incontinence persists in 20% of patients [23, 13].

Impotence occurs more commonly than incontinence after posterior urethral disruption [33]. This is due to damage of the S2–4 nerve root, which can occur anywhere from the posterior pelvis to the periprostatic tissue. It can be temporary for a period of 1–2 years, but it may be permanent. It may also occur in the absence of urethral injury and uncommonly occurs as a result of surgical repair, but determining what the impact of open surgical repair has on potency is difficult as most of these men are impotent during the time between injury and repair. Corriere et al. (1994, [35]) reported the erectile function of a group of 50 men, who sustained a pelvic fracture and posterior urethral disruption treated 6–26 months later. After the injury, 24 (48%) of patients were impotent both preoperatively and postoperatively, whereas 32% were still impotent at 1 year postoperatively; 32% had poor to fair quality erections and sought no further treatment and 36% had normal erections.

9.2 Classification

Posterior urethra injuries are typically classified by the location of the damage on urethrogram. The current classification system is based on a system proposed first by Colapinto and McCallum and later modified by Goldman. Partial and complete injuries use the same classification system. Partial tear of the urethral circumference has been reported to occur with an incidence of 20%–30% [14]. The current classification system is as follows:

Type I	Posterior urethra intact but stretched. The puboprostatic ligaments are ruptured and the prostate is displaced by the resulting hematoma.
Type II	Partial or complete injury with tear of membranous urethra above the urogenital diaphragm. No contrast is noted in the perineum. Composes 15% of posterior urethra injuries.
Type III	Partial or complete injury, combined with anterior injury. Disruption of the urogenital diaphragm is noted and contrast is present in the perineum. This is the most common type of injury.
Type IV	Bladder neck injury with extension into the urethra. High incidence of internal sphincter injury. Associated with 5% of pelvic fractures in women.
Type IVA	Injury of the base of the bladder with periurethral extravasation. The urethra is intact.

When the urethra elongates but remains intact, it is considered a Type I injury, while partial or complete separation with extravasation above the urogenital diaphragm is noted to be a Type II injury. This has traditionally been identified as the more prevalent type, but Goldman et al. have pointed out that the Type III injury, with extravasation into the perineum, is the more common variety (66%–85%). This type of injury predominantly involves the membranous portion of the urethra and its associated distal sphincteric component. The only active part of the sphincteric mechanism left in patients with Type III posterior urethral injuries is the smooth muscle of the proximal urethral mechanism and the bladder neck area. This becomes the major functioning sphincter anatomy, as clearly established by current urodynamic studies [23, 31].

9.3 Diagnosis

Posterior urethral disruption injuries are suspected in patients presenting with the entire spectrum of pelvic fractures and multiple visceral injuries. The classic presenting clinical picture of a posterior urethral injury includes urinary retention, blood at the urethral meatus, a palpable bladder, or a »high-riding« or nonpalpable prostate. A small number of patients will present with scrotal and perineal ecchymosis in the anal triangle.

The clinical presentation, however, may be misleading. In review of 47 patients with traumatic urethral injuries, Cass noted that a urethral injury could only be diagnosed clinically in four patients [15]. Elliott noted in a study of 57 patients that blood was documented at the urethral meatus in 57% of those injured and an abnormal rectal exam identified in only 35% [16]. Physical findings may require delayed observation since most patients seen in under 2 h following the trauma will fail to have abnormal physical findings [12].

A retrograde urethrogram is the key study for determining the presence of a posterior urethral rupture and is performed in any patient with any of the above findings. It is performed in a 38- to 40-degree oblique position with the penis placed perpendicular to the femur unless the patient is hemodynamically unstable. Extravasation of contrast material after gently injecting 20–30 cc of intravenously compatible contrast material without bladder visualization is characteristic of a complete urethral rupture. The presence of contrast material in the bladder associated with extravasation signifies a partial disruption. A diagnostic catheterization should be avoided in this clinical setting since it may infect a sterile hematoma or convert a partial urethral tear into a complete separation injury, although this is a debatable concept. An abdominal and pelvic CT scan will aid immensely in identifying other visceral injuries along with a bladder injury, which has been reported to occur in 10%–20% of cases, but will not be of any use in identifying a posterior urethral traumatic injury [17]. The role of MRI has not been completely defined in posterior urethral disruption trauma during the acute phase, when it is particularly difficult to position the patient with multiorgan injury, pelvic hematoma, hemodynamic or pelvic instability.

9.4 Treatment

The paramount goal of resolving a prostatomembranous urethral injury is to provide a patent urethral lumen without disturbing the potency or continence mechanisms. The decision process and algorithm of management will ultimately be governed by the extent of the injury and other co-morbid factors such as the type of associated orthopedic, neurosurgical, and abdominal injuries, but the surgeon's bias still remains a significant influence.

Early primary suture repair of the separated urethra has been uniformly abandoned, since the approach is associated with an unacceptable incidence of impotence and incontinence [18]. In a literature review of 871 patients treated from 1953 to 1995 by Koraitin, 37% were treated with primary immediate open reconstruction, resulting in a 21% incidence of incontinence and a 56% incidence of impotence [20]. The high incidences of incontinence and impotence are likely secondary to the gross distortion of tissues secondary to hematoma and edema coupled with release of the tamponade effect, resulting in continued injury to neurovascular and sphincter structures. On the other hand, the low incidence of incontinence after both primary alignment or suprapubic cystotomy with delayed reconstruction strongly implies that the severity of the trauma is the responsible source, not the treatment.

Currently, there are two distinct therapeutic approaches to managing the traumatic posterior urethral separation injury: 1) early catheter-assisted realignment and 2) suprapubic cystotomy and drainage followed by delayed urethral reconstruction.

Early realignment defined as the close approximation of the separated torn ends of the urethra over a stenting catheter with and without traction was first introduced by Ormand in 1934 [19]. This type of realignment depends substantially on catheter stenting, which acts as a guide that permits the separated urethral ends to come together as the hematoma is reabsorbed. Those urologists familiar with the various techniques of primary alignment strongly advise it as the procedure of choice when the clinical conditions of the patient are suitable. Suprapubic cystotomy drainage and delayed reconstruction is thus reserved for patients who are hemodynamically unstable, have other associated injuries, or have failed primary realignment.

The delayed approach has been the mainstay of therapy over the past two decades, as initially championed by Johanson [19] and subsequently popularized by Morehouse [29]. The proponents of this approach emphasize that it is the safest in the unstable patients, decreases the possibility of infecting a pelvic hematoma, and avoids injury to the nervi erigentes with the potential for erectile dysfunction. The subsequent repair, however, requires an experienced urethral surgeon. The delayed reconstructive procedure is versatile with the capability of resolving a wide range of long, complex obliterated strictures under controlled conditions, including the salvage of those who have had prior failed repairs [27].

9.4.1 Surgical Technique: Early Realignment

The technique of early realignment can be accomplished either by open or endoscopic techniques. Open surgical realignment needs to be selectively chosen for injuries with marked urethral separation (»pie in the sky bladder«), concurrent vesicle neck or bladder wall lacerations, or the presence of rectal perforations where a colostomy will be required. Open realignment entails surgical exploration of the retropubic space on day 5–7 when hemostasis is secure and the urine has been diverted with a percutaneous suprapubic cystotomy. In this technique, a vertical cystotomy is first performed. Then retrograde placement of a #18 catheter is introduced through the prostate and into the bladder. If successfully visualized in the bladder, the urethral catheter is combined with a suprapubic catheter and maintained for 4–6 weeks. If retrograde passage is unsuccessful, a combined passage of both an antegrade and a retrograde catheter is performed. The catheter tips are first identified through the open, torn proximal and distal ends of the urethra. The two catheters are then tied together in the retropubic space so that the antegrade catheter can be pulled out through the urethral meatus. This can be tied to a definitive #18 Foley catheter, which is drawn back into the bladder for stenting and drainage. Attempts to evacuate any retropubic or periprostatic hematoma should be avoided unless hemostasis or adequate exposure is required [21]. The suprapubic cystotomy can be placed high in the dome by peeling the peritoneum away from the bladder entry site and away from the hematoma. This permits optimal transvesical endoscopic access to the posterior urethra if subsequent reconstructive surgery is required.

Endourological early realignment constitutes a less morbid approach to the resolution of the pelvic fracture-related posterior urethral injury. This minimally invasive technique avoids hematoma exposure and urethral manipulation while maintaining continence and potency [1, 3] Optimal results are best obtained from early endoscopic realignment when the procedure is delayed for 5–7 days after an initial suprapubic cystotomy tube is placed. The suprapubic cystotomy tract is optimally placed in the upper dome of the bladder where the entry site can be optimally dilated by nephrostomy tract sequential dilators. The patient is then taken to the operating room where a combined antegrade and retrograde endoscopic method is used to gain access to the urethral gap. A flexible or rigid cystoscope can visualize the bladder wall and bladder neck for lacerations or the posterior urethra down to the transected urethral edge. A guidewire or urethral catheter can then be passed from the antegrade to the retrograde instrument. The guide can then be pulled out the urethral meatus and a stenting #18 French Foley catheter passed over this guide. The procedure can be performed in a modified lithotomy position if the pelvic fracture is stable or there has been orthopedic correction of the fractures.

The stenting urethral catheter in both the open and endoscopic early realignment procedure remains in place for 4–6 weeks along with the cystotomy tube. Before removal of the lower catheter, a guidewire is again passed through its lumen and left in place while the catheter itself is removed. A voiding cystourethrogram is then performed, and if extravasation or obstruction is noted at the level of the urethral injury, then the urethral catheter can be readily reinserted over the wire and the study repeated in 2–3 weeks.

9.4.2 Surgical Technique: Delayed Reconstruction

The ultimate expectation of a patent posterior urethra in a continent and potent patient is most often achieved when a completely severed posterior urethra is treated with suprapubic cystotomy and delayed primary anastomotic urethroplasty in the hands of an experienced surgeon. This is best accomplished by a tension-free, mucosa-to-mucosa anastomosis utilizing aggressive bulbopendulous spongiosal mobilization. The entire phase of this reconstruction is readily accomplished through the standard midline perineal exposure and rarely requires a transpubic abdominal approach. The transpubic approach is exclusively limited to patients with orthopedic deformity that limits surgical access, the presence of an excessively long defect that requires a lengthy skin flap or the treatment of the injury in children when exposure is difficult to achieve.

Gaining access to the posterior urethra and then performing a primary, spatulated urethroplasty is technically demanding and requires the skill of an experienced surgeon during the apical prostatic dissection. Several sequential maneuvers can be used to improve exposure, reduce the gap, and achieve the reconstructive success. First, if the intravesical sound or cystoscope cannot be readily palpated in the open perineum, then it is useful to incise the periosteum over the inferior surface of the pubis and perform an inferior pubectomy for apical and anterior prostatic exposure. An endoscopic examination can then be performed through an apical prostatic urethral incision to confirm if the proximal urethrostomy has been properly executed with a normal bladder neck. This often-overlooked maneuver can prevent considerable injury and morbidity to the continence mechanism. A ventral 6 o'clock spatulated incision is next extended across the injured proximal segment of urethra to produce a 40- to 45-Fr lumen. The distal bulbous urethra is then spatulated on the dorsal surface creating a matching urethral incision that will overlap the apical prostatic urethrotomy with minimal angulation and bring the redundant bulb into the space between the crura without incurring spongiosal bleeding. Finally, the prostatic apical urethral mucosa is everted with 4-0 monofilament absorbable sutures without excising the periurethral fibrosis.

Attempts to mobilize the severely injured posterior urethra should be avoided since a cavernous nerve injury may develop. Some of the enveloping fibrotic tissue must be excised if a pliable patent anastomosis cannot be achieved. Beneficial techniques to decrease tension on the anastamotic site include crural separation, inferior midline pubectomy, and rerouting of the spongiosa around the corporal crura to shorten the distance between the bulb and the prostatic urethra [25]. The need to excise prostatomembranous periapical fibrosis is a debatable issue with most surgeons showing a keen interest in radical excision. It is important that the surgeon adheres to midline dissection to avoid resection or mobilization of the prostatic apex when utilizing these techniques. This will prevent injury to the lateral cavernous nerves. Careful and meticulous dissection with the use of optical magnification in the intercrural and rectourethral spaces will also help identify the dorsal penile arteries. An intraoperative Doppler may be an invaluable tool at this point of the procedure to help identify these structures. Unfortunately, the perineal and periprostatic anatomy is so deformed at times that clear distinction and identification of these encased neurovascular and arterial strictures is not always possible. Consequently, patients need to be appropriately counseled that a 3%–5% incidence of impotence may occur after surgery. Furthermore, ventral chordee may also result from the procedure if a long stricture is repaired and aggressive mobilization techniques are utilized.

Successful primary anastomotic urethroplasty is based on the premise that the corpus spongiosa has a bipedal circulation and is particularly dependent on retrograde flow from the dorsal arteries of the penis when mobilized and detached from its proximal vascular supply. Compromise of this distal circulation by trauma or distal urethral pathology should result in ischemic necrosis to the mobilized portion of the bulbous urethra and subsequent stricture. This ischemia is probably the most common cause of postoperative delayed stricture recurrence. Given these limitations, posterior urethral injuries in patients with a prior anterior urethral stricture, hypospadius, or coexisting bilateral pudendal vascular injury clearly places anastomotic repairs at risk [26].

There are three substitution procedures suitable to salvage failed posterior urethral reconstruction or to bridge extensive primary defects: 1) penile and scrotal flaps, 2) staged mesh graft, and 3) one- or two-stage perineal artery medial thigh fasciocutaneous tube flap. Our experience with the two-stage Schreiter mesh graft supports the observation that a mesh graft results in a nonhirsute, time-proven, stable urethral lumen with a low restricture rate. It is technically the most difficult of the substitution procedures and requires compulsive attention to the detail of immobilization with a well-constructed stent dressing. Substitution techniques, in general involving flaps and grafts with transfer of skin to the posterior urethra, should only be considered as an option when the primary anastomotic operation is not feasible [27].

9.5 Results

Recurrent strictures following primary alignment range in incidence from 45% to 60% [22]. A contemporary meta analysis of 203 open and endoscopic primary alignments by Moudouni et al. revealed a urethral stricture incidence of 49%, an incidence of impotence of 22%, and incontinence of 4% [1]. These patients were a selected series where periurethral manipulation, primary suturing of the urethra and Foley balloon catheter traction were avoided. This experience convincingly demonstrates that early and minimally invasive realignment lessened the severity of the stricture without effecting erectile function or continence. Recurrent stricture formation following this approach occurs within 6 months and requires an average of 1.2 postrealignment procedures to resolve the obstructive lumen. However, long-term results from the primary realignment studies are not complete. Elliott and Barrett reported that 68% of patients treated with primary alignment had strictures after initial catheter removal. However, over half of these were treated with office dilation and did not require urethroplasty [16].

Excellent long-term results can be expected from a careful tension-free delayed reconstruction. Ennemoser et al. reconstructed 86 patients with posterior disruption and then followed the patients over a mean of 9.2 years. They noted only six patients with peak urinary flow rates under 15 ml/s [30]. Morey studied 82 patients with delayed one-stage urethral reconstruction after posterior disruption and found acceptable patency in 89% within 1 year after surgery. Other authors have reported similar success rates for stricture-free repairs [25, 27]. Long-term results from the primary realignment studies are still incomplete.

9.6 Conclusion

Pelvic fracture and straddle urethral injuries are no longer the hopeless problem that burdened the urological surgeon in prior decades. Optimal outcome still depends on an early, accurate diagnosis including an understanding of the type of injury, the associated comorbid events, and a flexible approach to the method of management. Type I and partial type II urethral tears are indisputably best managed initially by a stenting urethral catheter or suprapubic cystotomy. The complete type II and type III transsections and separation injuries will require an experienced endourological or reconstructive surgeon to select the endoscopic alignment approach if conditions of patient stability and extent of the injury permit. If there is any doubt about the suitability of such an option, then suprapubic cystotomy and a delayed progressive perineal primary anastomotic repair is the proper way to securely restore urethral patency. In specialized centers where an interest in this problem exists, the successful outcome of management of a posterior urethral disruption by an open reconstructive procedure approaches 93%–96%.

References

1. Moudouni SM, Patard JJ, Manunta A et al (2001) Early endoscopic realignment of post-traumatic posterior urethral disruption. Urology 57:628–632
2. Husman DA, Wilson WT, Boone TB, Allen TD (1990) Prostatomembranous urethral disruptions: management by suprapubic cystotomy and delayed urethroplasty. J Urol 144:76–78
3. Podestai ML, Medek R Castera, Duarte A (1997) Immediate management of posterior urethral disruptions due to pelvic fracture: therapeutic alternatives. J Urol 157:1444–1448
4. Demetriades D, Karaiskis M, Toutouzas K et al (2002) Pelvic fractures: epidemiology and predictors of associated abdominal injuries and outcomes. J Am Coll Surg 195:1–10
5. Carter CT, Schafer N (1993) Incidence of urethral disruption in females with traumatic pelvic fractures. Am J Emerg Med 11:218–220
6. Perry MO, Husmann DA (1992) Urethral injuries in female subjects following pelvic fractures. J Urol 147:139–143
7. Chapple CR, Png D (1999) Contemporary management of urethral trauma and post-traumatic stricture. Curr Opin Urol 9:253–260
8. Venn SN, Greenwell TJ, Mundy AR (1999) Pelvic fracture injuries of the female urethra. BJU Int 83:626–630
9. Pode D, Shapiro A (1990) Traumatic avulsion of the female urethra: case report. J Trauma 30:235
10. Snyder J, Williams DI (1977) Urethral injuries in children. BJU 48:663
11. Kricun ME (1990) Fractures of the pelvis. Ortho Clin North Amer. 21:573–590
12. Lowe MA, Mason JT, Luna GK et al (1988) Risk factors for urethral injuries in men with traumatic pelvic fractures. J Urol 140:506–507
13. Herschorn S, Thijssen A, Radomski SB (1992) The value of immediate or early catheterization of the traumatized posterior urethra. J Urol 148:1428–1431
14. Goldman SM, Sandler CM, Corriere JN, McGuire EJ (1997) Blunt urethral trauma: a unified anatomical mechanical classification. J Urol 157:85–89
15. Cass AS (1984) Urethral injury in the multiple injured patient. J Trauma 24:901–906
16. Elliott DS, Barrett D (1997) Long-term results of primary realignment of posterior urethral disruption. J Urol 157:814–816
17. Carroll PR, McAninch JW (1984) Bladder trauma: mechanism of injury and a unified method of diagnosis and repair. J Urol 132:154
18. Mundy AR (1991) The role of delayed primary repair in the acute management of pelvic fracture injuries of the urethra. Brit J Urol 68:273–276
19. Wilkinson, FOW (1961) Rupture of the posterior urethra. Lancet 1:1125
20. Koraitim MM (1996) Pelvic fracture urethral injuries: evaluation of various methods of management. J Urol 256:1288–1291
21. Follis H, Koch MO, McDougal WS (1992) Immediate management of prostatomembranous urethral disruptions. J Urol 147:1259
22. Husman DA, Wilson WT, Boone TB, Allan TD (1990) Prostatomembranous urethral disruption: management by suprapubic cystotomy and delayed urethroplasty. J Urol 144:76
23. Koraitim MM, Atta MA, Fatah GH, Ismail HR (2003) Mechanism of continence after repair of post traumatic posterior urethral stricture. Urology 61:287–290
24. Gheiler EL, Frontera JR (1997) Immediate primary realignment of prostatomembranous urethral disruptions using endourologic technique. Urology 49:596–601
25. Webster GD, Ramon J (1991) Repair of pelvic fracture posterior urethral defects using an elaborated perineal approach: experience with 74 cases. J Urol 145:744–748
26. Jordan GH, Secrest CL (1992) Arteriography in select patients with posterior urethral distraction injuries. J Urol Suppl 147:289A, Abstract 308
27. Mundy AR (1996) Urethroplasty for posterior urethral strictures. Brit J Urol 78:243–247
28. Morey, A. McAninch J (1997) Reconstruction of posterior urethral disruption injuries: outcome analysis in 82 patients. J Urol 157:506–510

29. Morehouse DD (1988) Management of posterior urethral rupture: a personal view. Brit J Urol 61:375–381
30. Ennemoser O, Colleselli K, Reissigl A et al (1997) Post-traumatic posterior urethral stricture repair: anatomy, surgical approach to long-term results. J Urol 157:499–505
31. Iselin CE, Webster GD (1999) The significance of the open bladder neck associated with pelvic fracture urethral distraction defects. J Urol 162:347–351
32. Turner-Warwick R (1989) Prevention of complications resulting from pelvic urethral injuries and from their surgical management. Urol Clin North Am 16:335–358
33. Pokorny M, Pontes JE, Pierce JM (1979) Urologic injuries associated with pelvic trauma. J Urol 121:455–457
34. Dhabuwala CB, Hamid S, Katsikas DM, Pierce JM (1990) Impotence following delayed repair of posterior urethral disruption. J Urol 144:677–678
35. Corriere JN Jr, Rudy DC, Benson GS (1994) Voiding and erectile function after delayed one-stage repaire of posterior urethral disruptions in 50 men with a fractured pelvis. J Trauma 37:589–590

The Endoscopic Treatment of Post-Traumatic Membranous Urethral Strictures

V. Pansadoro, P. Emiliozzi

The best approach to post-traumatic membranous urethral strictures is open surgical management, usually cystostomy followed by delayed bulboprostatic anastomosis. The success rate with these techniques exceeds 90% [1]. In recent years, endoscopic management of membranous urethral strictures has been proposed [2–5]. Endoscopic treatment may be a reasonable alternative option in selected patients who refuse open surgery or who are at high risk for surgery.

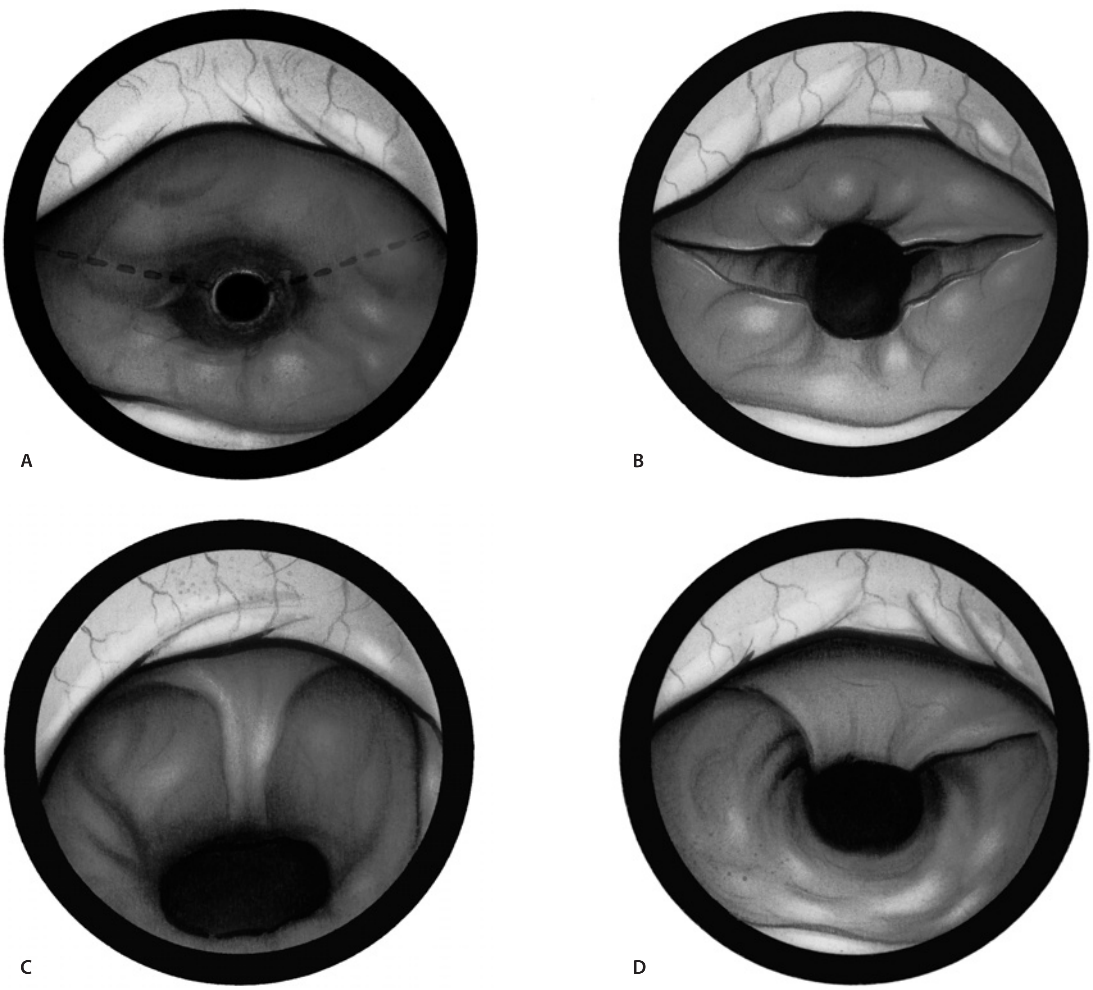
Other indications include previous surgery of the anterior urethra and hypospadia repair, when adequate mobilization of the urethra cannot be obtained and distal urethra blood supply may be impaired.

Endoscopic treatment can provide acceptable results in nearly 50% of patients and achieve satisfactory voiding in two-thirds of previously untreated patients.

Urethroplasty remains the gold standard of treatment of membranous urethral strictures. Good results have been reported in 105 patients with perineal or transpubic anastomosis, with success rates of 95% and 97%, respectively [6]. However, even in referring centers, recurrence rates can be as high as 20%, with prolonged follow-up (96 months) [7]. At 10 years, Mundy [8] observed 12% and 31% recurrence rates in 141 patients treated with transperineal bulboprostatic anastomotic urethroplasty, or patch urethroplasty, respectively. Open urethroplasty of the posterior urethra is a complex operation and the hospital stay is usually prolonged [9, 10].

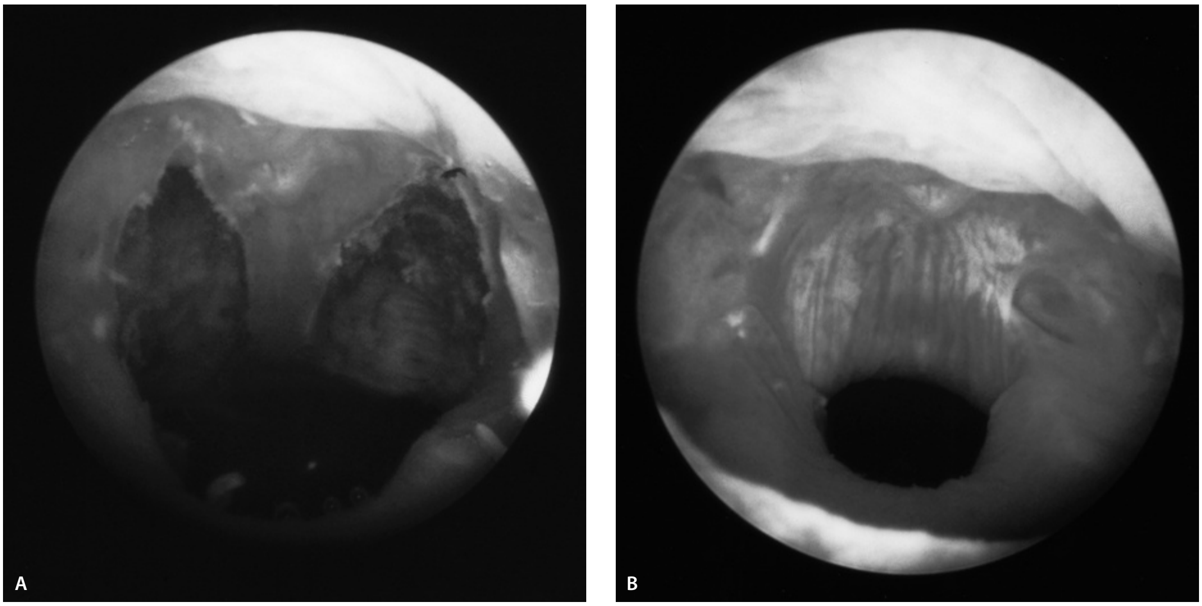
The endoscopic technique [4, 5] is based on three surgical principles: 1) only complete section of the block of scar tissue can achieve definitive good results; 2) a strip of epithelial tissue is preserved at the 6 and 12 o'clock positions in order to hasten the epithelialization process at the stricture site; and 3) hydraulic self-dilatation will maintain the operated membranous urethra open while the process of epithelialization is in progress.

The operation (◘ Fig. 10.1) is performed in the lithotomy position. The stricture is incised at 3 and 9 o'clock

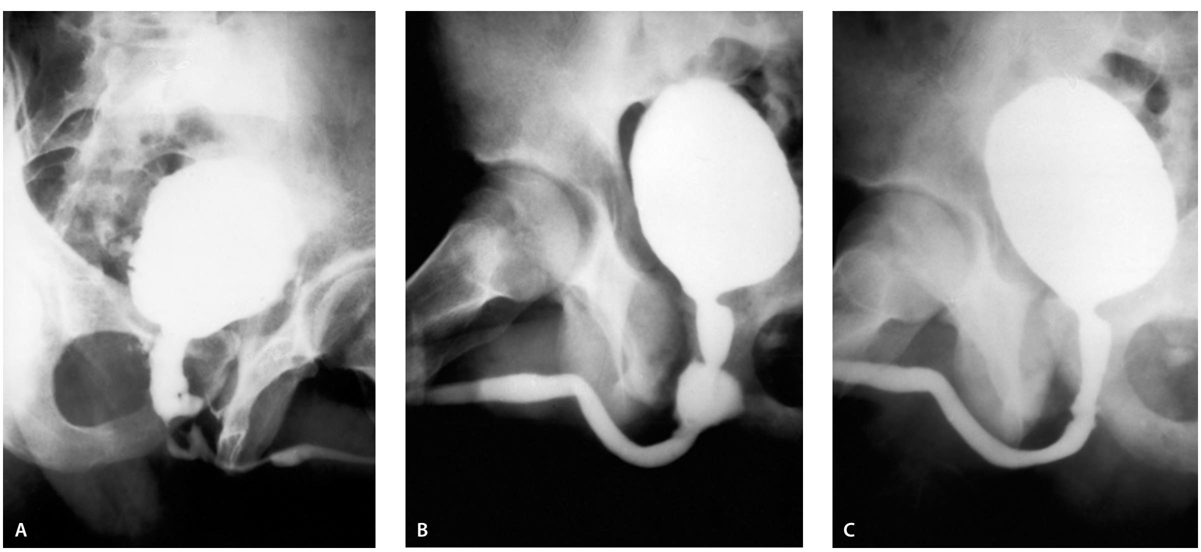


◘ **Fig. 10.1A–D.** Operative technique. **A** Incision of the scar tissue at 3 and 9'clock. **B** The block of scar tissue is divided into two halves, upper and lower. **C** Resection of the scar tissue is performed, leaving a strip of intact mucosa at 12 o'clock. **D** The strip of mucosa leads a faster re-epithelialization positions with a cold knife in order to preserve the mucosa at 6 and 12 o'clock. The two incisions are prolonged with a Collings knife, dividing the scar tissue block into two halves, upper and lower. With a cutting loop, all excess fibrous tissue is fully resected, until the scar is completely removed and healthy tissue is encountered. The strips of healthy mucosa, at the 6 and 12 o' clock positions, are preserved in order to obtain fast and multidirectional epithelialization and to prevent stricture recurrence (◘ Fig. 10.2). At the end of the procedure, a wide opening is obtained between the prostatic and the bulbar urethra (◘ Fig. 10.3). An indwelling Foley catheter is left for 48 h, and the patient is usually dismissed on the 4th postoperative day. Hydraulic self-dilatation is started at discharge and performed for the first 6 postoperative months.

Patients undergo urethrocystogram and uroflow at 1, 3, 6, and 12 months. After the 1st year, urethrocystogram is performed yearly.



◘ **Fig. 10.2. A** Endoscopic view at the end of the procedure. A strip of preserved mucosa is present at 12 o'clock. **B** Early epithelialization 2 weeks after the operation



◘ **Fig. 10.3. A** Preoperative urethrocystogram of a post-traumatic membranous urethra stricture. **B** Urethrocystogram 4 weeks after the procedure. A wide cavity is visible at the site of membranous urethra. **C** Urethrocystogram 36 months after the procedure

In our personal series, 23 patients with severe strictures of the membranous urethra following pelvic fracture and complete disruption of the urethra, were treated endoscopically for 16 years. The cause of pelvic injury was an automobile accident in 17 patients and work-related trauma in six patients.

At a median follow-up of 61 months, 19 patients were evaluable. Thirteen patients required more than one procedure. Excellent results (peak flow >15 ml/s) were obtained in seven patients (37%), satisfying results (peak flow between 10 and 15 ml/s) in three (16%), and poor results (peak flow <10 ml/s) in nine (47%). The complication rate was 32%, including urinary infection in three patients, postoperative bleeding not requiring transfusion in two patients and mild stress incontinence in one patient.

In conclusion, of the 19 patients in follow-up, seven (37%) required open urethroplasty with bulboprostatic anastomosis.

The endoscopic treatment of membranous urethral strictures for complete traumatic urethral obliteration has been described in several reports with small series [11–15].

However, in 1995 El Abd [16] published the largest series of patients treated with endoscopy for post-traumatic membranous urethral stricture.

A 58% success rate was reported in 396 patients treated with urethrotomy. Follow-up was 2 years. Success was defined as »good stream, continence and no further urethrotomy or dilatation.«

Strictures of the membranous urethra following complete traumatic disruption are surrounded by abundant scar tissue, often with a fistulous tract connecting the prostatic and bulbar urethras.

In our opinion, cold-knife urethrotomy is likely to be unsuccessful because the dense fibrous tissue remains stiff, inelastic, and unable to open to a wider caliber. The urogenital diaphragm and the sphincter mechanism support the development of early adherences of the urethrotomy, which may result in recurrent stricture. For this reason, extensive resection of all scar tissue must be performed to obtain a good and definitive result. The preserved strips of intact mucosa at the 6 and 12 o' clock positions help the epithelialization process, with fast coverage of the underlying tissue, thus preventing the growth of fibroblasts and recurrent strictures.

In several patients, multiple procedures may be required in order to obtain complete resection of all the scar tissue.

The limited number of patients does not allow us to identify prognostic factors and to select patients who will benefit from an endoscopic procedure.

The only significant prognostic indicator of a good result is the chance to achieve complete resection of the block of scar tissue.

References

1. Webster GD, Waxman SW (1995) Strictures of the male urethra. Chapter 35. In Gillenwater JY, Grayhack JT, Howards SS, Duckett JW (eds) Adult and pediatric urology 3rd edn. Lippincott, Williams, and Wilkins, Philadelphia
2. Chiou RK, Gonzalez R, Ortlip S, Fraley EE (1988) Endoscopic treatment of posterior urethral obliteration: long-term follow-up and comparison with transpubic urethroplasty. J Urol 140:508–511
3. Spirnak JP, Smith EM, Elder JS (1993) Posterior urethral obliteration treated by endoscopic reconstitution, internal urethrotomy and temporary self-dilation. J Urol 149:766–768
4. Pansadoro V, Scarpone P, Emiliozzi P (1993) The endoscopic treatment of membranous urethral strictures. J Endourol 7 [Suppl 1] 111
5. Pansadoro V, Defidio L (1981) Endoskopische Behandlung von Rezidivstenosen der Pars Membranacea der Urethra. Aktuelle Urologie 12:227–231
6. Koraitim MM (1995) The lessons of 145 post-traumatic posterior urethral strictures treated in 17 years. J Urol 153:63–66
7. Jenkins BJ, Badenoch DF, Fowler CG, Blandy JP (1992) Long-term results of treatment of urethral injuries in males caused by external trauma. Br J Urol 70:73–75
8. Mundy AR (1996) Urethroplasty for posterior urethral strictures. Br J Urol 78:243–247
9. Lieberman SF, Barry JM (1982) Retreat from transpubic urethroplasty for obliterated membranous urethral strictures. J Urol 128:379–381
10. Waterhouse K, Laungani G, Patil U (1980) The surgical repair of membranous urethral strictures: experience with 105 consecutive cases. J Urol 123500–505
11. Kehornan RM, Anwar KK, Johnston SR (1990) Complete urethral stricture of the membranous urethra: a different perspective. Br J Urol 65:51–54
12. White JL, Hirsch IH, Bagley DH (1994) Endoscopic urethroplasty of posterior urethral avulsion. Urology 44:100–105
13. Quint HJ, Stanisic TH (1993) Above and below delayed endoscopic treatment of traumatic posterior urethral disruptions. J Urol 149:484–487
14. Wu YA, Huang CH, Liu JH (1994) Transurethral resection in children with urethral stricture and occlusion. J Endourol 8:69–71
15. Goel MC, Mayank K, Kapoor R (1997) Endoscopic management of traumatic posterior urethral stricture: early results and followup. J Urol 157:95–97
16. El-Abd SA (1995) Endoscopic treatment of post-traumatic urethral obliteration: experience in 396 patients. J Urol 153:67–71

Endoscopic Realignment of Post-Traumatic Membranous Urethral Disruption

V. Pansadoro, P. Emiliozzi

Standard treatment of post-traumatic disruption of the membranous urethra is suprapubic cystostomy and delayed urethroplasty [1]. Other surgical options include primary suturing [2] and early endoscopic realignment. Endoscopic realignment has been gaining popularity in recent reports [3–5].

Endoscopic realignment is a safe and effective procedure for the treatment of post-traumatic membranous urethral disruption. A minority of patients heal without urethral stricture and require no further treatment. The subsequent treatment of patients who develop a stricture is easier because the length of the stricture is short, with a small amount of scar tissue. Early endoscopic realignment in stable patients is our first option. However, larger series are needed before early endoscopic realignment of membranous urethra disruption is accepted worldwide as a standard option. Endoscopic realignment of membranous urethral disruption has several advantages when compared to suprapubic cystostomy, followed by late repair. The procedure is relatively easy to perform, with low morbidity. After placement of suprapubic bladder drainage, preoperative antegrade and retrograde urethrocystograms are performed to evaluate the gap between the two ends of the disrupted urethra. The operation requires a stable clinical condition (usually 2–7 days after trauma).

Preoperative retrograde and antegrade (through suprapubic drainage) urethrocystograms must be performed before the operation. Adequate antibiotic coverage is provided.

With the patient in the lithotomy position, the suprapubic percutaneous tract is dilated and a metal sound is passed through the bladder neck into the prostatic urethra (▪ Fig. 11.1). A suprapubic flexible cystoscope, when available, can be used instead of a metal sound. At this point, a 20-Fr urethrotome, with its half sheath, is introduced into the urethra, and carefully advanced through the membranous urethra, into the pelvic hematoma (▪ Fig. 11.2). Under combined endoscopic and fluoroscopic guidance, the urethrotome meets the tip of the sound (or the light of the flexible cystoscope). Under endoscopic guidance, the urethrotome is further advanced into the prostatic urethra, while the sound is retracted to the bladder neck. The urethrotome is removed, leaving the half sheath in the bladder and urethra. Through the half sheath, an 18-Fr fenestrated silicon catheter is placed into the bladder, and left in place for 4–6 weeks. Hematoma extent and prostate position can be easily monitored by means of transrectal ultrasound. Antibiotic coverage is provided.

The two ends of the disrupted urethra have a gap and they are surrounded by pelvic hematoma. Early drainage of the hematoma through the catheter helps the descent of the dislodged prostate toward the membranous urethra.

All patients are followed with uroflow and urethrocystogram at 3, 6, and 12 months, and then yearly thereafter.

We have treated ten patients with complete disruption of the membranous urethra, following pelvic fractures, with early endoscopic realignment of the urethra. The mean age was 40 years (15–65 years). The etiology of the urethral disruption was car accident in seven patients and occupational trauma in three patients. The median delay from the acute trauma was 8 days (2–44 days). Mean operative time was 105 min (range, 40–180 min). In all patients, it was possible to pass the urethrotome into the bladder, and to realign the prostate with the membranous urethra.

Complications included hemorrhage requiring transfusion in one patient and persistent (6 and 8 weeks) urinary tract infection in two patients. The mean hospital stay for realignment was 6 days (range, 3–18 days). The median follow-up is now 81 months (40–194 months). Potency was good in seven of ten (70%) patients and moderately impaired in one. Continence was preserved in all patients.

Four of the ten patients are voiding well with a peak flow greater than 15 ml/s and did not require any further treatment. A secondary membranous urethral stricture developed in 6 patients (60%). Five of the six patients with post-traumatic membranous urethral strictures were treated successfully with endoscopic resection of the scar tissue. Three of them required two endoscopic procedures and one required three endoscopic procedures to obtain final stable results. At a median follow-up of 70 months, five out of six patients have good urinary peak flow (above 15 ml/s) with a satisfying urethral caliber. Only one patient required surgical repair with a bulboprostatic anastomosis.

Reducing the amount of scar tissue is mandatory while waiting for the endoscopic [6] or surgical procedure. In a minority of our patients (40%), the urethra healed after realignment without occurrence of a significant stricture, and no further treatment was required. The optimal timing for endoscopic realignment is at 3–4 days after disruption, when the patient is stable and pelvic bleeding has stopped.

After urethral disruption, suprapubic cystostomy alone is almost certainly followed by a membranous urethral stricture. These strictures need repair after a few months in a referral center by a highly specialized urologist [7, 8], where very high success rates, between 95% and 97%, are reported [9, 10]. However, with long-term follow-up, some authors have reported stricture recurrence rates of 20%–31% [11, 12]. For stable patients without additional injuries associated with the urethral disruption, early endoscopic realignment is probably the best option.

The continence and potency preservation rate for early realignment and for delayed urethroplasty has been compared in a review of literature by Herschorn: the incidence of impotence was 30% and 36% and the incidence of incontinence was 6% and 8% for delayed repair and early realignment, respectively [13].

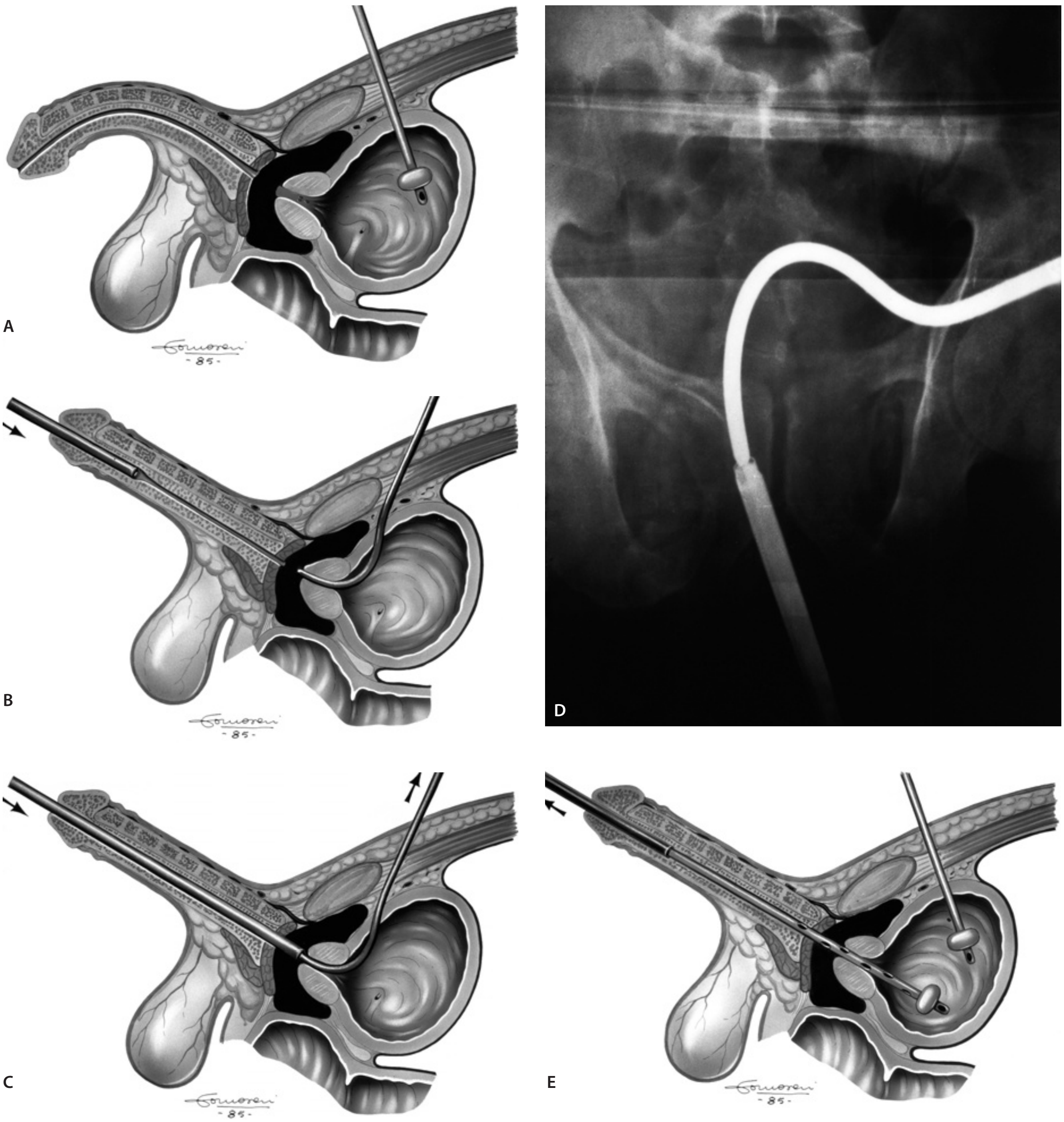
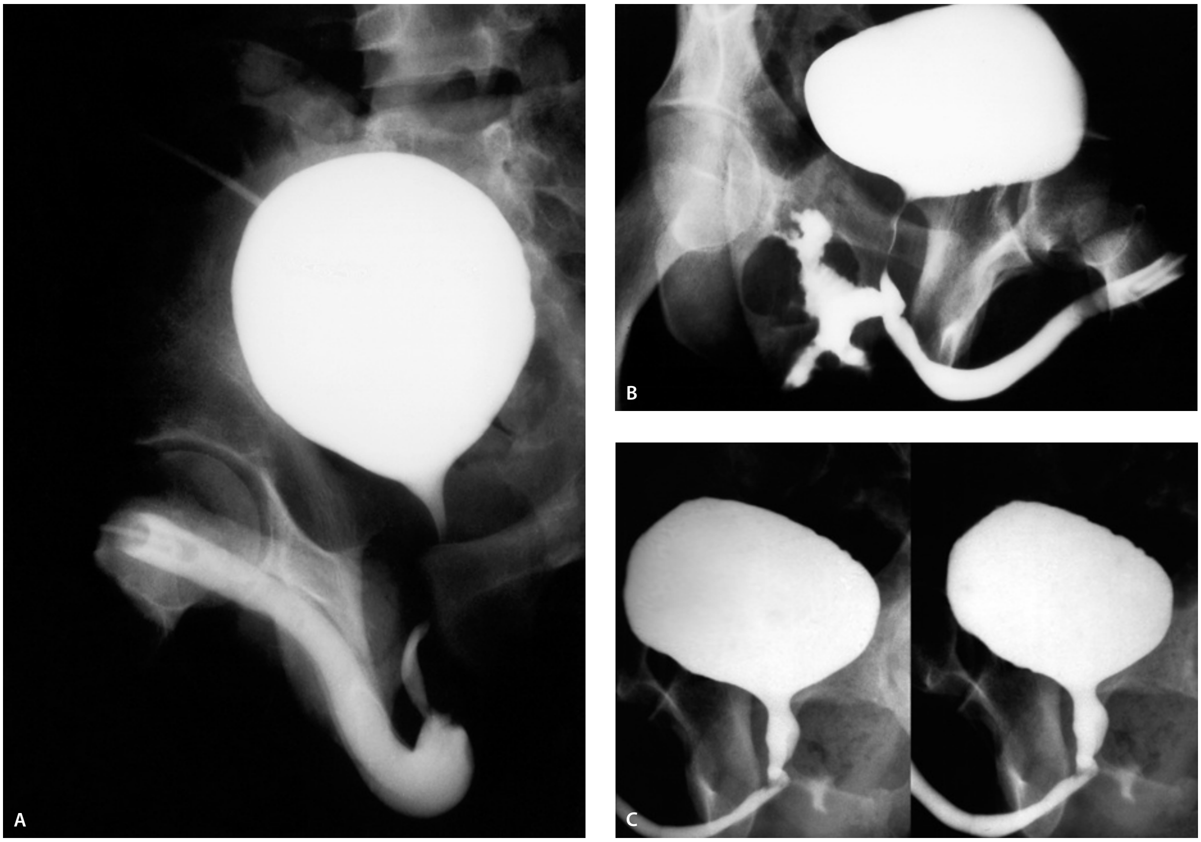


Fig. 11.1A–E. Operative technique. **A** After the acute trauma, a suprapubic tube is inserted. The procedure begins with the substitution of the suprapubic catheter with a metal sound (or flexible cystoscope). **B** The suprapubic sound (or flexible cystoscope) is gently passed through the bladder neck. A 20-Fr urethrotome with half sheath is carefully advanced along the urethra. **C** With endoscopic control, the urethrotome meets the tip of the metal sound (or flexible cystoscope) inside the pelvic hematoma. **D** Fluoroscopic control is used during the procedure. **E** The urethrotome reaches the bladder following the suprapubic instrument, which is slowly retracted. A fenestrated catheter is inserted through the half sheath. A suprapubic drainage is left

In an review of 871 cases, Koraitim [1] evaluated the morbidity of different treatment of post-traumatic urethral disruption. For suprapubic cystostomy, overall the incidence of stricture was 97%, the incidence of impotence was 19%; incontinence occurred in 4% of cases. For early or immediate surgical realignment, overall the incidence of stricture was 53%, the incidence of impotence was 36%; incontinence occurred in 5%. However, caution must be exercised when comparing retrospective series published over more than 40 years. The treatment of disruption is not related to the incidence of impotence and incontinence, which are rather due to trauma itself [14]. Open surgery performed immediately after the trauma might impair potency because of iatrogenic damage of neurovas-



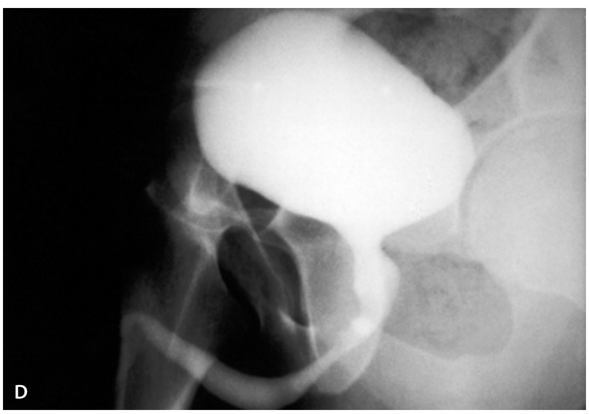


Fig. 11.2. A Combined antegrade and retrograde urethrocystogram after the trauma shows complete urethral disruption. **B** Retrograde urethrogram 15 days after endoscopy realignment with extravasation of contrast medium into pelvic hematoma. **C** Retrograde urethrogram 30 days after endoscopic realignment. A slight extravasation is still present. **D** At 1 year the membranous urethra has healed at a good caliber

cular bundles. Endoscopic realignment is minimally invasive and it is unlikely to impair potency. Elliott and Barrett [2] reported 10-year results of immediate primary surgical realignment for membranous urethral disruption in 57 cases. In these patients, 34% had no evidence of stricture and 43% had mild strictures managed by dilatation. Full potency was preserved in 79% of cases. Mild stress incontinence occurred in 4% of cases (Table 11.1).

In a review of literature, Jepson et al. found 36 cases of endoscopic realignment of posterior urethral disruption, including their series. Successful realignment was achieved in 35 cases (97%); impotence and incontinence rates were overall 7/35 (20%) and 2/36 (6%). Open surgery was

Table 11.1.

Author	cases	days after trauma	stricture	f-up (mos)
Londergan [3]	5	7 (2–42)	3	16
Cohen [4]	5	(7–19)	4	
Melekos [5]	4		4	
Gheiler [15]	3	1	2	
Wilbert [16]	8	35 (7–84)	8	40
Benz [17]	9		5	>24
Jepson [18]	8	9 (0–19)	4	50
Moudouni [19]	29	0–8	16	68
Our series	10	8 (2–44)	6	81

The best realignment time is probably as soon as the patient is stable, in order to prevent early scarring. Alternative realignment procedures have been proposed. The use of coaxial magnetic urethral catheters was successful in establishing urethral continuity in 11 of 13 patients with traumatic urethral disruption [20]. With the development of more advanced endourological instruments, urethral realignment will become an easier technique.

References

1. Koraitim MM (1996) Pelvic fracture urethral injuries: evaluation of various methods of management. J Urol 156:1288–1291
2. Elliott DS, Barrett DM (1997) Long-term followup and evaluation of primary realignment of posterior urethral disruptions. J Urol 157:814–816
3. Londergan TA, Gundersen LH, Van Every MJ (1997) Early fluoroscopic realignment for traumatic urethral injuries. Urology 49:101–103
4. Cohen JK, Berg G, Carl GH, Diamond DD (1991) Primary endoscopic realignment following posterior urethral disruption. J Urol 146:1540–1550
5. Melekos MD, Panatzakos A, Daouaher H, Papatsoris G (1992) Primary endourologic re-establishment of urethral continuity after disruption of prostatomembranous urethra. Urology 39:135–138
6. Pansadoro V, Scarpone P, Emiliozzi P (1993) The endoscopic treatment of membranous urethral strictures. J Endourol 7 [Suppl 1] 111
7. Lieberman SF, Barry JM (1982) Retreat from transpubic urethroplasty for obliterated membranous urethral strictures. J Urol 128:379–382
8. Waterhouse K, Laungani G, Patil U (1980) The surgical repair of membranous urethral strictures: experience with 105 consecutive cases. J Urol 123:500–502
9. Webster GD, Waxman SW (1995) Strictures of the male urethra. Chapter 35. In Gillenwater JY, Grayhack JT, Howards SS, Duckett JW (eds) Adult and pediatric urology. 3rd edn. Lippincott, Williams, and Wilkins, Philadelphia
10. Koraitim MM (1995) The lessons of 145 post-traumatic posterior urethral strictures treated in 17 years. J Urol 153:63–66
11. Jenkins BJ, Badenoch DF, Fowler CG, Blandy JP (1992) Long-term results of treatment of urethral injuries in males caused by external trauma. Br J Urol 70:73–75
12. Mundy AR (1996) Urethroplasty for posterior urethral strictures. Br J Urol 78:243–247
13. Herschorn S, Thijssen A, Radomski SB (1992) The value of immediate or early catheterization of the traumatized posterior urethra. J Urol 148:1428–1431
14. Kotkin L, Koch MO (1996) Impotence and incontinence after immediate realignment of posterior urethral trauma: result of injury or management? J Urol 155:1600–1603
15. Gheiler EL, Frontera JR (1997) Immediate primary realignment of prostatomembranous urethral disruptions using endourologic techniques. Urology 49:596–599
16. Wilbert DM, Schoettle T, Lahme S, Bichler KH (1998) Endoscopic realignment after posterior urethral injury – long term results. J Urol 159:261 (abstract 1002)
17. Benz TB, George RN, Miller RJ, Cohen JK, Benoit RM (1999) Results of primary urethral realignment for the repair of urethral disruption. J Urol 161 [Suppl 4]:16 (abstract 62)
18. Jepson BR, Boullier JA, Moore RG, Parra RO (1999) Traumatic posterior urethral injury and early primary endoscopic realignment: evaluation of long-term follow-up. Urology 53:1205–1210
19. Moudouni SM, Patard JJ, Manunta A, Guiraud P, Lobel B, Guille F (2001) Early endoscopic realignment of post-traumatic posterior urethral disruption. Urology 57:628–632
20. Porter JR, Takayama TK, Defalco AJ (1997) Traumatic posterior urethral injury and early realignment using magnetic urethral catheters. J Urol 158:425–430. 1997

The Role of Bouginage, Visual Urethrotomy, and Stents Today

H. Sperling, M. Goepel, H. Rübben

Endoscopic treatment of urethral strictures is a controversially discussed problem in urology and has developed in the last 500 years. Paré in 1560, Physick in 1795, Amussat and Reybard in 1818, Maisonneuve in 1853, and Otis in 1872 are associated with blind urethrotomy and the attempts of urological surgeons to enlarge a stricture by internal urethrotomy. Today the visual urethrotomy by operating in a precise manner due to the use of an optical urethrotome is the standard procedure (Sachse 1973, Gaches et al. 1979).

A scar in the urethra, resulting from tissue injury due to inflammation or trauma, leads to a decrease in urethral diameter (Fig. 12.1). A normal urethra has a diameter of 10 mm (30 Fr). The resulting area of the lumen is 78 mm^2. If the inelastic scar reduces the circumferences to 15 Fr, the diameter is 5 mm and the reduced area of the lumen is 25% of the normal area, with a significant impact on the urodynamics (Devine et al. 1992).

The success of different therapeutical options depends on the procedure, the etiology of the stricture, the length, the location, and the changes in the urethra and the periurethral tissue after the urethral injury that leads to the stricture.

Strictures after urethral manipulation have a better postoperative outcome than strictures after inflammation or pelvic and penile trauma (Niesel et al. 1995). This seems obvious given the changes due to a stricture with mild or moderate inflammation in the spongy tissue or a complex stricture with inflammation and fibrosis outside the corpus spongiosum (Fig. 12.2) (Sperling et al. 1998).

Short strictures have higher success rates. Strictures less than 1 cm have success rates of 71%–84% after endoscopic treatment, contrary to those patients with longer or multiple strictures (35%–54%) (Sacknoff et Knerr 1980).

Bulbar urethral strictures are associated with good results (recurrence rate, 58%) in comparison to recurrence rates in penile location of 84% and 89% for penile bulbar urethral strictures (Pansadoro and Emiliozzi 1996).

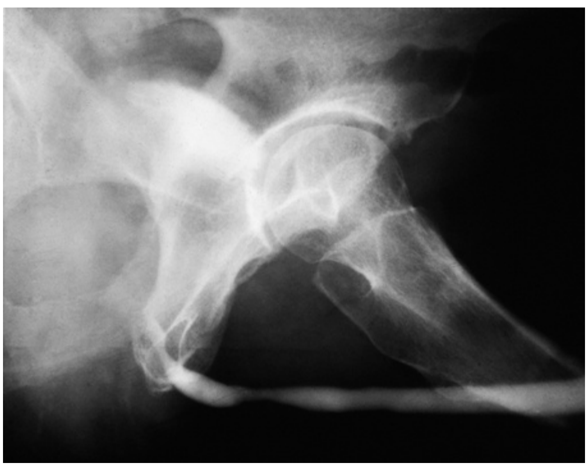


Fig. 12.1. Iatrogenic urethral stricture

12.1 Visual Urethrotomy

Since its introduction in 1973, visual urethrotomy is the standard therapy for anterior urethral strictures. It is performed in local or general anesthesia. The urethrotome is positioned in the 12 o'clock position to cut the stricture. Some surgeons prefer incisions in the 10 and 12 o'clock positions and others in the 2, 6 and 10 o'clock positions. These varying proceedings have to be seen in relation to the anatomic situation of the erectile nerves to protect the patient from secondary erectile dysfunction due to internal urethrotomy (Fig. 12.3).

The incisions have to be full-thickness incisions through the depth of the scar and not simply superficial lacerations. In short strictures, only one cut may be necessary; in longer strictures multiple cuts need to be performed.

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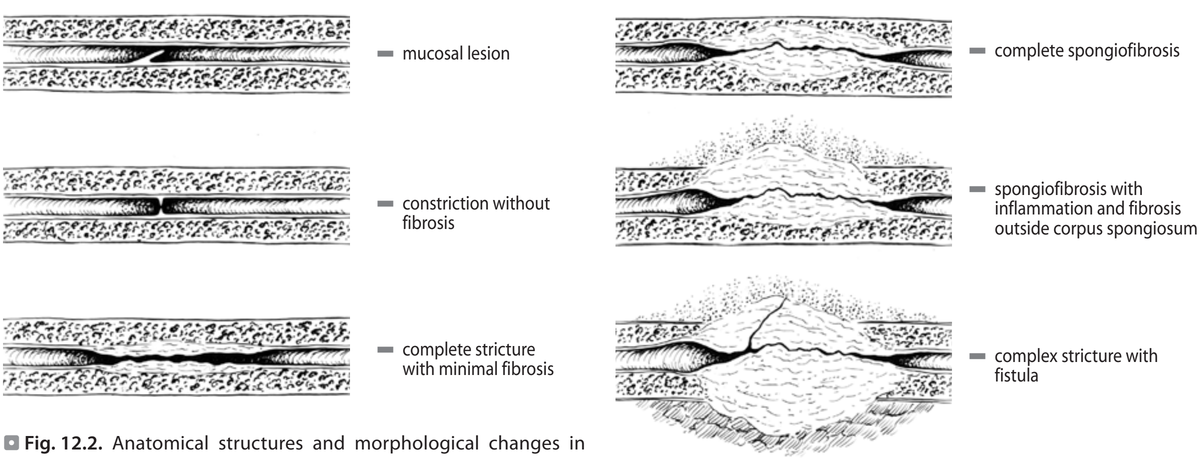


Fig. 12.2. Anatomical structures and morphological changes in urethral strictures (modified from Devine et al. 1992)

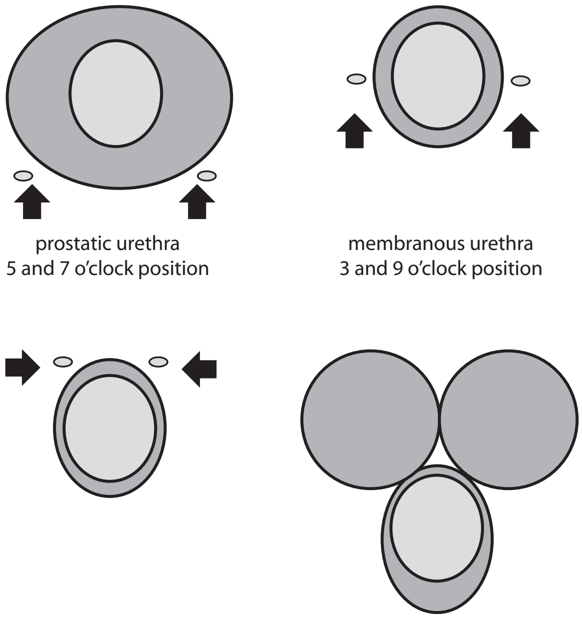


Fig. 12.3. Position of the nn. cavernosi to the urethra

In the case of a longer stricture, a guidewire or a 5-Fr ureteral catheter may be helpful to define the direction. When the scar has been incised, it should be examined in case further touch-up work has to be done. The urethra should be opened until a 24-Fr catheter can be passed with ease in adults and appropriately smaller in boys. A silicone catheter is left in the urethra after the internal urethrotomy (Devine et al. 1992, Schneider et al. 2001).

The results of the internal urethrotomy are debated controversially. A few studies in the literature report long-term results either in favor or against the method. However, long-term results and objective follow-up criteria are needed to evaluate the efficacy of visual urethrotomy. According to the criterion that 90% of the patients are cured if there is no recurrence of the stricture after more than 3 years, the follow-up should be at least 3 years. Nielsen and Nordling showed that a urinary flow less than 10 ml/s detects a clinically significant stricture in 96% of patients (Nielsen and Nordling 1990). Different uroflowmetry (6, 8, 10, and 15 ml/s) values are reported. In the past few years, a urinary peak flow of 15 ml/s has been established as the lower limit of treatment failure. This flow rate should be able to detect a significant recurrence of the stricture (Holm-Nielsen et al. 1984, Desmond et al. 1981, Smith et al. 1983, Pansadoro et Emiliozzi 1996). According to these criteria, the success rates differ enormously (Table 12.1).

These data include different locations of the stricture. Pansadoro et Emiliozzi showed that the recurrence

Table 12.1. Success rates referring to follow-up with flow over 15 ml/s

Author	Patients	Success rate	Follow-up
Gaches	197	81%	3 months
Bekirov	128	85%	6 months
Charbit	69	27%	60 months
Pansadoro	224	32%	60 months

rate after the 1st urethrotomy was overall 68% after 60 months. But bulbar stricture recurred in 58%, penile stricture in 84%, and penile bulbar urethral strictures in 89% (Pansadoro et Emiliozzi 1996). Therefore they defined the optimal stricture for visual urethrotomy as first-line treatment with a success rate of 77%: a single stricture, less than 1 cm in the bulbar urethra.

Better postoperative management might be another route to improve results.

In terms of removing the catheter, Albers et al. showed that the indwelling catheter after internal urethrotomy should be removed at most after 3 days (Albers et al. 1996).

Antibiotic therapy (norfloxacine) should be given for 15 days, which is not usually common practice, because it can reduce urethral strictures after transurethral resection of the prostate. Further prospective studies are not available (Hammarsten et Lindquist 1993).

Urethral intralesional steroid administration is not standard procedure because there is no randomized data and both positive and negative data have been reported (Korhonnen et al. 1990, Niesel et al. 1995).

Intermittent self-catheterization seems to be a way to reduce the recurrence rates of urethral strictures after visual urethrotomy. Kjaergaard et al. showed reduced recurrence from 68% to 19% after clean intermittent catheterization once a week in 43 patients (Kjaergaard et al. 1994).

12.2 Bouginage

Bouginage or dilatation is the oldest method to treat urethral strictures. Wooden tubes were used in ancient Egypt (Pansadoro et Emiliozzi 1998).

The dilatation of the stricture is achieved with dynamic stretching. It is important that no epithelial wound is induced, because this would lead to additional fibrosis of the corpus spongiosum. Experimental data show circumscribed histological findings. The muscular fibers are destroyed with consecutive hemorrhagic induced scarring (Thompson and Baker 1970). After dilatation these changes are more expressed than after internal urethrotomy, but after 3–6 months they are no longer detectable (Leverett et Halverstadt 1972).

Usually the dilatation is performed with urethral bougies in expanding sizes. Catheters and metal bougies are both used, but there is an advantage to using metal bougies for bulbar strictures and catheters for penile strictures. During dilatation with bougies, one must be aware of urethral injury such as via falsa or mucosal lesions. The dilatation should be stopped at 24 Fr, it may be necessary to perform several consecutive dilatations (Pansadoro et Emiliozzi 1998).

Balloon dilatation in the treatment of urethral strictures might be safer, because of a difference in the physical forces on the stricture. Therefore eccentric procedures should be treated with the balloon longitudinally using a bougie (Niesel et al. 1997).

Balloon dilatation is performed with local anesthesia. Under visual guidance, a guidewire is placed in the bladder. The catheter with the dilatation balloon is placed in the strictural region, filled with contrast medium, and inflated under radiological guidance. The dilatation takes 1–5 min. After the procedure, some authors do not place a catheter, others place a urethral catheter for at most 72 h (Mohammed et Wirima 1988, Daughtry et al. 1988).

The results are controversial. Balloon dilatation is a treatment with low co-morbidity, but there is very little data on long-term effects, and success rates of 40%–60% after 12 months are lower than after internal urethrotomy (Mohammed et Wirima 1988, Ravery et al 1998). Furthermore, there are conflicting data on cost; Ravery et al. report that it is a low-cost alternative to open surgery, whereas Niesel et al. point out high costs in connection with low effectiveness (Ravery et al. 1998, Niesel et al. 1997). It might be an alternative treatment to self catheretization as prophylaxis of recurrence after urethrotomy.

12

12.3 Urethral Stents

The first to use stents in the urethra was Fabian, who successfully placed a metal stent in the prostate (Fabian 1980). These stents had the disadvantage of incrustations, dislocations, and recurrent infections. Milroy and Allen first reported a new type of urethral stent. Referring to the experience gained with stents in cardiology after angioplasty, they developed a stent that holds open the previously dilatated urethra while becoming covered with urethral epithelium. This covering avoids contact with urine, consecutive incrustation and/or infection and stent dislocation (Milroy et Allen 1996). After this pioneering work, a number of modified stents were developed. We divide the stents into two types, permanent ones such as the Milroy UroLume or temporary stents such as UROcoil (Milroy et Allen 1996, Yachia et Beyar 1991). In the last few years, bioabsorbable self-reinforced stents have been developed (Isotalo et al. 1998).

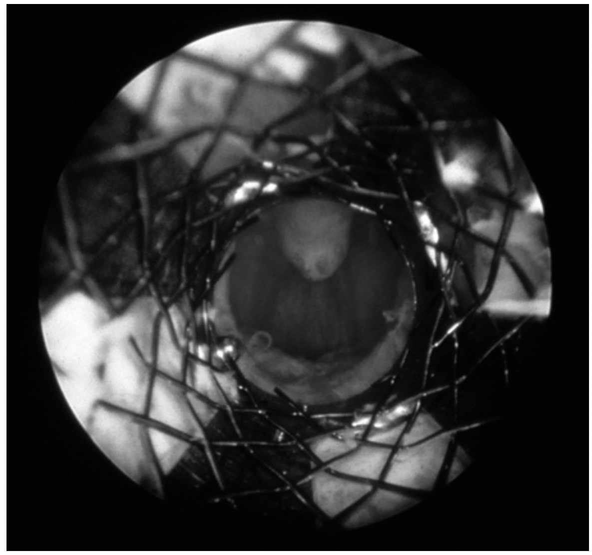


Fig. 12.4. Urethral stent in the prostatic urethra

These stents are easy to place under local anesthesia. Later transurethral manipulations are possible (Fig. 12.4). The stent should be placed at least 0.5 cm from the external sphincter and the use of several stents for longer strictures is possible. Stents should not be used in the penile urethra, due to their mobility. A catheter is not necessary after the procedure. Complications include dislocation of the stent (5%), perineal pain (22%), hematuria (6%), incontinence (11%–14%), and recurrent urinary tract infections (4%) (Milroy 1998, Ashken et al. 1991, Goepel et al. 1997).

Long-term results are presented by Milroy et Allen, who showed that 84% of 50 patients had an open urethral lumen 5 years after implantation (Milroy et Allen 1996). Yachia and Beyar showed that 75% of their patients had no recurrence of the stricture during the urethral stenting with a follow-up of 8–14 months (Yachia et Beyar 1991). Ricciotti et al. (1995) evaluated two mucosal hyperplasias in 21 patients after using a heat-expansible permanent stent (Memotherm). For the bioabsorbable stents Iotalo et al. (1998) showed that it is a promising method in recurrent urethral strictures. Twelve months after insertion, no foreign material was found in the urethra, but 10 of 22 patients needed further treatment during the follow-up of 12 months. A urethral stent is probably limited to strictures that have recurred after simple treatments that did not include periurethral fibrosis, to be used in the bulbar urethra and in older patients or those with severe co-morbidity.

Even if there are promising alternatives for the treatment of urethral strictures, internal urethrotomy remains the accepted therapy, especially for the untreated, short, bulbar stricture without periurethral fibrosis (Table 12.2).

Table 12.2. Pros and cons of bouginage, internal urethrotomy, and stents

Procedure	Indication	Advantage	Disadvantage
Bouginage	Simple stricture	Less trauma	High recurrence
Balloon dilatation	Co-morbidity	High-cost of balloon	
Stents	Recurrent bulbomembranous stricture	Simple procedure, low recurrence	Dislocation, infection, incrustation
Internal urethrotomy	short stricture without fibrosis	Best results, simple procedure	Deterioration of fibrosis

References

Albers P, Fichtner J, Brühl P, Müller SC (1996) Long-term results of internal urethrotomy. J Urol 156:1611–1614
Ashken MH, Coulange C, Millroy EJG, Sarramon JP (1991) European experience with the urethral wallstent for urethral strictures. Eur Urol 19:181–185
Bekirov HM, Tein AB, Reid RA, Freed SZ (1982) Internal urethrotomy under vision in men. J Urol 128:37–38
Charbit L, Mersel A, Beurton D, Cukier J (1990) Five year results of internal urethrotomy for urethral strictures in adults. Ann Urol (Paris) 24:66–67
Cohen JK, Berg G, Carl GH, Diamond DD (1991) Primary endoscopic realignment following posterior urethral disruption. J Urol 146:1548–1550
Daughtry JD, Rodan BA, Bean WJ (1988) Balloon dilatation of urethral strictures. Urology 31:231–233
Desmond AD, Evans CM, Jameson RM, Woolfenden K, Gibbon NO (1981) Critical evaluation of direct vision urethrotomy by urinary flow measurement. Brit J Urol 53:630–633
Devine, CJ Jr, Jordan GH, Schlossberg SM (1992) in Campbell's Urology (6th ed) Walsh P (Hrsg) Urethral Stricture, WB Saunders, Philadelphia pp 2982–3006
Fabian KM (1980) The intraprostatic partial catheter (urological spiral) Urologe A 19:236–238
Gaches CGC, Ashken MH, Dunn M, Hammonds JC, Jenkins IL, Smith PJB (1979) The role of selective internal urethrotomy in the management of urethral stricture: a multi-centre evaluation. Br J Urol 51:579–583
Goepel M, Senge A, Otto T, Rübben H (1997) Langzeitergebnisse der Wallstent-Implantation bei benigner Prostatahyperplasie und hohem Risikostatus. Urologe A 36:151–156
Hammarsten J, Lindquist K (1993) Norfloxacin as prophylaxis against urethral strictures following transurethral resection of the prostate: an open, prospective, randomized trial. J Urol 150:1722–1724
Holm-Nielsen A, Schultz A, Moller-Pedersen V (1984) Direct vision internal urethrotomy. A critical review of 365 operations. Brit J Urol 56:308–312
Isotalo T, Tammela TL, Talja M, Välimaa T, Törmälä P (1998) A bioabsorbable self-expandable, self-reinforced poly-l-actic acid urethral stent for recurrent urethral strictures: a preliminary report. J Urol 160:2033–2036
Kjaergaard B, Walter S, Bartholin J, Andersen JT, Nohr S, Beck H, Jensen BN, Lokdam A, Glavind K (1994) Prevention of urethral stricture recurrence using clean intermittent self-catheterization. Br J Urol 73:692–695
Korhonnen P, Talja M, Ruutu M, Alfthan O (1990) Intralesional corticosteroid injections in combination with internal urethrotomy in the treatment of urethral strictures. Int Urol Nephrol 22:263–269
Leverett CL, Halverstadt DB (1972) Dilatation and internal urethrotomy: histologic study on the female canine urethra. J Urol 107:63–71
Milroy E (1996) Editorial. Treatment of recurrent urethral strictures. J Urol 156:78–79
Milroy E (1998) Stents in der Therapei von Harnröhrenstrikturen. Urologe A 37:51–55
Milroy E, Allen A (1996) Long-term results of UroLume urethral stent for recurrent urethral stricture. J Urol 156:904–908
Mohammed SH, Wirima J (1988) Balloon catheter dilatation of urethral strictures. AJR 150:327–330
Morey AF, McAnnich JW (1997) Reconstruction of posterior urethral disruption injuries: outcome analysis in 82 patients. J Urol 157:506–510
Niesel T, Moore RG, Alfert HJ, Kavoussi R (1995) Alternative endoscopic management in the treatment of urethral strictures. J Endourol 9:31–39
Niesel T, Moore RG, Hofmann R, Kavoussi R (1997) Alternativ endourologische Methoden zur Behandlung der Harnröhrenstriktur – eine Literaturübersicht. Urologe A 37:56–65
Pansadoro V, Emiliozzi P (1996) Internal urethrotomy in the management of anterior urethral strictures: long-term followup. J Urol 156:73–75
Pansadoro V, Emiliozzi P (1998) Die Urethrotomia interna. Urologe A 37:21–24
Ravery V, de la Taille A, Hoffmann P, Moulinier f, Mermieu JF, Delmas V, Boccon-Gibod L (1998) Balloon catheter dilatation in the treatment of ureteral and ureteroenteric stricture. J Endourol 12:335–340
Ricciotti G, Bozzo W, Perachino M, Pezzica C, Puppo P (1995) Heat-expansible permanent intraurethral stents for benign prostatic hyperplasia and urethral strictures. J Endourol 9:417–422
Sachse H (1973) Die transurethrale scharfe Schlitzung der Harnröhrenstriktur mit einem Sichturethrotom. Verhandl Deut Gesell Urol 24:143
Sacknoff EJ, Knerr WS (1980) Direct vision cold knife urethrotomy. J Urol 123:492–496
Schneider T, Sperling H, Lümmen G, Rübben H (2001) Direct-vision internal urethrotomy. Is erectile dysfunction a possible complication? Urologe A 40:38–41
Smith PJ, Roberts JB, Ball AJ, Kaisary AV (1983) Long-term results of optical urethrotomy. Brit J Urol 55:698–700
Sperling H, Lümmen G, Rübben H (1997) Harnröhrenstriktur: Was ist bie der Behandlung und Nachbehandlung gesichert. Urologe B 38:14–18
Thompson IM, Baker JJ (1970) The histologic effect of dilatation and internal urethrotomy on the canine urethra. J Urol 103:168–173
Yachia D, Beyar M (1991) Temporarily implanted urethral coil stent for the treatment of recurrent urethral strictures: a preliminary report. J Urol 146:1001–1004

Alternative Endourological Techniques in the Treatment of Urethral Strictures – Review of the Current Literature

E. Geist, R. Hartung

One of the traditional methods for treating urethral stricture is internal urethrotomy by endoscopy. Unfortunately, this method is accompanied by a high rate of relapse. Various authors report of relapse rates between 24% and 68% [8, 12, 13, 16, 22, 85, 93, 101, 119]. For this reason, various endourological methods have been developed in order to improve the success rate in the treatment of strictures and to reduce the relapse rate.

In this chapter, the latest endourological methods such as balloon dilatation, laser urethrotomy, endoscopic urethroplasty, »cut-to-the-light« and »core-through« techniques as well as urethral stents will be critically scrutinized regarding their success rate and place of indication [77, 78].

To check the efficacy of the above-mentioned methods, diverse factors have to be taken into account. For instance, the success rate in the treatment of strictures depends on different variables, such as localization, length, number, and etiology of the strictures [111, 117].

As described in the available literature, the relapse rate of bulbar urethral strictures is lower than that of distal stenosis [85, 119]. Pansardo et al. published relapse rates after a singular urethrotomy of 58% for bulbar and 84% for penile urethral strictures [85]. The success of the treatment is also dependent on the length of the stricture [89]. With stricture lengths of under 1 cm, success rates of between 71% and 87% are reported [16, 85, 101].

Compared to a success rate of 70% for patients with a singular urethral stricture only, the success rate of urethral cutting endoscopically with patients who have several strictures is only between 35% and 54% [8, 85, 101].

The results after treatment of strictures caused iatrogenically [90] are better than after the therapy of post-traumatic and postinflammatory strictures [16, 38, 44, 101].

A further prognostic criteria is the extent of the spongiofibrosis in the area of the respective stenosis. By using ultrasonography, many authors were able to demonstrate the extent of the spongiofibrosis besides the length and localization of the stricture, partly also in comparison to the histological specimen [9, 28, 48, 52, 74]. The more clearly marked the urethral and periurethral spongiofibrosis is, the lower the chance of success using endoscopic techniques [71]. In addition, the lower success rate of repeated urethral slitting may also be attributable to the increase in periurethral fibrosis through urethrotomy [71]. Through these increasing histological alterations, an open urethral reconstruction is made more difficult.

Finally, the different surgical techniques between different surgeons and schools also affects the success rate, as well as the differences in postoperative management; among other things the period of catheterization, the use of intraurethral steroid applications [58] and the performance of postoperative self-catheterization influence the success of the therapy [50, 57].

Some basic principles should be observed in the treatment of urethral strictures.

- The preoperative urine should be aseptic. Urinary tract infections lead to fibrosis and increased scar formation.
- Antibiotic prophylaxis should prevent infection during the healing process.
- Preoperatively, the localization and length of the urethral stenosis should be determined by means of antegrade and retrograde urethrography or ultrasonography.
- Above all in the case of recidivating urethral stenosis, the extent of the urethral and periurethral fibrosis should be determined by means of ultrasonography, in order to check the indications for endoscopic procedures.
- Sufficient anesthesia is an absolute necessity during the treatment.
- Exaggerated force during the manipulation should be avoided, to keep the tissue trauma as low as possible.

13.1 Balloon Dilatation

One of the earliest and most common methods for treating urethral stenosis is dilatation [5]. The advantage of this technique is its simple execution and its immediate therapeutic success. On the other hand, the relapse rate is high and the patients need frequent retreatment, which leads to the patient's dependence on the doctor [33, 123].

Furthermore, longitudinal traction at the insertion of the dilatation catheter can lead to mucous membrane trauma with consecutive scarring, via falsa, and bleeding.

This should be avoided by using balloon dilatation. The eccentrically active forces of the dilating balloon are possibly less traumatic for the urethral mucous membrane and accompanied by less extravasation than the longitudinal traction in the traditional methods of dilatation.

Balloon dilatation can be performed on an outpatient basis under local anesthesia. With direct endoscopic guidance, a guidewire is pushed forward across the stenosis into the bladder. After that, a balloon dilatation catheter is placed via the wire in the region of the stenosis, whereby metal markers simplify its positioning.

Various balloon lengths (between 5 and 10 cm) and diameters (between 24 and 40 charr) are available. Moreover, various catheter tips are obtainable, in order to ease the passage of the stricture. Most surgeons use balloon catheters, which are also available for other endourological methods, such as ureter dilatation or percutaneous nephrostomy dilatation.

After reaching the area of the stenosis, the balloon is then inflated with contrast medium by a high pressure screw syringe. Under radiological guidance, a refiguration of the balloon in the area of the stenosis can be observed, which should then disappear on further inflating the balloon. The dilatation takes between 1 and 5 min [31, 32, 73]. If the refiguration does not disappear, the balloon can be deflated and then be refilled again until the stenosis has been cleared away. Opinions differ in the literature on postoperative bladder catheterization. While some authors do not place any catheters [73], others recommend a silastic Foley catheter for 48–72 h [31, 32].

13.1.1 Results

Almost all studies on balloon dilatation report an initial success rate of 100% [1, 43, 53, 64, 79, 100]. The number of patients involved, however, was in all studies under ten, with the exception of one case of more than 40 [43]. The main complications were burst balloon catheters. Acute or chronic cases of morbidity did not occur in any of the research groups.

The main point for criticism of these studies is that no long-term results are available. Although Daugherty describes some patients who did not have any relapses over a 4-year period, other urologists only found a success rate of 60% in a 12-month follow-up [73].

Ramchandani et al. describe this method as an alternative for treatment of anastomotic strictures after radical prostatectomy [95]. They report a success rate of 59% (16/27). There was no occurrence of incontinence among these patients.

13.1.2 Critical Assessment

Although balloon dilatation must be regarded as most likely less traumatic than conventional dilatation, as yet no one has managed to prove the clinical advantage of this method as opposed to internal urethrotomy. In particular, the relatively high costs or the devices must be taken into account when considering its application.

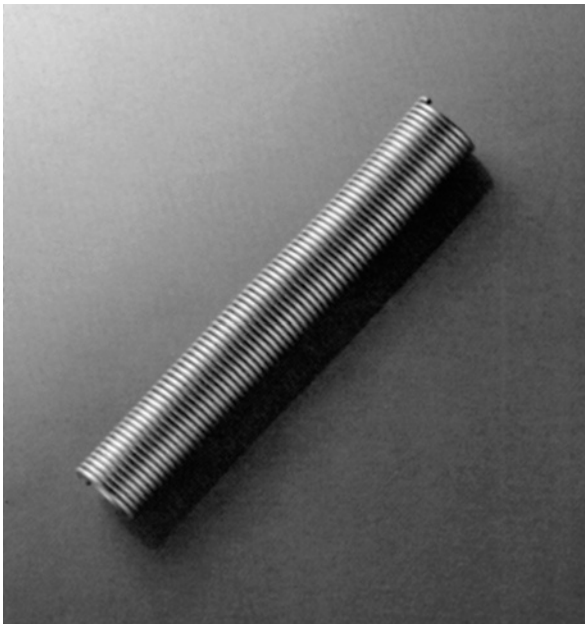
On the other hand, dilatation with balloon catheters can even be successful where conventional dilatation catheters cannot be pushed past a very rigid stricture. Furthermore, this method can be very helpful in the treatment of strictures close to the sphincter, as it reduces the risk of an additional trauma in this area and the danger of »viae falsae«.

13.2 Urethral Stents

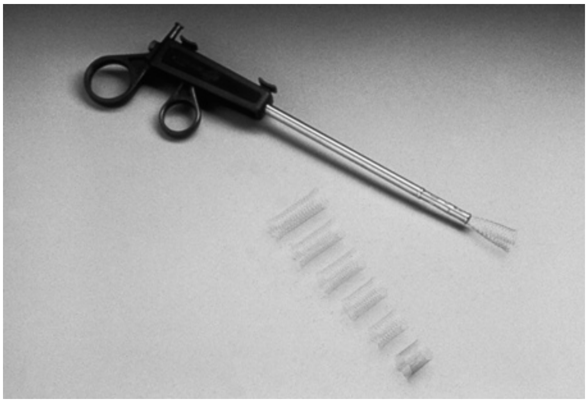
Self-expanding stents were used first to reduce the risk of an endoluminal restricturation after balloon dilatation [36].

Soon afterwards, urologists began to treat strictures in the urethra with this technique. Both permanently as well as short-term implanted stents were inserted and examined in the treatment of recurrent urethral strictures. These stents, due to their elastic, radial expanding power, are supposed to press against the wall of the urethra, thus on the one hand keeping the lumen open, and on the other hand not slipping.

The basic construction of a urethral stent consists of a woven, self-expanding wire mesh (see ◘ Figs. 13.1, 13.2). Due to its biocompatibility, already known in other fields, and its being stainless, the material generally in use is stainless steel, nitinol, and titan. Urethral stents are available in different lengths and a large variety of diameters. Thermolabile materials are also used [92, 97]. At body temperature, the material expands and thus should lead to improved anchoring in the urethra. Nonmetallic materials such as polyurethane are also used for temporary stents,



◘ **Fig. 13.1.** (Instent Urocoil)



◘ **Fig. 13.2.** (permanent Urolume)

in order to avoid incrustations [80]. There is no long-term experience in the use of either of these materials.

Although urethral stents can also be placed in position using radiological guidance, endoscopic positioning is to be preferred. To start with, a guidewire is pushed forward past the urethral stricture into the bladder. Afterwards, the stricture is opened endoscopically [4, 86, 88]. The length of the stricture can be measured with the cystoscope and suitable catheters. Urethral stents are delivered in compressed form on an application tool. With the help of a 0°-optic, the exact position of the stent is checked, before the stent is unloaded. Most systems allow for a correction of the position as long as the stent has not been completely thrown off.

Furthermore, we should keep in mind that the stent contracts after delivery. Stents ought to be placed at least 0.5 cm away from the extern sphincter, to avoid incontinence [82]. In cases of longer strictures, the stents can by all means be placed above each other, or overlapping [85].

Postoperatively, catheter insertions are not necessary, as most patients are able to void immediately. The epithelialization of the stent through its mesh happens within the following 6 months; the stent thus becomes incorporated into the urethral wall.

Besides these permanent stents, other stents have recently become, which are applied in the treatment of recurrence urethral strictures [80, 125–127]. The idea behind this development is that by doing so, no materials foreign to the body are left permanently in the urethra. These stents, also made of biocompatible material, are only supposed to keep the urethra open during the process of healing after urethrotomy interna, and can then be removed after a period of 9–14 months (Fig. 13.2).

13.2.1 Results

Since E. Millroy's first publication in 1988 [68], several studies have described the efficiency of urethral stents [4, 6, 7, 17, 34, 45, 49, 56, 62, 63, 67–70, 72, 80–84, 94, 96, 97, 103–107, 115]. The implantation is described as being simple, and does not prevent later endoscopic operations. Most of the medical teams report a success rate of over 90% [4, 45, 62, 63, 67, 83, 94, 104, 106, 107]. However, the follow-up period in these studies seldom exceeded 2 years [4, 6, 70, 72, 94, 103, 104, 107, 115].

In 1993, Oesterling and Defalco [83] reported about a larger number of cases, 131 patients, with recurrent bulbar urethral strictures. After 12 months, all the stents had been epithelialized. Infections, incontinence, impotence, nor dislocations of the stents occurred. Long-term results from this multicenter study described a relapse frequency of 14.3% 2 years later. Only in 3% of the patients did stents have to be explanted [7].

In 1991, Ashken et al. [4] published a European study on patients with urethral stents who had been followed up for 3 years. In a total of 16 out of 71 patients examined, perineal pain occurred; four patients reported macroscopic hematuria. Dripping loss of urine was found among 28 patients in the following 3 months and among ten patients after 8 months. Three patients experienced recurrent infections of the lower urinary tract. Urethrography 3 months after intervention showed that almost all patients (95%) had no relapse of the urethral stricture. In two patients, however, the lumen was restricted by hyperplastic tissue, so that a transurethral resection became necessary.

A follow-up over more than 5 years (n=27) is reported by Milroy and Allen [72]. In 84% of their patients, an open urethral lumen was still found after this period of time, following stent implantation. Relapses that occurred were partly due to a preoperatively existing, extensive periurethral fibrosis; the authors recommend that stent implantations ought to be avoided in these cases.

Experiences using several stents localized one behind the other are mentioned in a prospective multicenter study. They discovered a higher relapse rate among patients with several stents in comparison to those with only one stent [120].

Yachia et al. [125–127] as well as Sikafi [110] report on their experience with removable stents [URO coil]. After an average interval of 8–14 months, the nonpermanent stents were removed. The mean follow-up time averaged 21 (8–40), or respectively 9 (6–18) months; approximately 75% of the patients remained without any stricture relapse in these periods.

The insertion of thermolabile stents (Memotherm) was examined by Ricciotti et al. [97]. Two out of 21 patients developed severe hyperplasia of the endothelial tissue. Despite promising data, as yet no long-term results have been made available.

13.2.2 Critical Assessment

Stent implantations are accompanied by complications [88]. Several studies report that stents dislocate if they are not attached properly against the urinary wall [6, 17, 34, 45, 56, 62, 70, 98, 102, 104]. Thus new strictures can be caused by hyperplastic tissue growing from one end of the stent into the lumen thus narrowing the lumen. This tissue can be removed by transurethral resection. There is, however, the risk of a relapse.

Apart from perineal pain, lithogenesis and incontinence can occur. Most of these symptoms disappear with time. When they do not, it may be necessary to remove the stent. The long-term effect of the implanted foreign material on the tissue of the urethra is not known. Possible effects such as chronic inflammation, calculogenesis, and oncogenesis could occur. Temporary stents have the obvious advantage over permanent stents that no foreign material is left in the urethra. Great care is also needed in the use of any sort of permanent device, either the Urolume or the Memotherm device. These should not be used in children and should be avoided in young adults. The majority of strictures in this age group are in any case treated more easily by single-stage urethroplasty procedures. The use of permanent epithelial covering stents should be limited to the bulbomembranous urethra, with the possible exception of carefully selected sphincter strictures used in combination with an artificial urinary sphincter. The difficulty at the present time is our inability to define exactly which traumatic stricture or posturethroplasty stricture will succeed and which will fail.

As the recurrence of strictures is partly due to a preoperatively existing extensive periurethral spongiofibrosis, this prognostic factor should be taken into account preoperatively through a sonography, and in ases of extensive periurethral spongitis, a stent implantation should be avoided.

13.3 Laser Urethrotomy

Laser energy is used as an alternative to »cold« internal urethrotomy according to Sachse in the treatment of urethral strictures. In theory, the advantage of using lasers rests on the assumption that high-focus energy reduces tissue damage and removes fibrous tissue. Both neodymium-YAG (Nd/YAG), as well as argon, holmium, and CTP lasers are used to treat urethral strictures [19, 23, 35]. The Nd/YAG laser has a wavelength of 1,060 nm, which is poorly absorbed by tissue, resulting in a great depth of penetration [116]. Thus a clean cut with a depth of 5 mm and good hemostasis are achieved [114]. The calium-titanyl-phosphate (CTP) laser produces energy with a wavelength of 532 nm, leading to a carbonization and vaporization of the tissue. Hemostasis is achieved as well as the removal of scar tissue [19, 118].

Treatment using laser energy can be done with local, spinal, or general anesthesia. The energy is transported across a cystoscopic shaft with a special laser adapter via a 600-micron laser fiber. Various power levels from 25 to 45 W have been used. The laser energy should be guided along the total circumference of the stricture, whereby using direct contact seems to be advantageous [114]. Postoperatively, a bladder catheter should hinder urinary retention on the basis of the tissue edema [99].

13.3.1 Results

Several studies analyze the use of the Nd/YAG [14, 15, 18, 108, 112, 113, 124] as well as the argon [2, 11], holmium [23, 59], and the CTP lasers [54, 109, 121] in the treatment of urethral strictures.

The difficulty in comparing these studies stems from the different electric power used in different periods of time. Moreover, the surgical techniques vary, as some prefer a simple incision, others a treatment of the total circumference. The number of patients also varies between 6 and 57, the follow-up between 0 and 53 months.

In tests with the Nd/YAG laser, the success rate was between 36% [112] and 100% [109]. After treatment with the CTP laser, there were reports of success rates of 59% [122] to 83% [54]. Treatment with the argon laser showed a lasting success with 78% of the patients [2]. Contrary to this, Becker et al. found, after an average follow-up of 15.2 months with 450 patients, a urethral relapse of 70.1% after argon therapy. Nearly 50% of these relapses appeared within the 1st year [11]. The main complication was urethral perforation [108], infection of the mucous membrane of the rectum [108], as well as urethral skin fistula [109].

Patients with short strictures had just as low relapse rates after laser treatment (4%) as with traditional Sachse urethrotomy [15]. Patients with extensive strictures also showed relapse rates of 77% with laser treatment [15].

Vincente et al. [124] reported of a random study on 30 patients with urethral strictures, who had either been treated by conventional internal urethrotomy or Nd/YAG laser. The patients were re-examined by means of clinical examination with the help of »uroflow« and miction cystourethrography. The urethrotomy group had a success rate of 80% after 1 year and 60% after 2 years. The laser group showed a satisfactory result for 73% of the patients after the 1st and 2ndyear. The differences were not of statistical significance.

13.3.2 Critical Assessment

The above-mentioned differences in methods, the short follow-up periods, the lack of differentiation of the patients selected corresponding to pathogenesis, and the lack of other criteria of quality make a conclusive assessment of laser urethrotomy difficult.

Given the high costs and after reviewing the available reports, at the moment there is no clinical advantage in using laser treatment in comparison to conventional urethrotomy interna. It is possible that future developments will improve the success of the treatment

13.4 Endoscopic Urethroplasty

In endoscopic urethroplasty, a free skin transplant is placed in position with the aid of a cystoscope above a urethral stricture, which had been previously incised by means of urethrotomy interna [24–26, 41, 75, 76, 91, 98, 129]. The indication for this technique is the complex, recurrent urethral stricture that could not be treated successfully by urethrotomy. The theory of this method is the epithelialization of the urethra with an available skin graft. The availability of healthy epithelial tissue should reduce the forming of scars and the relapse frequency.

The method requires first that the urethral stricture be incised at the 12 o'clock position. Additionally, a resection of the scar tissue may be necessary in order to create a healthy bed for the skin transplant [42]. After measuring the length of the stricture with the cystoscope, a free skin transplant is taken from the forearm or prepuce. The graft should have a thickness of 0.45 cm, the length of the graft should be 2 cm longer than the length measured to allow for sufficient coverage [75]. The width of the graft should be 20 mm and its circumference should correspond to a 20-charr silastic catheter. The overlapping ends become necrotic and will drop off postoperatively.

The next step is to measure the distance between the bladder neck and the proximal end of the urethral stricture with the aid of a measuring balloon. This distance is then marked on a Foley catheter. Then the skin transplant is fixed to the catheter with 4.0-cat-chromic sutures over the measured spots. The epithelialized surface should be facing the catheter. After that the catheter with the graft is pushed forward into the bladder, the balloon is inflated and pulled back to the bladder neck. Then a pressure pack is applied to the penis shaft, in order to fix the transplant in the area of the incised stricture. By means of a suprapubic urine drainage, the bladder should be drained to minimize a flow of urine along the catheter and the thereby resulting damage for the transplant. The patients should be ordered to strict bed rest for a period of 6 days. The urethral catheter will be removed after 10 days and the suprapubic urine drainage 4–6 weeks later.

An alternative method for fixing the transplant is described by Naude [75]. Under endoscope guidance, two thin hollow needles are pushed across the perineum into the urethra – one at the proximal, and one at the distal end of the incised stricture. Nonresorbable sutures are pushed forward from outside into the urethra through the hollow needles and are pulled out through the meatus with the cystoscope. The free transplant is fixed circularly via a balloon dilatation catheter, and both the sutures coming out of the meatus are fixed to each particular end of the graft, and are then pulled back by means of a needle. Then the catheter with the graft is placed above the urethral stricture by pulling at the proximal and in addition at the perineal sutures. The nonresorbable sutures are then fixed across a foam cushion to the perineum. The dilatation balloon is expanded with sodium chloride, in order to fix the transplant to the urethra. A week after the operation, the external sutures are pulled, the balloon unblocked and removed.

13.4.1 Results

The results with this method are very promising [24–26, 41, 75, 76, 91, 98, 129].

Petterson et al. [91] were the first to report four patients with bulbar urethral strictures who were treated successfully with this method. During a 4- to 12-month follow-up, no dilatation was needed, the transplants were well healed, and there was no stricture relapse.

Naude [75, 76] reports the longest follow-up examination period and the greatest experience using this technique. in 41 out of 44 patients after 5 years of follow-up, it was observed that the transplants were well healed without any stricture relapses.

The complication rates were low. There were single cases of urethral infections [91] or bladder neck strictures [98]. Incontinence problems were not mentioned by any of the authors.

Later reports by Chiou et al. describe the successful use of this technique with two patients, after radical prostatectomy, who had developed high-level recurrent anastomotic strictures. Eleven of these patients were free of any relapse 25 months later. The patient who had been continent before the endourological operation remained continent afterward [27].

13.4.2 Critical Assessment

Compared to open urethroplasty, this method is less invasive and simpler to carry out. To achieve sufficient contact between the transplant and the urethra, the balloon dilatation catheter seems to be suitable. Any relapses were caused by the complexity of the strictures treated.

On the other hand, the number of studies is small and the results are not adequately documented, which also points to considerable problems in the acceptance of the method. A stricture can also stay open if the skin graft dislodges. The actual taking of such a free transplant can only be proved bioptically, which was not undertaken in any of the studies.

In our opinion, there is too little experience with this method to actually be able to recommend it as a method for selection in cases of recurrent strictures.

13.5 Endoscopic Treatment of a Complete Urethral Occlusion

Complete urethral occlusion is generally the result of a pelvic trauma and one of the most difficult urethral strictures to be treated endoscopically [21]. Even after radical prostatectomy, complete occlusion of the urethra can occur [3, 20].

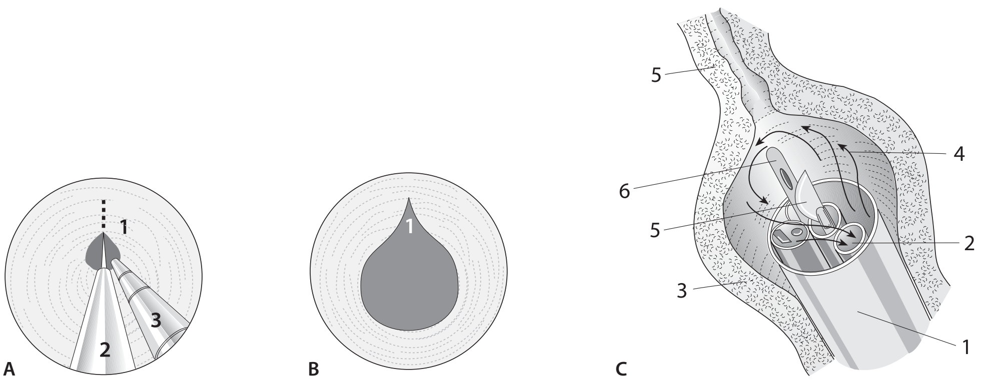


Fig. 13.3. Endoscopic urethrotomy is done with the aim of penetrating and following the contour of the previously existing urethra to the urethral cavity. **A**: 1 = direction of the incision 12 o'clock, 2 = urethrotome, 3 = guide wire or ureteral catheter; **B** = 1 opening of the stricture at 12 o'clock; **C**: opening of the stricture at 12 o'clock. 1 = urethrotome, 2 = tube for irrigation, 3 = urethral wall, 4 = urethral cavity, 5 = urethrotome, 6 = guide wire or ureteral catheter

By means of endoscopic cut-to-the-light [3, 20, 21, 24–27, 60, 65, 66] and core-through [10, 37, 39, 42, 46, 47, 51, 61, 121, 128] techniques, it is possible to restore the continuity of the urethra, as an alternative to open surgery techniques (see Fig. 13.3)

The techniques describe vary minutely and are all very similar in their basic principles.

In most cases, during the initial care after the trauma, a suprapubic urine drain was put into place. Thus antegrade and retrograde radiological studies are possible to determine the length of the obstructed urethral segment. Endourological recanalization techniques should not be used in cases of an obstruction length of more than 3 cm, as the greater the length, the higher the risk of hemorrhaging, incontinence, and injury to the rectum [65]. The endourological restoration of the urethra is carried out in the lithotomy position. At first the suprapubic aperture is dilated up and a flexible cystoscope is placed through the neck of the bladder in front of the proximal end of the stricture. A rigid cystoscope with a 0°-optics is pushed transurethrally in front of the distal end of the stricture. Some authors prefer a rigid nephroscope, as in this way a straight trocar needle can be pushed forward under endoscopy [65].

The lighting in the operation room and the light of the transurethral cystoscope are turned off. The light of the flexible cystoscope can then be seen transurethrally through the scar tissue. If the light cannot be seen, one should pay attention to the protrusion in the tissue, caused by pushing the flexible cystoscope forward. As an alternative to the cystoscope, a metal dilatator can also be used in the core-through technique, to cause a protrusion. Under fluoroscopy, a trocar needle or a urethrotomy scalpel is pushed forward through the scar tissue in the direction of the light or the protrusion. Attention must be paid to the outer sphincter muscle, to keep the risk of postoperative incontinence as low as possible.

As soon as the connection between the bladder and the urethra has been restored, a guidewire is inserted across the stricture. Subsequently, either a resection of the scar tissue, for example with a children's resectoscope [65], or a dilatation with catheters up to 28-charr in width can be carried out.

A Foley catheter is inserted into the bladder with the guidewire and left in the bladder for 3–4 weeks, to allow for epithelialization. The suprapubic urine drain should be left in place until after the removal of the urethral catheter. Perioperative antibiotic treatment is recommended.

Some authors recommend injecting cortisone into the scar tissue, to reduce the incidence of a relapse [65]. Yet the reported results on the success of this measure are quite contradictory [30, 58].

Performing a regime of self-dilatation seems to be more promising. Here urethral bougineage is carried out twice a day in the first 4 weeks, daily in the following 3 weeks and then every second day in the following 3 months [116].

14.5.1 Results

The successful endoscopic restoration of the urethra using the above-described methods has been reported by several authors. This method helps a large number of patients remain continent and potent.

The number of cases, however, is limited, varying between two and 12 patients. After follow-up periods between 2 and 96 months, success rates of 50%–100% were mentioned [3, 25–27, 29, 39, 46, 61, 65, 121]. Several patients, however, needed narrow-meshed dilatations of the stricture.

Some study groups [10, 25, 30, 61, 65, 66, 128] report impotence rates between 17% and 60%, although most of these patients had already been impotent before the endourological operation [10, 25, 61, 66, 128]. Incontinence rates up to 40% were reported [26], though the number of cases was very low.

Carr and Webster [20] as well as Appel and Lebenson [3] reported using this method for patients with obliterated anastomosis stricture after radical prostatectomy. In both groups, it was possible to restore continuity between the bladder and the urethra. Although incontinence appeared in two out of four patients, because of the gravity of the symptoms, only one patient had to have an artificial sphincter implanted [20].

A combination of the core-through technique with an endourethroplasty was reported about by Chiou et al. in one case report. On finding an extensive membranous obliteration, the continuity was restored first of all, and then an endourethroplasty was carried out; 13 months later an artificial sphincter was implanted without any problems, so that the patient was continent and relapse-free 3 years later [27].

14.5.2 Critical Assessment

Nearly all publications mentioned that for renewed strictures instant urethrotomy, transurethral resection of scar tissue [54], or an open urethroplasty [30] may be necessary. The incidence of urethral stricture relapses can be reduced by narrow-meshed urethral bougineages.

Furthermore, the cut-to-the-light or core-through method can be combined with an endourological urethroplasty to reduce stricture recurrence. In our opinion, a trial treatment with this method would be warranted for cases of complete urethra obliteration. In recurrent disease, open urethroplasty should be taken into consideration.

13.6 Conclusion

The progressive development of endourological instruments and endourological techniques helped to widen the spectrum of possible therapeutic methods (Table 13.1). Transurethral incision should be the treatment favored for primary, uncomplicated urethral strictures.

Repeated cutting of the urethra induces progressive spongiofibrosis and, besides the worsening of the success rate, it also makes any later necessary urethral reconstructions more difficult. Therefore, repeated urethrotomy should be limited to those patients whose general condition is too poor for curative methods, or who refuse other operation techniques.

Balloon dilatation as well as laser incision have not yet proved to be more advantageous than incision with the urethrotomy scalpel, so that the increased costs of these methods are not justified at the place of indication.

Another promising method for treatment of urethral strictures is the insertion of urethral stents. Careful patient selection is essential in order to achieve the best results and we need more long-term results before the final role of these devices in the treatment of urethral strictures can

Table 13.1. Overview. Alternative endourological techniques in the treatment of urethral strictures

Procedure	Indication	Advantage	Disadvantage	Complication	Conclusion
Urethrotomia interna	Simple short stricture, stricture of anastomosis after RRP	Simple handling	High recurrence rate	Increase in spongiofibrosis	First-line therapy
Balloon dilatation	Simple short stricture, stricture of anastomosis after RRP	Less traumatic, immediate success, outstanding patient procedure	High recurrence rate expansive		Too expansive from a cost-benefit standpoint
Stents	Recurrent strictures without spongiofibrosis	Simple handling, immediate success	Expansive	Migration, foreign material, stimulation of spongiofibrosis	Treatment only for recurrent or rather bulbar strictures
Laser-urethrotomy	Simple short stricture	Less tissue damage	High costs		Too expansive from a cost-benefit standpoint
Cut to the light, core through	Complete urethral stricture	Less invasive than open surgery	Very high recurrence rate	Incontinence, impotence, fistulas, perforation of the rectum	In some cases alternative to open surgery
Endoscopic urethroplasty	Alternative to the open surgery, recurrent strictures	Less invasive than open surgery	No long-term results, no skilled procedure	Loss of the transplant infection	Alternative to open surgery

be determined. Until now, the success rates have been between 50% and 100%, however for short follow-up periods. Also, nothing is known of the risk of a permanent foreign body in the urethra. The best results will be obtained by using stents in strictures with a short history before multiple urethrotomies and dilatations have been carried out and before extensive urethral and periurethral fibrosis has occurred.

The endourological deposit of a free skin transplant above the incised urethral stricture has shown promising results, with a success rate of 90%, and appears to be an alternative to urethroplasty. In our opinion, the experience with this method is too limited to be able to recommend it as a possible method for the treatment of recurrent strictures.

The endourological restoration of the completely obstructed urethra with the aid of cut-to-the-light and core-through methods seems to be an alternative treatment to open urethroplasty. Results from different clinical groups show the success of the method with little risk to potency and continence. For approximately 25% of the patients with renewed scar tissue, further endourological measures are necessary, in order to keep the urethra open and prevent a relapse of the stricture through scar formation. In these cases, open urethroplasty should be taken into consideration.

References

1. Acunas B, Acunas G, Gokmen LC (1988) Ballon dilatation of iatrogenic urethral strictures. Europ J Radiol 8:214–216
2. Adkins WC (1988) Argon laser treatment of urethral stricture and vesicalneck contracture. Las Surg Med 6:600–603
3. Appel RA, Lebenson BS (1989) Endoscopic management of urethrovesical anastomotic obliteration following radial retropubic prostatectomy. J Urol 142:818–820
4. Ashken MH, C. Coulange C, Milroy EJG, Sarramon JP (1991) European experience with the urethral wallstent for urethral strictures. Eur Urol 19:181–185
5. Attwater HL (1943) The history of urethral stricture. Br J Urol 15:39–43
6. Baert J (1993) Long term consequences of urethral stents. J Urol 150:853–855
7. Badlani GH, Press SM, Defalco A, Oesterling JE, Smith AD (1995) Urolume endourethral prosthesis for the treatment of urethral stricture disease:longterm results of the North American Multicenter UroLume Trial. Urology 45:846–856
8. Ballanger P, Midy D, Vely JF (1987) Resultats de l`urethrotomie endoscopique-dans le traitment des retrecissements de l`urethre: a propos de 72 observations. J. Urol (Paris) 89:95–99
9. Barbagli G, Azzaro F, Menchi I, Amorose A, Selli C (1995) Bacteriologic, histologic and ultrasonographic findings in strictures recurring after urethrotomy. A preliminary study. Scand J Urol Nephrol 29:193–195
10. Barry JM (1989) Visual urethrotomy in the management of the obliterated membraneous urethra. Urol Clin North Am 16:319–324
11. Becker HC, Miller J, Noske HD, Klask JP, Weidner W (1995) Transurethral laser urethrotomy with argon laser:experience with 900 urethrotomies in 450 patients from 1978 to 1993. Urol Int 55:150–153
12. Bellorofonte C, Dell`Acqua S, Mastromarino, et al, Urethral and posttraumatic urologic endoscopic surgery in day hospital. Arch Ital Urol. Androl. (Italy), Jun. 98 70 (3), 127–129
13. Bircan MK, Sahin H, Korkmaz K, Diagnosis of urethral strictures:is retrograd urethrography still necassary?, Int. Urol. Nephrol (Hungary), 96, 28 (6), 801–804
14. Blitz BF, Rukstalis DB, Levine LA (1992) Treatment of anterior and posterior urethral strictures with Nd:YAG contact tip laser visual internal urethrotomy (abstract). J Urol A 147:370
15. Bloiso G, Warner R, Cohen M (1988) Treatment of urethral diseases with Neodymium:YAG laser. Urology 32:106–110
16. Boccon-Gibod L, Le Portz B (1982) Endoscopic urethrotomy:Does it live up ist promises? J Urol 127:433–435
17. Boccon-Gibod L, Barthelemy Y (1995) Late (1–4 years) results of the wall stent endourethral prosthesis in strictures of the male urethra. J Urol 153:579 (abstract)
18. Bos SD, Ypma AFGVM, Buijs GAEM (1993) Laser urethrotomy for urethral strictures (abstract). J Endourol 7:111
19. Buelow H, Buelow V (1978) Transurethral stenosis treated with lasers. Proc German Soc Urol 434
20. Carr LK, Webster GD (1996) Endoscopic management of the obliterated anastomosis following redical prostatectomy. J Urol 156:70–72
21. Chang SY, Endourologic management of impassable urethra stricture, J Formos Med Assoc. (Taiwan), Aug. 1994, 93 (8), 694–696
22. Chebil M, Horchamoi A, Zmerli S (1987) Appreciation des resultats de l`urethrotomie interne endoscopique dans le traitment du retrecissement. J Urol (Paris) 93:25–30
23. Chepurov AK, Neuenova AA, Zeukov SS, et.al. The Holmium laser in the endoscolpic treatment of uretral strictures, Urol. Nefrol. (mosk, Russia), Mar.-April 1997, (2), 19–22
24. Chiou RK, Gonzales R 81985) Endoscopic treatment of complete urethral obstruction using thin trocar. Urology 25:175–178
25. Chiou RK, Gonzales R, Ortlip S, Fraley EE (1988) Endoscopic treatment of posterior urethral obliteration:long-term follow-up and comparsison with transpubic urethroplasty. J Urol 140:508–511
26. Chiou RK (1988) Endourethroplasty in the management of complicated posterior urethral strictures. J Urol 140:607–609
27. Chiou RK, Grune M, Rosisky D, Kaveggia FF, Mays SD, Taylor RJ (1995) repair of extensive traumatic membranous urethral disruption with endourethroplasty and artificial sphincter:case report. J Endourol 9:509–512
28. Chiou RK, Anderson JC, Trans T, Patterson RH, Wobig R, Taylor RJ (1996) Evaluation of urethral strictures and associated abnormalities using high-resolution and color Doppler ultrasound. Urology 47:102–107
29. Chiou RK, How S, Morton JJ, Grune MT, Taylor RJ (1996) treatment of recurrent vesicourethral anastomtic stricture after radical prostatectomy with endourethroplasty. Urology 47:422–425
30. Cohen JK, Berg G, Carl GH, Diamond DD (1991) Primary endoscopic realignment following posterior urethral disruption. J Urol 146:1548–1550
31. Daughtry JD, Rodan BA, Bean WJ (1988) Ballon dilatation of urethral strictures. Urology 31:231–233
32. Daughtry JD (1989) retrograde ballon dilatation of urethra. Urology 33:257–259
33. Devereux MH, Burfield GD (1970) Prolonged follow-up of urethral strictures treated by intermittent dilatation. Br J Urol 42:321–323
34. Donald JJ, Rickards D, Milroy EJG (1991) Stricture disease radiology of urethral stents. Radiology 180:447–450
35. Dondukov Ts V, Chep AK, The endoscopic treatment of urethral stricture and stone by using the HO:Yag laser, Urol. Nefrol (Mosk, Russia), Jan.-Febr. 1997, (1), 44–48
36. Dotter CT (1969) Transluminally-placed coilspring endarterial tube grafts long-term patency in canine popliteal artery. Invest Radiol 4:329–334

37. El-Abd S (1993) Endoscopic treatment of impassable urethral obliteration, traumatic or inflammatory (abstract). J Urol A 149:229
38. El-Abd SA, Endoscopic treatment of posttraumatic urethral obliteration experience in 369 patients, J Urol (United States), Jan. 95, 153 (1), 67–71
39 Fishman IJ, Hirsch ICH, Toombs BD (1987) Endourological reconstruction of posterior urethral disruption. J Urol 137:283–286
40. Fishman IJ (1992) Experience with an hydraulic ballon urethral dilator for office and selffilatation (abstract). J Urol A 147:287
41. Gaur DD (1983) Endourethral urethroplasty – use of a new catheter. J Urol 130:905
42. Giannakopoulos X, meniateis E, Gatzios, et al, Sachse urethrotomy versus endoscopic urethrotomy plus transurethral resection of the fibrosus callus (Guillemin`s technique) in the treatment of urethral stricture. Urology (US), Feb. 1997, 49 (2), 243–247
43. Giesy JD, Finn JC, Hermann GD, Kinney TB, Fogarty TJ (1984) Coaxial ballon dilation and calibration of urethral strictures. Am J Surg 147:611–614
44. Goel MC, Kumar M, Kapoor R, Endoscopic management of traumatic posterior urethral strictuary results and follow up (see comments). J Urol. (US), Jan. 1997, 157 (1), 95–97
45. Goepel M, Broecheler A, Ruebben H (1991) Treatment of BPH and urethral stenosis with the wallstent-prosthesis (abstract). J Endourol 5:142
46. Gonzales R, Chiou RK, Hekmat K, Fraley EE (1983) Endoscopic reestablishment of urethral continuity after traumatic disruption of the membranous urethra. J Urol 130:785–787
47. Gupta NP, Gill IS V (1986) Core-through optical internal urethrotomy in management of impassable traumatic posterior urethral strictures. J Urol 136:1018–1021
48. Gupta S, Majumdar B, Tiwari A, Gupta RK, Kumar A, Gujral RB (1993) Sonourethrography in the evaluation of anterior urethral strictures:correlation with radiographic urethrography. J Clin Ultrasound 21:231–239
49. Guzman Martinez-Valls PL, Ferrero Doria R, Tomas RosM, et al., Endourethral prothesis in recurrent urethral stenosis, long term follow-up, Arch. Esp. Urol. (Spain), May 96, 49 (4), 421–425
50. Harriss DR, Beckingham IJ, Lemberger RJ, Lawrence WT (1994) Long-term results of intermittend low-friction self-catheterization in patients with recurrent urethral strictures. Br J Urol 74:790–792
51. Hefty TR (1990) The Goodwin sound an aid in treating obliterated membranous urethral strictures endoscopically. Urol Clin North Am 17:31–33
52. Heidenreich A, Derschum W, Bonfig R, Wilbert DM (1994) Ultrasound in the evaluation of urethral stricture disease:a prospective study in 175 pents. Br J Urol 74:93–98
53. Hubler J, Solt J (1991) Ballon catheter for the dilatation of the urethra. Orvosi Hetilap 132:925–927
54. Ireton RC (1988) Treatment of urologic lesions with the KTP-532NM laser system (abstract). J Urol A 139:319
55. Kamalov AA, Martov AG, Cushchin BL, et al, The endoscopic treatment of extensive urethral strictures and obliteration of the urethra and bladder neck, Urol. Nefrol. (Mosk; Russia), Nov.-Dez. 97, (6), 28–33
56. Katz G, Shapiro A, Pode D (1994) Obstruction of urethral stents by mucosal overgrowth. J Endourol 8:73–74
57. Kjaergaard B, Walter S, Bartholin J et al. (1994) Prevention of urethral stricture recurrence using clean intermittend self-catheterization. Br J Urol 73:692–695
58. Korhonen P, Talja M, Ruutu M, Alfthan O (1990) Intralesional corticosteroid injections in combination with internal urethrotomy in treatment of urethral structures. Int Uro Nephro 22:263–269
59. Kurul AR, Coskuner ER, Cenik I, Holmium laser ablation of recurrent strictures of urethra and bladder neck, preliminary results. J. Endourol. (US), April 2000, 14 (3), 301–304
60. Leonard MP, Emtage J, Perez R, Morales (1990) Endoscopic management of urethral stricture »cut to the light« procedure. Urology 35:117–120
61. Liebermann SF, Barry JM (1992) Retreat from transpubic urethroplasty for obliterated membraneous urethral strictures. J Urol 147:379–381
62. Lock TMTW, De Hond HAPM, El-Din A, Boon TA (1991) Wallstents prosthesis for recurrent urethral obstruction (abstract). J Endourol 5:144
63. Lymberpoulos S, Gouvalis S, Schwinges-Lymberopoulos M (1991) The permanent wallstents endoprosthesis in the treatment of recurrent posterior urethral stricture (abstract). J Endoruol 5:144
64. Mac Diarmid SA, Hamjan CT, Cottone JL, et al. Assessment of a new transurethral balloon dilatation catheter in the treatment of urethral strictur disease. Orology (US), März 2000, 55 (3), 408–413
65. Marshall FF, Chang R, Gearhart JP (1987) Endoscopic reconstruction of traumatic membraneous urethral transsection. J Urol 138:306–309
66. Mc Coy GB, Barry JM, Liebermann SF, Pearse HD, Wicklund R (1987) Treatment of obliterated membraneous and bulbous urethras by direct vision internal urethrotomy. J Trauma 27:883–886
67. Meyer WW, Rachel U, Liermann D, Jonas D (1991) Endourethral prosthesis for bulbar urethral stricture (abstract). J Endourol 5:143
68. Milroy EJG, Chapple CR, Eldin A, Wallsten H (1989) A new treatment for urethral strictures:a permanently implanted urethral stent. J. Urol 141:1120–1122
69. Milroy EJG, Chapple CR, Eldin A, Wallsten H (1989) A new stent for the treatment of urethral strictures. Preliminary report. Br J Urol 63:392–396
70. Milroy EJG (1994) Urethral wallstents for urethral strictures Long term results (abstract). J Urol A 151:361
71. Milroy EJG (1996) Editorial:treatment of recurrent urethral strictures. J Urol 156:78–79
72. Milroy E, Allen A (1996) Long-term results of urolume urethral stent for recurrent urethral strictures. J Urol 155:904–908
73. Mohammed SH, Wirima J (1988) Ballon catheter dilataion of urethral strictures. AJR 150:327–330
74. Nash PA, McAninch JW, Bruce JE, Hanks DK (1995) Sono-urethrography in the evaluation of anor urethral strictures. J Urol 154:72–76
75. Naude JH (1988) Endoscopic urethroplasty. J Endourol 2:395–501
76. Naude JH (1991) Current concepts in the management of urethral strictures. Ann Surg 23:69–80
77. Niesel T, Moore RG, Hofmann R, et al, Alternative endourological method for treatment of urethral strictures. Urologe A (Germany), Jan. 1998, 37 (1), 56–65
78. Niesel T, Moore RG, Alfert AY, et al, Alternative endoscopic management in the treatment of urethral strictures. J. Endourol. (United States), Feb. 1995, 9 (1), 31–39
79. Nishiyama T, Go H, Takashima A, Kawakami Y, Takeda M, Sato S (1991) Ballon dilatation for entrethral stricture. Urol Int 4:232–234
80. Nissenkorn I (1995) A simple nonmetal stent for treatment of urethral strictures:a preliminary repo J Urol 154:1117–1118
81. Oesterling JE, Wilson TM (1991) Intraurethral stent as an alternative treatment for bulbar urethral strictures:preliminary results. Sixtyseventh Annual Meeting of the American Urological Association, Western Section, Vancouver, British Colombia
82. Oesterling JE (1993) Urologic applications of a permanent ephitelializing urethral endoprosthesis. Urology 41:10–18
83. Oesterling JE, Defalco A (1993) The urolume endoprosthesis as a treatment for recurrent bulbar urethral strictures long term results from the North American clinical trial (abstract). J Urol A 149:505
84. Pansadoro V, Scarpone P, Emiliozzi P (1994) Treatment of a recurrent penobulbar urethral stricture after wallstent implantation with a second inner wallstent. Urology 43:248–250

85. Pansardoro V, Emiliozzi P (1996) Internal urethrotomy in the management of anterior urethral strictures. J Urol 156:78–79
86. Parra RO (1991) treatment of posterior urethral strictures with a titanium urethral stent. J Urol 146:997–1000
87. Parra RO (1991) Experience with titanium urethral stents in men with urethral strictures and bladderoutlet obstruction (abstract). J Endourol 5:143
88. Parra RO, Boullier J, Cummings J (1993) Endoluminal urethral stents, a review. J Endourol 7:117–123
89. Pauchev P, Kumanov H, Stavov CH, et al, The treatment of severe and complicated urethral strictures. Khirurgiia (Sofiia; Bulgaria), 1997, 50 (1), 53–56
90. Pausadoro V, Emiliozzi P, Iatrogenic prostatic urethral strictures:Classification and endoscopic treatment. Urology (US), April 1999, 53 (4), 784–789
91. Petterson S, Asklin B, Bratt CC (1978) Endourethral urethroplasty a simple method for treatment of urethral strictures by internal urethrotomy and primary split skin grafting. Br J Urol 50:257–261
92. Pouce Campuzano A, Gonzalez Satue C, Rodriguez Tolra J, et al. Treatment of urethral stenosis with thermo-expandable prothesis »Memotherm«. Our experience. Arch Esp. Urol. (Spain), April 2000, 53 (3), 253–258
93. Rabade R, Fernandez Gomez JM, Martin Huescar A, et al, Long term results of endoscopic urethrotomy. Arch. Esp. Urol. (Spain), Dez. 1995, 48 (10), 1027–1034
94. Rachel UK, Meyer WW, Kramer W (1993) Endourethral stents for bulbar urethral strictures (abstract). J Endourol 7:113
95. Ramchandani P, Banner MP, Berlin JW, Dannenbaum MS, Wein AJ (1994) Vesicourethral anastomtic strictures after radikal prostatectomy:efficacy of transurethral balloon dilatation. Radiology 193:345–349
96. Resel L, Blanco E, Platas A (1991) Usefulness of Wallstent prosthesis on the urethral stenosis one year follow-up (abstract). Proceedings of the 22nd Congress, Societe Internationale d`Urologie, November 1991, p418
97. Ricciotti G, Bozzo W, Perachino M, Pezzica C, Puppo P (1995) Heat-expansible permanent intrauthral stents for benign prostatic hyperplasia and urethral strictures. J Endourol 9:417–422
98. Rosin RD, Edwards L (1979) Endourethral urethroplasty. Br J Urol 51:584–586
99. Rothauge CF (1980) Urethroscopic recanalization of urethral stenosis using argon laser. Urology 16:158–161
100. Russinovich NAE, Lloyd LK, Griggs WP, Jander HP (1980) Ballon dilatation of urethral strictures. Ul Radiol 2:33–37
101. Sacknoff EJ, Kerr WS (1980) Direct vision cold kn urethrotomy. J Urol 123:492–496
102. Saporta L, Beyar M, Yachia D (1993) New temporary coil stent (Urocoil for treatment of recurrent urethral strictures. J Endourol 7:57–59
103. Sarramon JP, Joffre F, Rischmann P, Rousseau H, Eldin A (1990) Use of the wallstent endourethral prosthesis in the treatment of recurrent urethral strictures. Eur Urol 18:281–285
104. Sarramon JP, Rischmann P, Bournel P, Malavaud B (1991) Late results with the use of the endourethral »wallstent« prosthesis in the treatment of recurrent urethral stricture (abstract). J Endourol 5:91
105. Schaetz A, LeDuc A, Teillac P, Cussenot O, Le Thai B, Cortesse A (1992) Endoscopic surveillance of self-expandable metal protheses in recurrent urethral strictures. J Endourol 6:269–273
106. Schettini M, Fortunato P, Sorcini A, Acconcia A (1991) The »urolume« stent in the treatment of the urethral strictures (abstract). J Endourol 5:144
107. Schnapp DS, Badlani GH (1993) Treatment of recurrent bulbar urethral strictures using the urolume endoprosthesis the North American experience (abstract). J Endourol 7:113
108. Shanberg AM, Chalfin SA, Tansey LA (1984) Neodmium-YAG laser new treatment for urethral stricture disease. Urology 24:15–17
109. Sikafi ZH (1996) A self expanding, self retaining temporary urethral stent (Urocoil TM) in the treatment of recurrent urethral strictures:preliminary results. Br J Urol 77:701–704
110. Shanberg A, Baghdassaria R, Tansey L, Sawyer D (1988) KTP 532 laser in treatment of urethral strictures. Urology 32:517–520
111. Shinno Y, Morita K, Sasaki Y, et al, Endourology update. Hokkaido Jg aku Zasshi (Japan), Mai 1995, 70 (3), 391–396
112. Smith JA, Dixon JA (1984) Neodymium YAG laser treatment of benign urethral strictures. J Urol 131:1080
113. Smith JA (1989) Treatment of benign urethral strictures using a saphire tipped neodymium YAG laser. J Urol 142:1221–1222
114. Smith JA (1991) Application of laser energy in urologic surgery. Surg Ann 23:81–97
115. Sneller WZ, Boosch RJLH (1992) Restenosis of the urethra despite indwelling Wallstent. J Urol 148:145–147
116. Spirnak JP, Smith EM, Elder JS (1993) Posterior urethral obliteration treated by endoscopic reconstruction, internal urethrotomy and temporary self-dilatation. J Urol 149:766–768
117. Stack RS, Schlossberg SM, General principles in treatment of urethral strictures. Urologe A (germany), Jan. 1998, 37 (1), 10–20
118. Stein B (1986) Laser physics and tissue interaction. Urol Clin North Am 13:365–380
119. Stone AR, Randall JR, Shorrock K (1983) Optical urethrotomy in a 3-year experience. Br J Urol 55:701–704
120. Tillem SM, Press SM, Badlkani GH, Oesterling J, Defalco K (1995) Multiple urolume endourethral prostheses for the treatment of recurrent bulbar urethral strictures results of the North American Urolume Trial (abstract). J Urol 153:580
121. Towler JM, Eisen SM (1987) A new technique for the management of urethral injuries. Br J Urol 60:162–166
122. Turek PJ, Carpiniello VL, Malloy TR, Wein AJ, Cendron M (1992) KTP-532 laser ablation of urethral strictures. Urology 40:330–334
123. Webster GD. Endoscopy and Dilatation of urethral defects and stricture (editorial, comment). J. Urol. (US), Jan. 1997, 157 (1), 102–103
124. Vincente J, Salvador J, Caffaratti J (1990) Endoscopic urethrotomy versus urethrotomy plus strictures. Eur Urol 18:166–168
125. Yachia D, Beyar M (1991) Temporarily implanted urethral coil stent for the treatment of recurrent urethral strictures a preliminary report. J Urol 146:1001–1004
126. Yachia D, Beyar M, Aridogan IA (1993) Minimal invasive treatment of penile, bulbomembranous and penile urethral strictures using tailored temporary coil stent Urocoil, Urocoil-S, Urocoil-Twin and Prostacoil (abstract). J Endourol 7:112
127. Yachia D, Aridogan IA, Erlich N (1995) Longterm follow up of recurrent urethral strictures treated with a removable urethral stent of the uro-coilsystem (abstract). J Urol 153:577
128. Yasuda K, Yamanishi T, Isaka S, Okano T, Masai M, Shimazaki J (1991) Endoscopic re-establishment of membranous urethral disruption. J Urol 145:977–979
129. Zang JL, Zhang DY, Pan PN, Liu YM (1989) Endourethral urethroplasty with prepuce graft for long posterior urethral stricture. Chin Med J 102:165–168

One-Stage Procedures

Reconstruction of the Bulbar and Membranous Urethra

F. Schreiter, B. Schönberger, R. Olianas*

* Professor Schönberger has died since this chapter was completed.

14.1 Introduction

Destruction or rupture of the posterior urethra is caused mainly by forces that occur during traumatic pelvic rupture. This trauma results in partial or complete rupture of the urethra. A complete rupture often results in destruction of the posterior urethra and may damage the sphincteric structures, while always damaging the neurovascular bundles, which results in impotence and incontinence.

For a long time, conventional urological wisdom was that the urethral rupture in men occurs at the prostatomembranous junction by a shearing force that avulses the prostatic apex from the urogenital diaphragma. Recent studies suggest that this traditional belief may be a misconception. The urethral sphincter extends from the bladder neck to the perineal membrane (diaphragma urogenitale) The muscular lining and surrounding of the membranous urethra are directly continuous with similar muscle fibers of the prostatic urethra and end abruptly at the perineal membrane

Hence, the weakness may lie in the bulbomembranous junction rather than the membranoprostatic junction at which the posterior urethra is liable to rupture (Fig. 14.1).

As the sphincteric component remains intact, incontinence occurs only when the bladder neck is impaired (post-TUR-P) or when the bladder neck is involved in the traumatic rupture, which occurs mainly in children.

14.2 Acute Management of Posterior Urethral Trauma

Although the urethral injury is seldom the main problem of these often severally and severely traumatized patients, consequences of the urethral trauma such as urethral strictures, erectile dysfunction, and (in some cases) urinary incontinence may be problems with lifelong ramifications for these patients.

In this connection, primary urological treatment should be directed at preventing early complications and minimizing the risk of the aforementioned potential problems. A satisfactory outcome is dependent on a correct diagnosis, along with thorough and well-planned urological therapy.

Meanwhile, the controversy surrounding immediate vs delayed treatment of urethral injuries is still unresolved. The perfect treatment plan still remains to be developed; the value of the different approaches including recent evolution of innovative endourological techniques to achieve urethral continuity needs to be determined.

The following treatment strategies are available for acute management:

1. Primary open suturing of the disrupted urethra
2. Endoscopic or surgical realignment by insertion of a transurethral »railroad« catheter
3. Suprapubic cystostomy and delayed repair
4. Acute surgical intervention is indicated for the following:
   - Concomitant rectal tear
   - Bladder neck laceration
   - Serious, life-threatening bleeding, mainly from the inferior or superior gluteal arteries

A large gap between the bladder neck and the disrupted urethra, also known as »pie in the sky bladder,« is a relative indication for open surgical exploration (Fig. 14.2).

Nevertheless, immediate surgical exploration does not necessarily indicate exploration of the urethral injury site. Exploration of the urethral injury also involves release of the tamponade effect of the hematoma in the small pelvis and may compromise control of the venous bleeding.

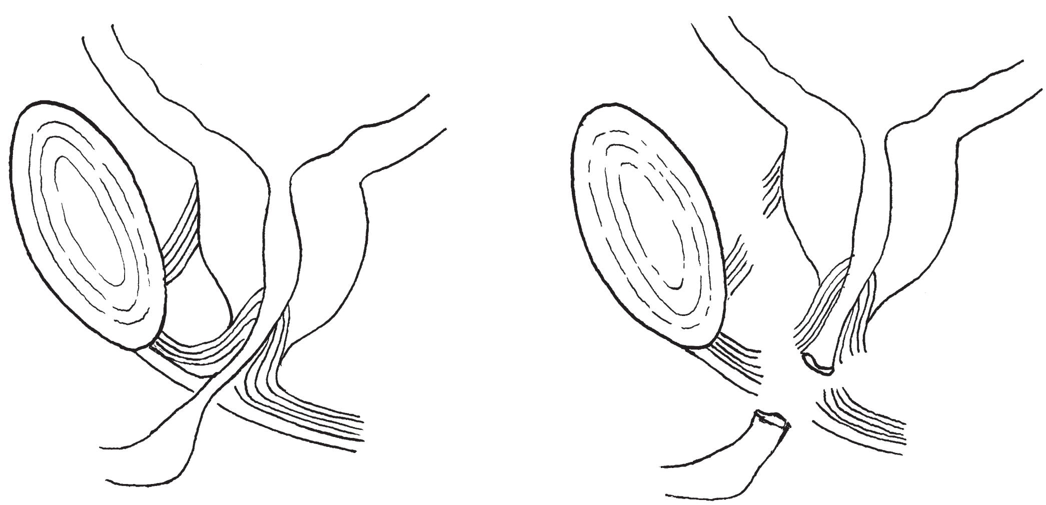


Fig. 14.1. Mechanism of membranous urethral disruption

Fig. 14.2. Pie in the sky bladder

Attempts to suture both ends of the urethra are challenging – dissection of the periurethral and prostatic tissues can cause additional damage to the neurovascular bundles and the intrinsic urethral sphincter structures. Due to the increased risk of iatrogenic impotency and incontinence, primary anastomotic repair is no longer recommended. Reconstructive procedures should be limited to open surgical placement of the transurethral catheter and suprapubic drainage of the bladder.

Therefore, for primary therapy of posterior urethral injury, we recommend urinary diversion using a suprapubic catheter and/or by endoscopically inserting a transurethral catheter. Several researchers have described a number of different railroading techniques to manipulate the catheter across the urethral gap into the bladder. It may be useful to railroad the prostate to the urethra by using a suprapubic sound or an endoscope. Sometimes it is also useful to drain the pelvic hematoma via the endoscope.

Additional traction obtained by applying additional weight to the transurethral catheter has been shown to produce pressure damage to the bladder neck and subsequently increase the risk of urinary incontinence. In addition, the traction may pull the prostatic gland into an abnormal position, causing misalignment or malrotation. For these reasons, traction has been abandoned, as has »vest sutures,« which are introduced through the prostatic apex and brought out through the perineum.

The purpose of the realignment is to reduce the number of secondary urethral strictures, and to decrease the stricture length in comparison to both suprapubic cystostomy and delayed repair. Although the ultimate value of this procedure is still under discussion, there is clear evidence that realignment can significantly decrease the incidence of strictures (Koraitim 1985, 53% vs 97%). On the other hand, this procedure may be associated with an increased risk of erectile dysfunction. (Koraitim 1996, 36% vs 19%). In another study (McAnninch 1997), the incidence of erectile dysfunction was reported at up to 55% after immediate realignment.

14.3 Delayed Repair

There is a widespread acceptance of a hands-off-policy in the acute management of posterior urethral injury, i.e., limiting initial treatment to placing a suprapubic cystostomy, which necessitates later stricture repair in most cases. Spontaneous healing after 2–3 weeks can be expected only if the urethral rupture is incomplete.

Thus end-to-end anastomosis remains the gold standard in repairing obliterated membranous urethral strictures. Experts are divided on the other treatment options. Endosurgical procedures such as »cutting to the light« have very limited indications and value. In most cases, they do not cure the stricture.

14.3.1 Indications

1. Partial or incomplete rupture of the bulbar urethra following a primary straddle trauma or a secondary development of a stricture
2. Rupture (distraction) of the membranous urethra, usually as a result of pelvic fracture
3. Short strictures (e.g., iatrogenic or inflammatory) the bulbar and membranous urethra

14.3.2 Counterindications

1. Stricture length greater than 3 cm (cave: penile curvature or shortening)
2. Injuries to the membranous urethra, involving the prostate and the bladder neck
3. Circulatory dysfunction of the proximal urethra, e.g., following a anterior urethral plasty, and if the urethra's corpus spongiosus cannot be mobilized extensively enough

14.3.3 Instruments and Suture Material

1. Special retractor (Scott retractor or Buckwalter retractor)
2. Curved metal probes and flexible cystoscope
3. Extended nose speculum (see Fig. 14.18)
4. Microcoagulation
5. Magnifying glasses and headlight
6. Monofilic, absorbable suture material 3–0 to 5–0.

14.4 Surgical Technique

14.4.1 Reconstruction of the Bulbar Urethra

Post-traumatic strictures of the posterior urethra are broken down into bulbar strictures (anterior strictures) and membranous strictures (posterior strictures).

Bulbar strictures are usually caused by straddle trauma, while membranous strictures are typically the result of urethral disruption due to a pelvic fracture.

The anterior and posterior strictures are usually short, which makes them ideally suited for a stricture resection by means of spatulated end-to-end anastomosis.

If a stricture is longer than 3 cm, penile curvature or penile shortening usually results. This should be taken into account when choosing this surgical procedure, and the patient should be informed of the repercussions. The literature (Webster et al. 1999) describes satisfactory results up to a stricture length of 7 cm; but in our experience, the resultant penile curvatures and penile injuries cause patients to be dissatisfied with the results of the surgery (Kessler et al. 2002).

14.4.1.1 Stricture Resection and Bulbar End-to-End Anastomosis

Lithotomy Position

Slightly hyperextended lithotomy position. In our experience, a hyperextended lithotomy position is not necessary (Fig. 14.3).

Perineal Approach

We prefer a median perineal incision extending close to the anus. However, a lambdoid cut or perianal incision with extension in the midline of the perineum is also possible (Fig. 14.4).

Incising the Bulbocavernosus Muscle

The bulbocavernosus muscle is split down the middle and the urethral bulbus is laid open in the area of the stricture. Although the urethral injury is rarely the main problem of these often multiple and severely traumatized patients, consequences of the urethral trauma such as urethral strictures, erectile dysfunction, and sometimes urinary incontinence are potential problems with lifelong ramifications. The stricture may be localized using a 20-Fr curved metal probe or with a flexible cystoscope (Fig. 14.5).

The urethra is mobilized from the cavernous corpora (Fig. 14.6).

Resecting the Stricture

The stricture is resected into the healthy corpus spongiosum, i.e., when blood begins to drip from the urethral stumps. Note that the spongiofibrosis may extend beyond the actual stricture itself, in which case it must also be resected (Fig. 14.7).

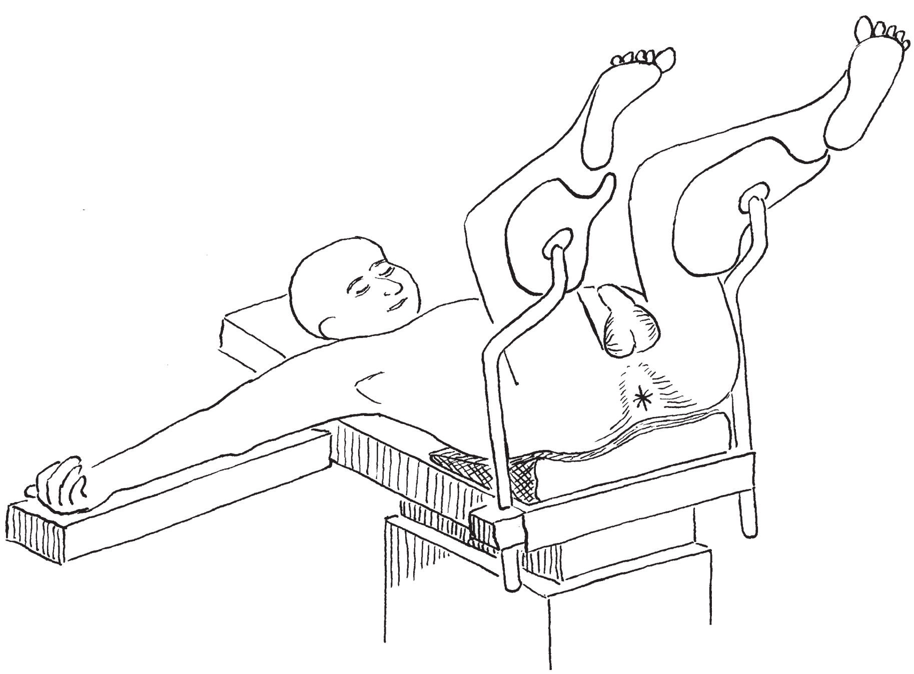


Fig. 14.3. Lithotomy position

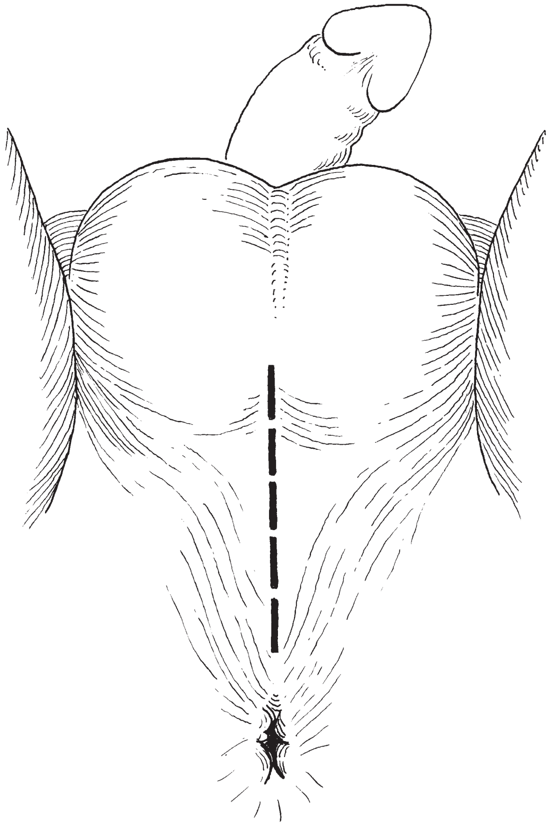


Fig. 14.4. Perineal approach

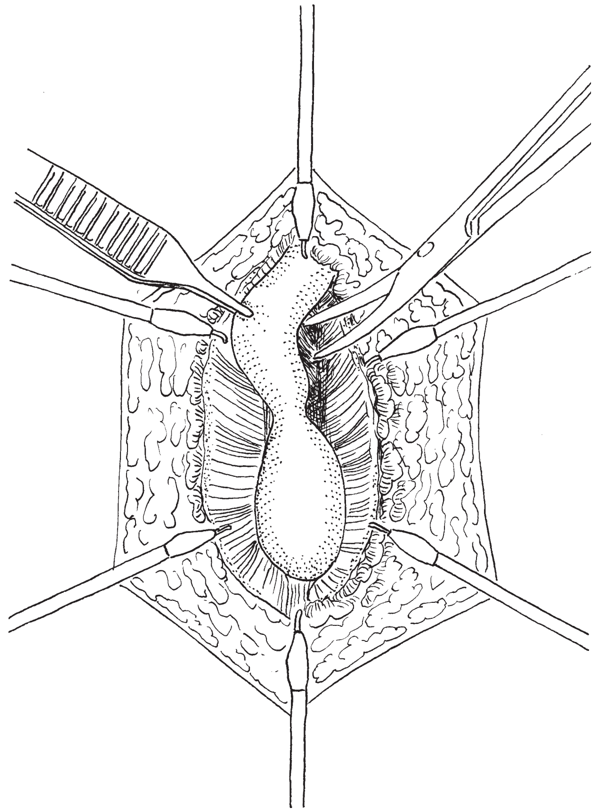


Fig. 14.6. Mobilizing the stricture

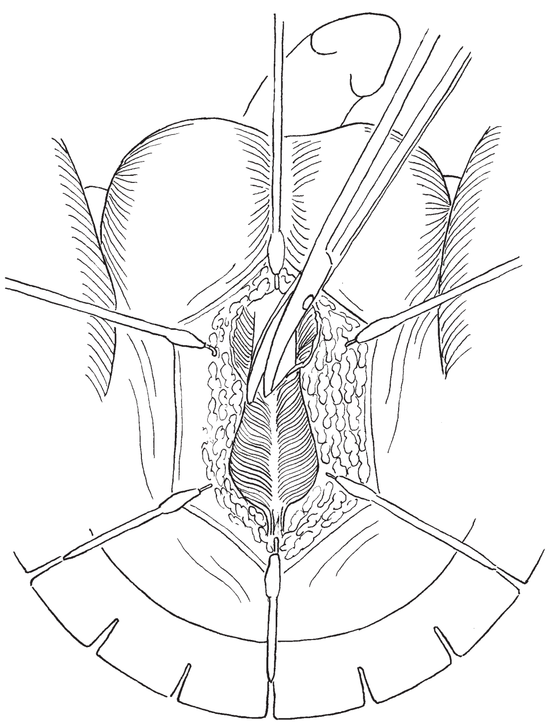


Fig. 14.5. Incising the bulbocavernosus muscle

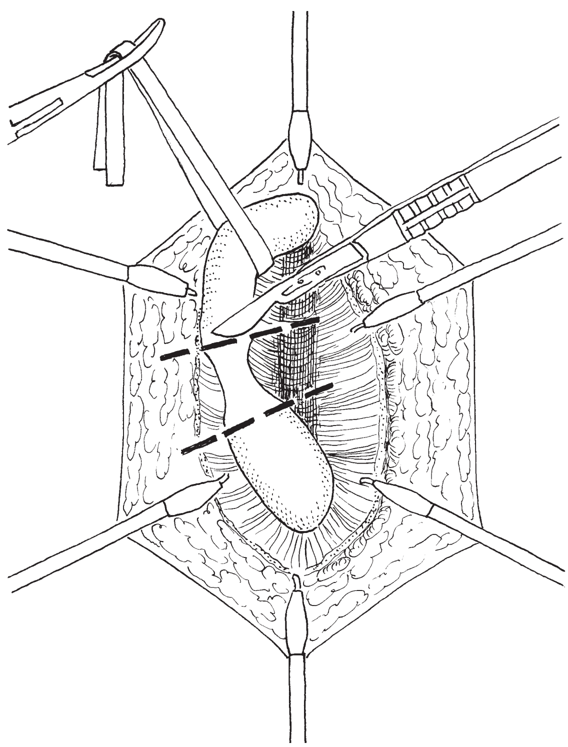


Fig. 14.7. Resecting the stricture

Spatulating the Urethral Stumps

The adequately mobilized urethral stumps are spatulated at 6 and 12 o'clock, to arrive at a sufficiently wide anastomosis later. Please consider that the anastomosis will shrink by roughly 20% (Fig. 14.8).

Suturing the Posterior Wall

It should be possible to adapt the mobilized urethral stumps without any tension. First, the posterior wall is sutured with four to six single stitches; the stitches are sewn in two layers (mucous layer and corpus spongiosum); however, a single-layer suture that catches all layers of the wall is also possible (Fig. 14.9).

Suturing the Anterior Wall

Finally, the same suture technique is used to suture the anterior wall, to arrive at a wide, tension-free anastomosis. To take some of the tension off the anastomosis suture, the urethral stumps may be fixed to the area surrounding the urethra with several single-stitch sutures (Figs. 14.10, 14.11).

Suturing the Bulbocavernosus Muscle

Finally, the bulbocavernosus muscle is reconstructed over the urethra. If there is enough cavernous tissue, it may be sutured across the anastomosis as a Turner-Warwick plasty.

The wound is drained with suction drainage, and the perineal incision closed layer by layer (Figs. 14.12, 14.13).

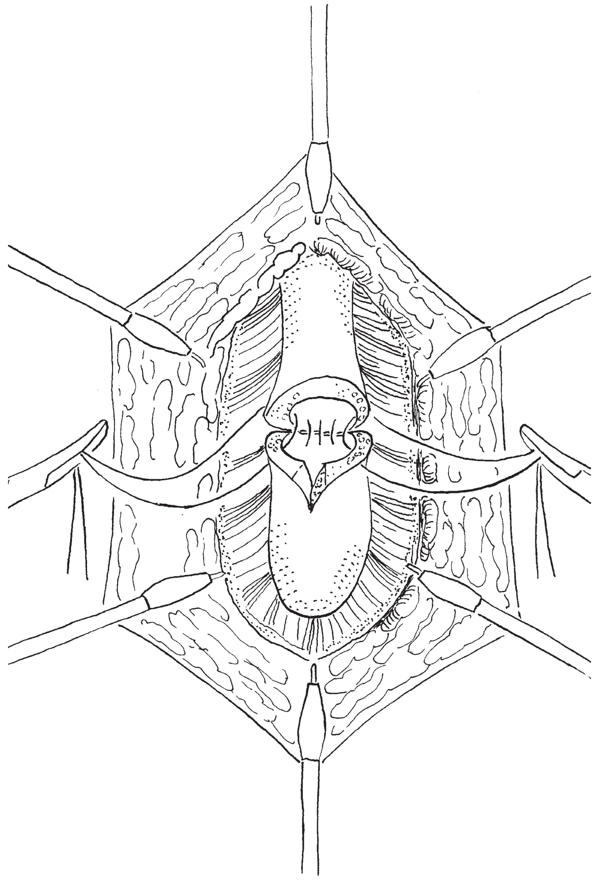


Fig. 14.9. Suturing the posterior wall

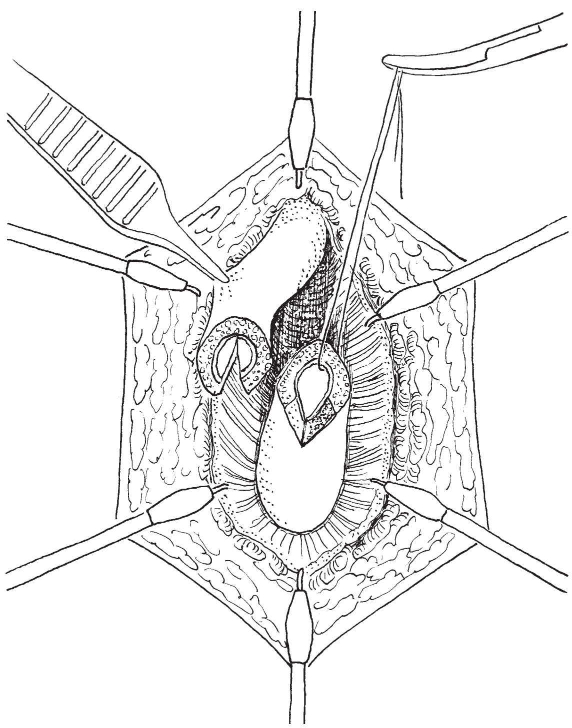


Fig. 14.8. Spatulating the urethral stumps

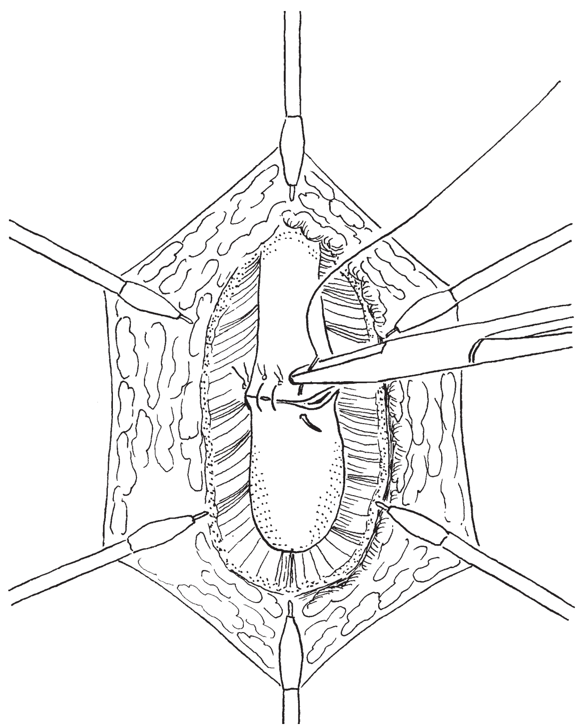


Fig. 14.10. Suturing the anterior wall

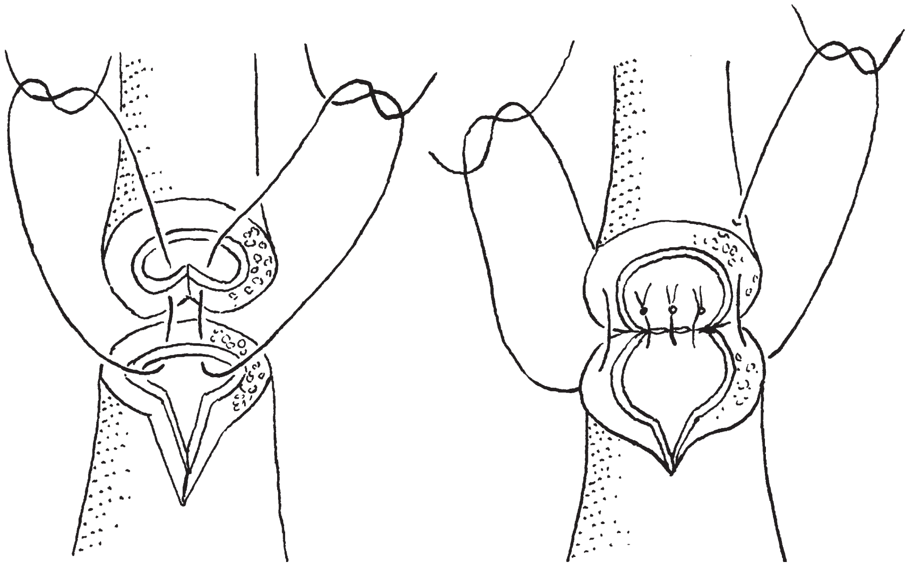


Fig. 14.11. Suturing the anterior wall

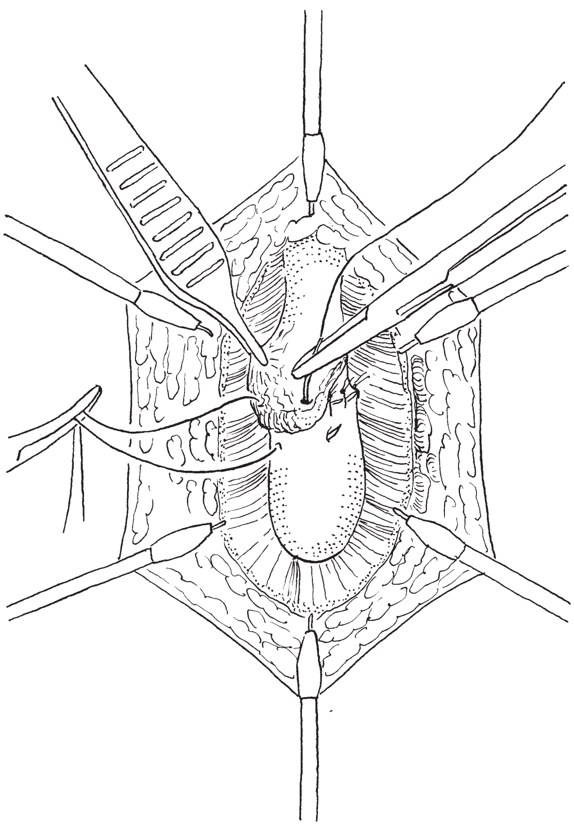


Fig. 14.12. Turner-Warwick roof plasty

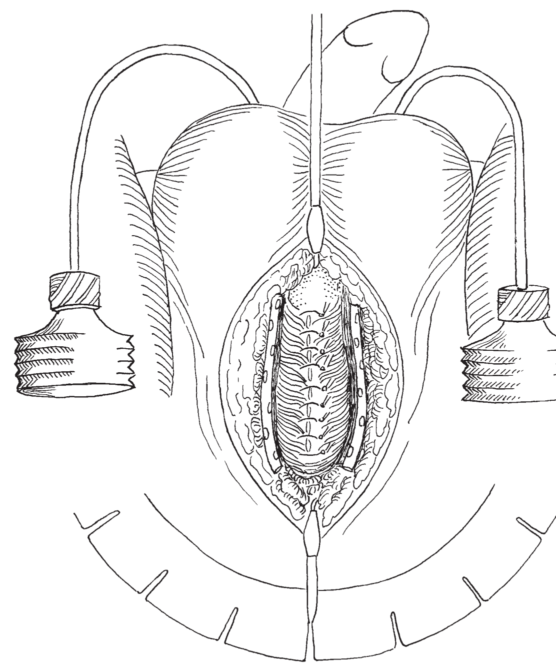


Fig. 14.13. Suturing the bulbocavernous muscle

14.4.2 Reconstructing the Membranous Urethra (Bulboprostatic Anastomosis)

14.4.2.1 Combined MCU Retrograde Urethrogram

A combined MCU-retrograde urethrogram, carried out in a 45° Lauenstein position, is the best way to determine the precise length. Any additional spongiofibrosis is best detected using a 10-MHz ultrasound probe. Counterindications for bulboprostatic anastomosis are the same as for bulbobulbar anastomosis. The stricture length should not exceed 2–3 cm (◘ Fig. 14.14).

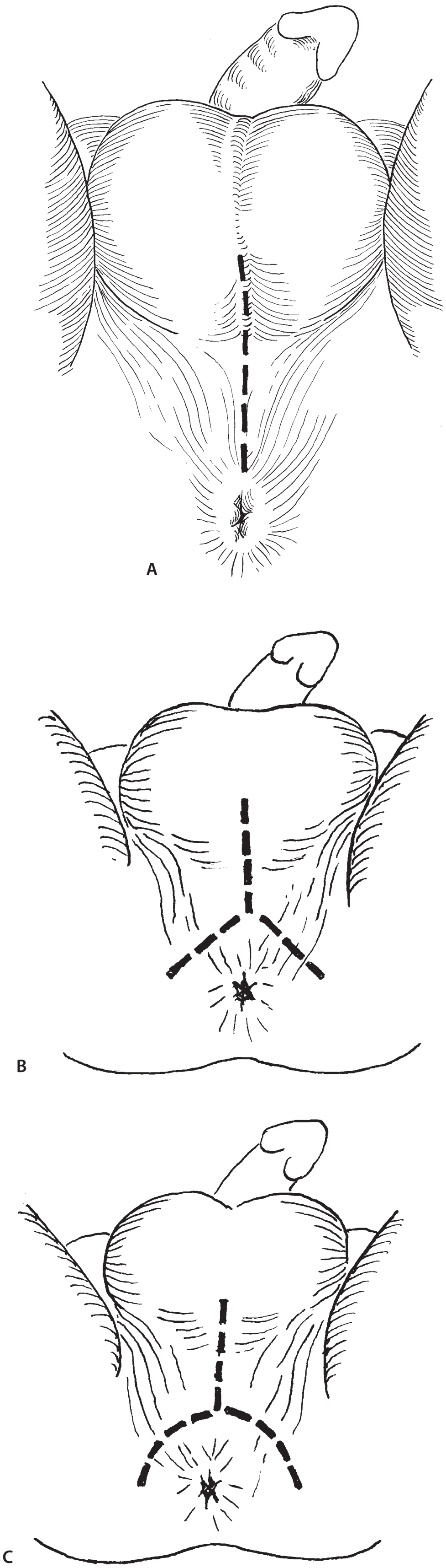
14.4.3 Surgical Approach

A reconstruction of the membranous urethra is usually also possible by perineal access. The abdominal or abdominoperineal access is reserved for cases that cannot assume a lithotomy position because of extreme loss of motion, and for rare 6- to 9-cm defects in the membranous and prostatic urethra including a demonstrably severe injury to the bladder neck requiring bladder neck reconstruction (◘ Fig. 14.15).

Preparing the Central Tendons

The central tendon is dissected to expose the prostatic apex, taking care to completely remove all scar tissue that surrounds the stricture. The end of the stricture may be located using a suprapubically inserted curved metal probe or a flexible cystoscope. The scar tissue must be removed down to the healthy tissue of the prostatic apex, which has sufficient blood supply, keeping as much as possible of the intrinsic sphincter structures intact. The distal end of the stricture is easily determined by inserting a transurethral probe, and is cut off in the healthy tissue (◘ Fig. 14.16).

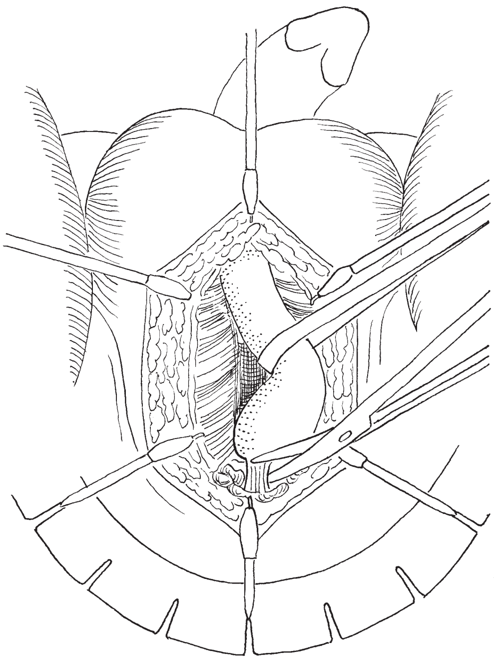
◘ **Fig. 14.14.** Combined urethrogram and MCU



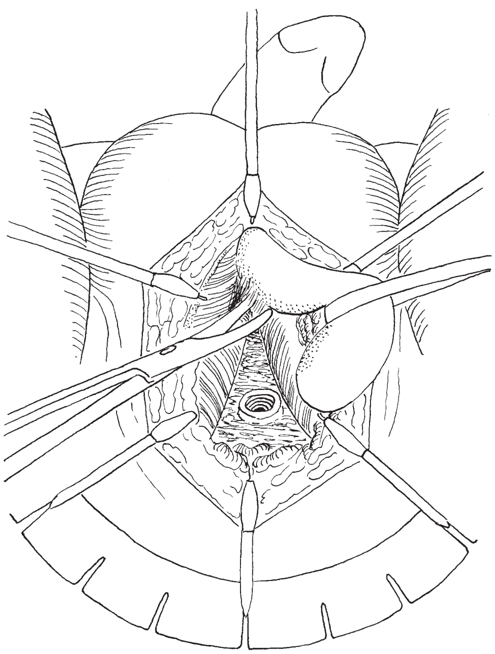
◘ **Fig. 14.15A–C**. Surgical approach

Mobilizing the Posterior Urethra

The posterior urethra is extensively dissected proximally. Here, too, the bulbocavernosus muscle is split above the urethra, taking advantage of the bulbar and anterior urethra's elasticity to suture a tension-free bulboprostatic anastomosis later (◘ Fig. 14.17).



◘ **Fig. 14.16.** Dissecting the central tendon



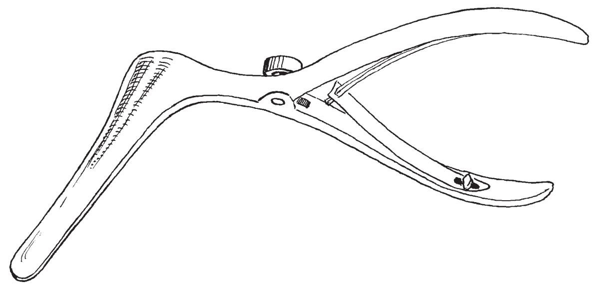
◘ **Fig. 14.17.** Mobilizing of the posterior urethra

Nose Speculum

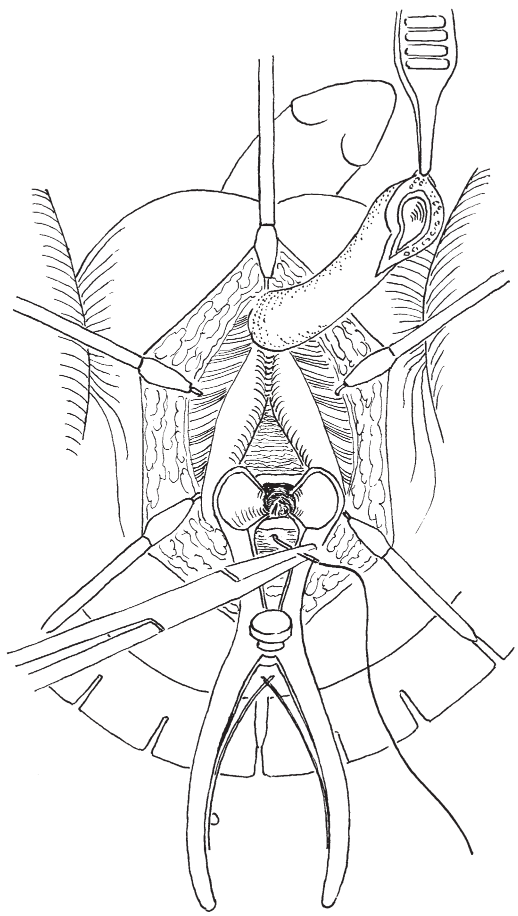
A special long nose speculum was designed, long enough to open the apex of the prostate sufficiently in the depth of situs (◘ Fig. 14.18).

Using the Nose Speculum and Applying a Circular Single-Stitch Suture to the Prostatic Apex

A nose speculum is used to hold open the prostatic apex. Now, 10–12 anastomosis sutures can easily be sewn in full view (◘ Fig. 14.19).



◘ **Fig. 14.18.** The special speculum



◘ **Fig. 14.19.** Using the speculum to open the prostatic apex

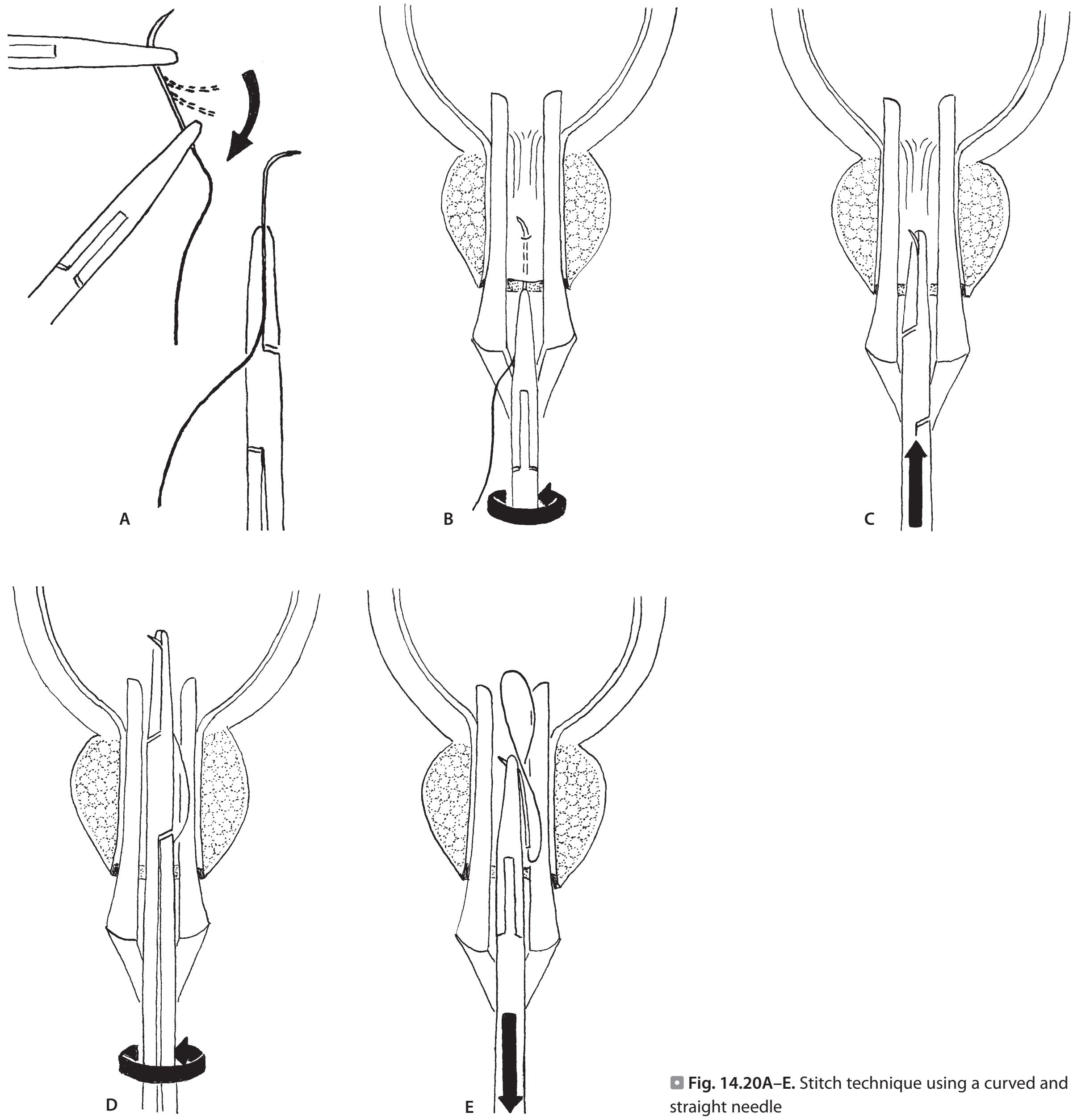


Fig. 14.20A–E. Stitch technique using a curved and straight needle

Stitching Technique Once the Prostatic Apex Is Spread Open

A bent-open curved needle (e.g., CT 2) is inserted lengthwise in the needle holder and used to pierce the apex from the outside in, including the mucous tissue. Gripping the tip of the needle with the needle holder, the needle is pushed into the bladder, where it may be easily turned and led to the outside without traumatizing the urethral tissue (Fig. 14.20).

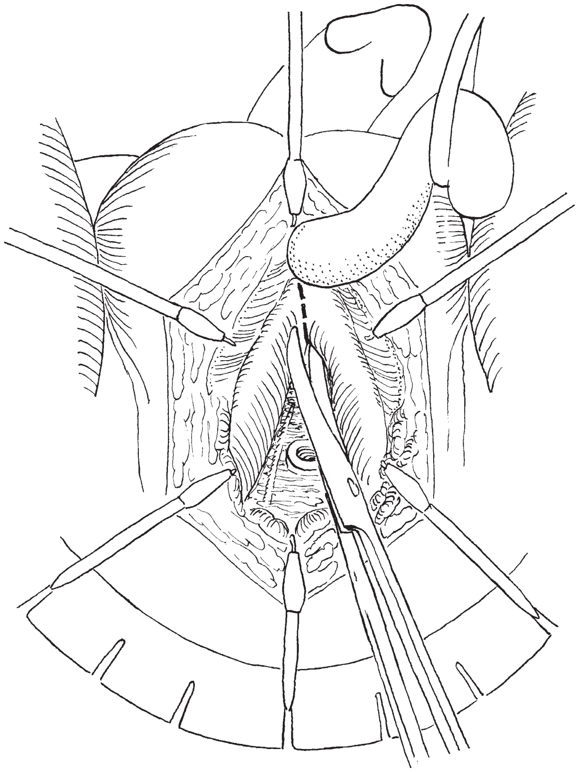
Procedure for Short Distal Urethra

The distal urethral stump is spatulated to approximate the width of the prostatic apex.

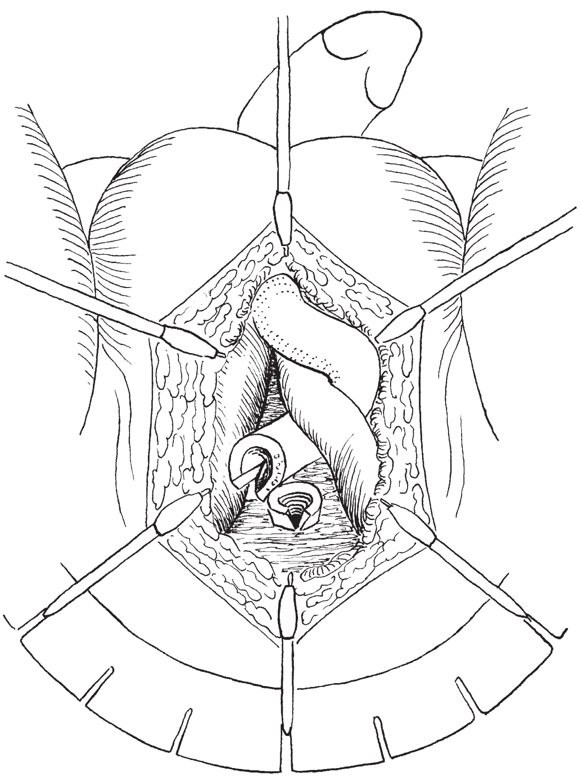
If the anastomosis cannot be adapted without tension because the urethral stump is too short or inelastic, the path to the apex may be shortened by splitting the corpora cavernosa down the midline. This may shorten the distance to the apex by 1–2 cm (Fig. 14.21).

Detaching One Crus of the Corpora Cavernosa

A similar result may be achieved by detaching one crus of the corpora cavernosa. This too may help to reduce the tension on the anastomosis by reducing the distance between the apex and the urethral stump by another 1–2 cm (Fig. 14.22).



▪ **Fig. 14.21.** Separation of the penile corporal bodies to shorten the distance to the prostatic apex



▪ **Fig. 14.22.** Rerouting the mobilized urethra behind the circumferentially dissected corporal body on one side

14.4.4 Partial Resection of the Symphysis

Sometimes it is necessary to partially resect the symphysis to shorten the distance. The resection is carried out at the lower edge of the symphysis using a bone chisel and does not impact pelvic stability. A complete resection of the symphysis, as in abdominoperineal surgery, is only very rarely necessary (▪ Fig. 14.23).

14.4.5 Finishing the Anastomosis

Like in bulbobulbar anastomosis, the anastomosis is sewn with 10–12 single-stitch sutures throughout all layers using monofilic 3-0 absorbable suture material. The wound is also drained and closed as in the bulbobulbar anastomosis technique (▪ Fig. 14.24).

14.4.6 Results and Risks of the Surgery

14.4.6.1 Stricture Resection and Anastomotic Repair in the Bulbar Stricture

At our institute, 42 patients with bulbar stricture were treated with stricture resection and end-to-end anastomosis. In only one case (2.4%) did a stricture relapse, requiring another surgical intervention. None of the patients suffered incontinence as a result of the surgery.

Five patients (11.9%) already had erectile dysfunction prior to the operation. No additional impotence was observed following the surgery.

Therefore, bulbar stricture resection with end-to-end anastomosis is the safest known procedure, with excellent long-term results.

14.4.6.2 Stricture Resection and Anastomotic Repair in Membranous Strictures

In these usually complex strictures, stricture resection and bulboprostatic anastomosis yielded good results.

Because these strictures are usually the result of severe pelvic trauma in which the urethra is disrupted from the pelvic floor, and during which neurovascular bundles that are essential to erection are torn, 30%–50% (Corriere 1994) of the patients already have erectile dysfunction prior to the bulboprostatic anastomosis. The surgery bears the risk of additional loss of erection. There may also be postoperative incontinence due to surgery-related damage to the intrinsic sphincter organ when the bladder neck is incompetent, i.e., when the bladder neck is involved in the primary trauma or after a TUR-prostate. Our institution has carried out 63 bulboprostatic anastomosis procedures following a complete urethral disruption.

Thirty patients (48%) had been rendered impotent by the primary trauma, four patients (54%) became impotent

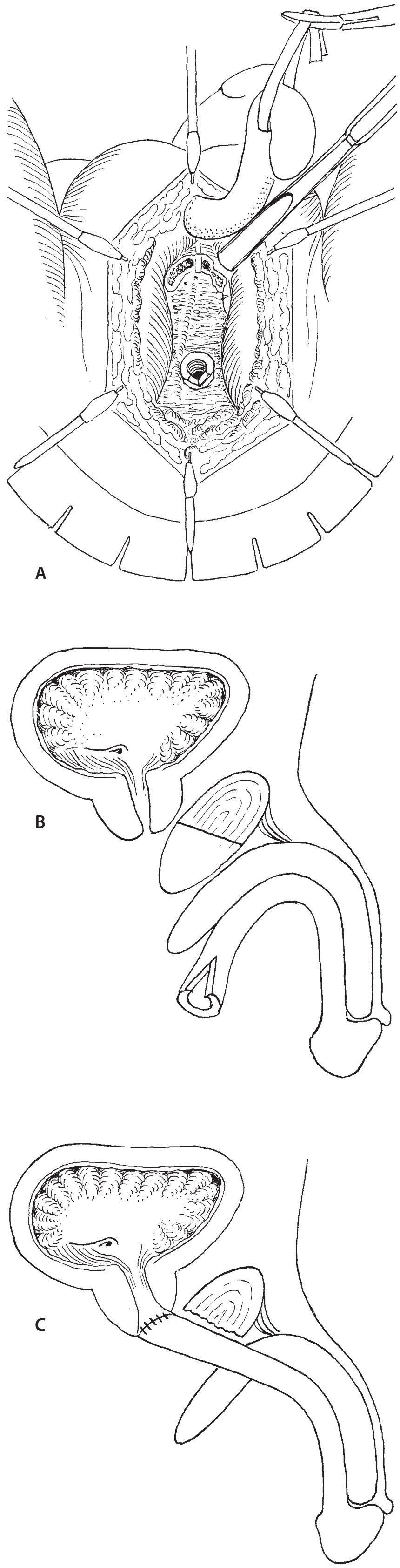


Fig. 14.23A–C. Excising the lower limb of the pubis bone under the separated corporal bodies

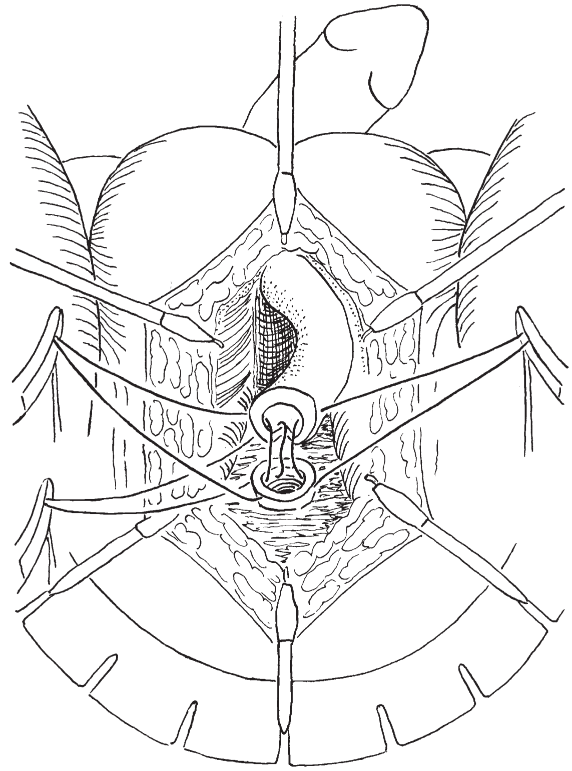


Fig. 14.24. Suturing the anastomosis

as a result of the operation, and three patients experienced postoperative stress-related incontinence.

14.4.6.3 Alternative Procedures in Bulboprostatic Anastomosis

Because there is a duty to inform patients about these consequences of the surgery, younger patients who continue to be potent after the pelvic trauma will usually refrain from a bulboprostatic anastomosis. We recommended that these patients undergo a suprapubic urinary diversion, e.g., a Mitrofanoff procedure, and proceeded thusly in most cases.

In cases of incomplete membranous stricture (e.g., membranous catheter strictures, incomplete urethral ruptures, etc.), the stricture should be split exactly down the midline with buccal mucosa onlay plasty, inner prepucial patch, or two-stage mesh-graft plasty. Dissecting strictly down the midline ensures that tissue that is important for erectile function and urethral blood flow is not severed.

14.5 Buccal Mucosa Onlay Plasty

The long-term results our institution with buccal mucosa onlay plasty has seen from this surgical procedure are also satisfactory (Fig. 14.25).

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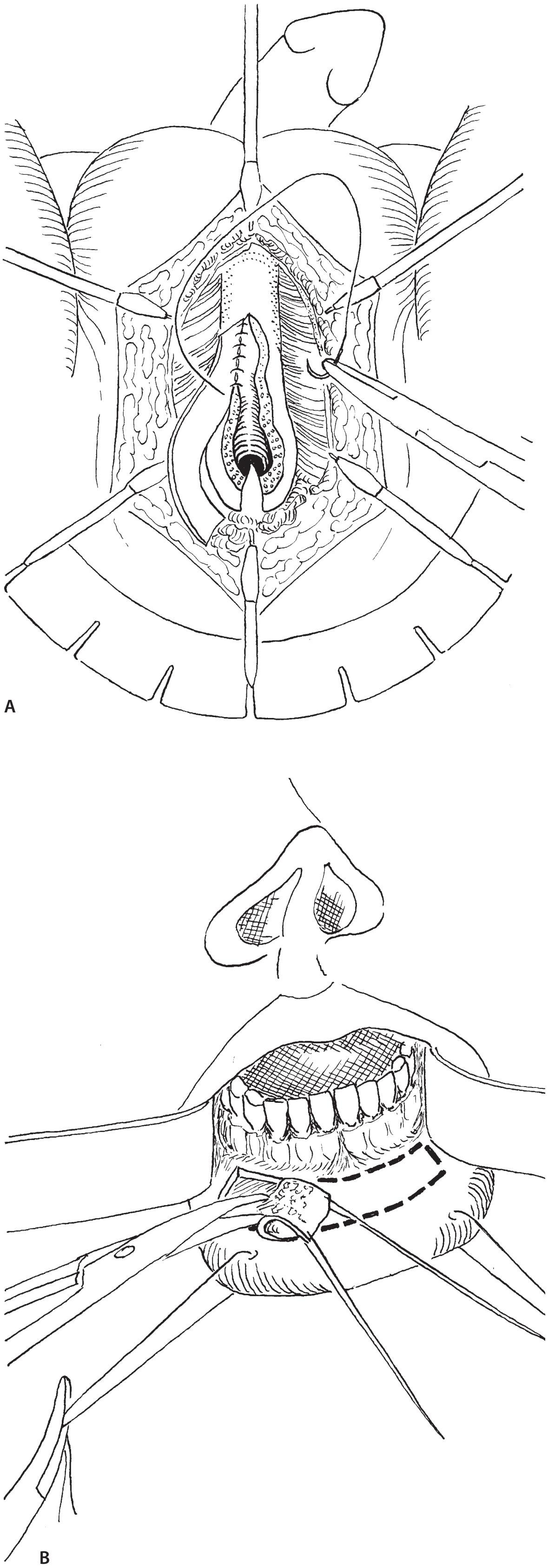
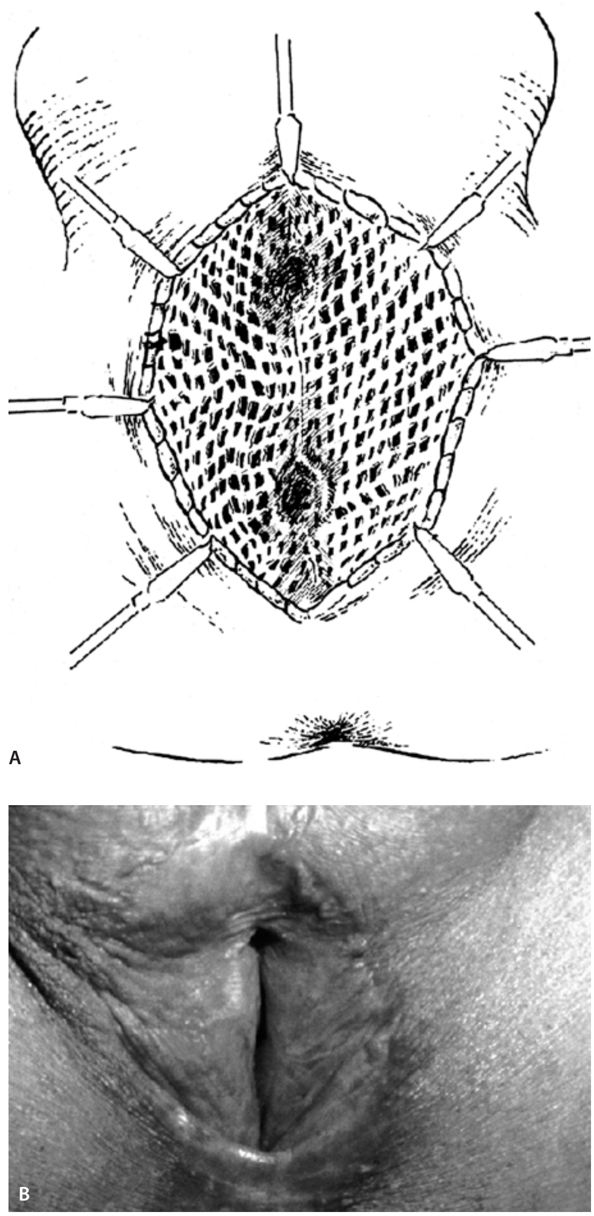


■ **Fig. 14.25A, B.** Patch plasty with buccal mucosa (alternative inner prepucial patch)

We carried out buccal mucosa patch plasties in 22 cases and saw three relapsed strictures over a period of 7 years.

Similarly satisfactory results were achieved in similar cases using one-stage penile flap urethroplasty in 18 cases, and two-stage posterior mesh-graft urethroplasty in 14 cases (■ Fig. 14.26).

All these methods are equally suited for reconstructing the posterior urethra; today, buccal mucosa is preferred because of its simple harvesting, the specific tissue characteristics and the excellent immunity.



■ **Fig. 14.26A, B.** Two-stage posterior mesh-graft inlay

14.6 Conclusion

End-to-end anastomosis of the bulbar urethra and the bulboprostatic anastomosis to reconstruct short bulbar and complex membranous urethral strictures are excellent methods for keeping the posterior urethra open over the long term. Surgery is usually possible via a perineal approach. The complication rates are low and the rate of success lies at over 95%. To avoid serious complications such as postoperative impotence, the alternative techniques described in this article should be used for young, potent men.

References

Carr LK, Webster GD (1997) Posterior urethral reconstruction. Atlas Urol Clin N Am 5

Corriere JN, Rudy DC, Benson GS (1994) Voiding and erectile function after delayed one-stage repair of posterior urethral disruptions in 50 men with a fractured pelvis. J Trauma 37:587–589; discussion 589–590

Jordan GH (1988) Wide mobilisation of the urethra. J Urol 139:332

Jordan GH (1999) End-zu-End Harnröhrenanastomose bei posttraumatischen Harnröhrenstrikturen. Akt Urol 30:275–286

Kessler TM, Fisch M, Heitz M, Olianas R, Schreiter F (2002) Patients satisfaction with the outcome of surgery for urethral strictures. J Urol 167:2507–2511

Kessler TM, Schreiter F, Kralidis G, Heitz M, Olianas R, Fisch M (2003) Long-term results of surgery for urethral stricture: a statistical analysis. J Urol 170:840–844

Koraitim MM (1985) Experience with 170 cases of posterior urethral strictures during 7 years. J Urol 133:408

Koraitim MM (1996) Pelvic fracture urethral injuries: evaluation of various methods of management. J Urol 156:1288–1291

Morey AF, Mc Anninch JW (1997) Reconstruction of posterior urethral disruption injuries: outcome analysis in 82 patients. J Urol 157:506–510

Mundy AR (1997) Reconstruction of posterior urethral distraction defects. Atlas Urol Clin Am. 5

Schreiter F (1998) Die zweizeitige Urethraplastik. Urologe A 37:42–50

Schreiter F, Noll F (1989) Mesh-graft urethroplasty using split-thickness skin graft or foreskin. J Urol 142:1223–1226

Webster GD, Ramon J: Repair of Pelvic Fracture Posterior Urethral defects Using an elaborated Perineal Approach: Experience with 74 Cases. J Urol 145:535, 1999

The Sagittal Posterior (Transcoccygeal Transrectal Transsphincteric) Approach for Reconstruction of the Posterior Urethra

D. Streit

15.1 Introduction

In the 1880s Kocher and Kraske described the transsacral approach for removal of rectal tumors where an inverted U-shaped small segment of sacrum was removed [1–4]. This incision became referred a later as Kraske's procedure. Due to understandable surgical limitations of that period, the approach fell into disuse until the 1970s when York Mason published modifications and refinements of this incision in treating rectal cancer and popularized it among anorectal surgeons [5–7]. Also called sagittal posterior approach, it had been used in proctology in treating retrorectal presacral tumors [8], benign strictures of the rectum and rectopexy in cases of severe rectal prolapse [9].

In pediatric surgery, Peña and deVries [10] refined the sacral approach described by Stephens in 1953 [11] and it has now become the procedure of choice in treating anorectal malformations.

In urology, this approach had been used for several indications by a few authors. It is better known in closure of urethrorectal and prostatorectal fistula [12–14], but it had met indications also in removal of müllerian remnants [15], seminal vesical surgery [16], urethroplasty [17], and reconstruction of high vaginal stricture associated with urethral pathology [18]. In specific cases it may find indications in radical prostatectomy [19–21], radical cistectomy [22] and implantation of I125 seeds for carcinoma of the prostate [23]. In pediatric urology, it had been a useful tool in reconstruction of urogenital sinus malformations [24].

In this chapter, we emphasize urethral reconstructive procedures using this approach, mainly posterior urethral stricture treatment.

15.2 Patient Preparation

There is no need to submit the patient to fecal diversion with protective colostomy before the transrectal approach.

A rigorous bowel cleansing with oral laxatives, associated or not with enemas, is mandatory. Before surgery it must be checked that this preparation was really effective.

As it is not possible to sterilize the bowel before the operation, wide-spectrum antibiotics are started at the moment the patient is anesthetized, and continued for 7 days after the procedure.

It must be stressed that positioning the patient on the operating table is very important to take advantage of the best field the access can offer. The patient is placed in the prone-jackknife position (Fig. 15.1) and the buttocks spread with two broad tapes fixed at the operating table, to provide better exposure of the perianal area. The legs are widely opened to expose the genitalia (Fig. 15.2) and allow the surgeon to work comfortably between them.

When treating urethral stricture, a urethral catheter is inserted with its tip at the stenotic area and fixed to the glans with a prolene stitch. The catheter will help delimit the distal area of the stricture during surgery.

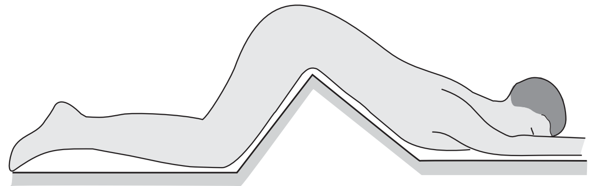


Fig. 15.1. Lateral view of the patient in the jackknife position

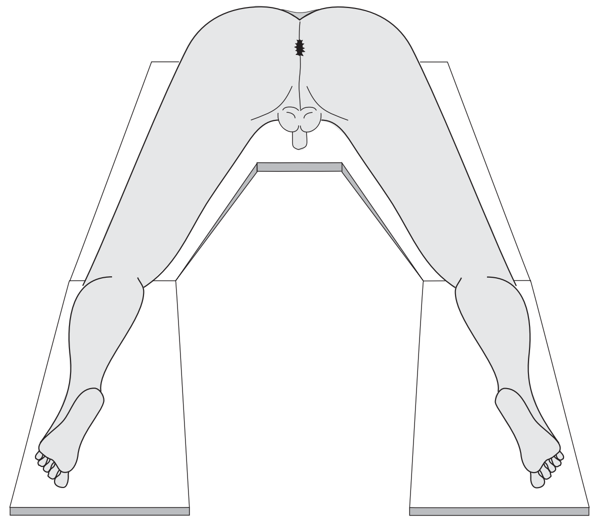


Fig. 15.2. Patient in the jackknife position with the legs well opend

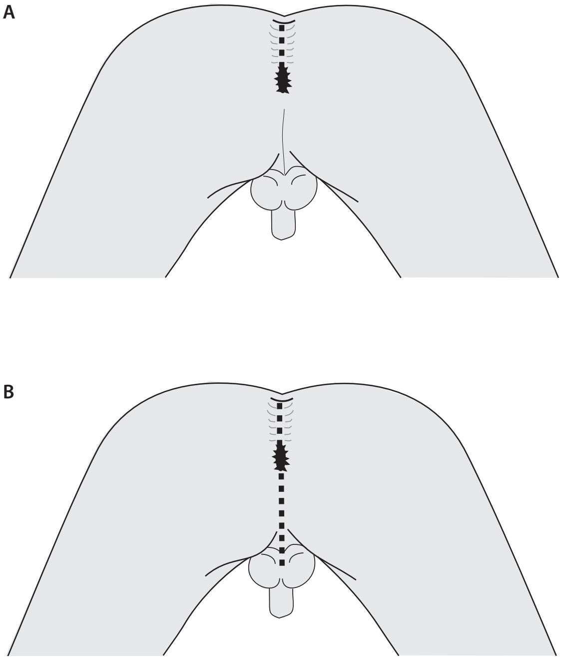
The bladder is filled with saline and methylene blue through the suprapubic Foley that is kept closed during the procedure. This maneuver favors identification and dissection of the posterior face of the bladder and urethra.

When treating other pathologies than urethral stenosis, a Foley urethrovesical catheter is left to help identify the urethra.

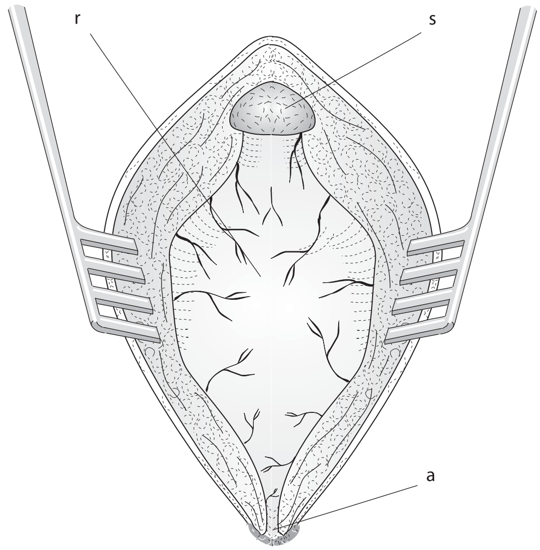
15.3 Surgical Technique

When treating urethrorectal fistulas, the incision starts at the sacrococcygeal juncture and ends at the anal orifice (Fig. 15.3a). Operating on other pathologies, the incision is extendes to the base of the scrotum (Fig. 15.3b). It must be emphasized that the incision must be kept in the midline in order to avoid anal sphincteric damage.

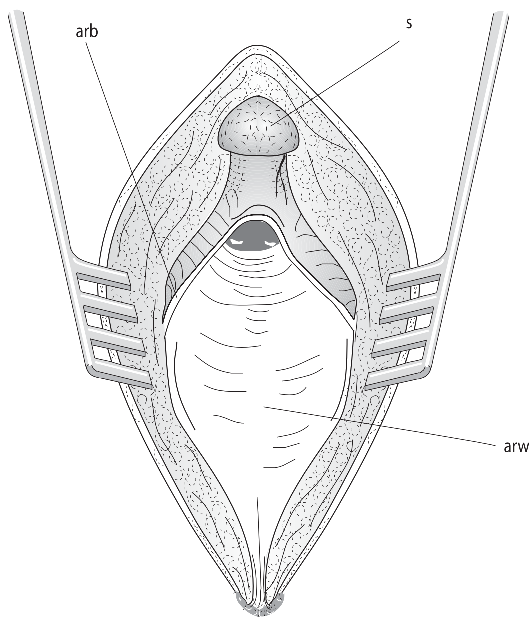
The intergluteal incision is deepened through the subcutaneous fat until the coccyx is met. Next, the coccyx ist resected. In young patients, it is usually possible to maintain the periosteum in place by incising it vertically and separating it from the coccygeal small verteb-



◻ **Fig. 15.3A, B.** The dashed line shows the location and extension of the incision. **A** To open only the posterior rectal wall when treating urethrorectal fistuias. **B** To expose the urethra, prostate, seminal vesicles, and posterior bladder wall, opening the posterior and anterior rectal wall and perineum



◻ **Fig. 15.4.** Incision from the sacrococcygeal juncture to the anus, with the skin and subcutaneous rectracted, coccyx resected, exposing the posterior rectal wall. *s* sacrum, *r* posterior rectal wall, *a* anus



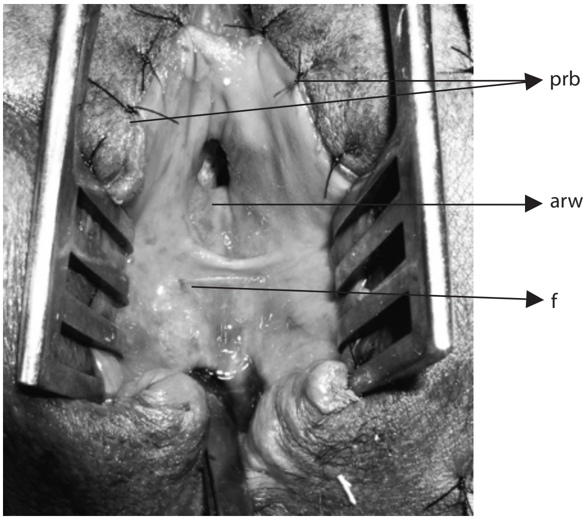
◻ **Fig. 15.5.** Skin, subcutaneous posterior rectal wall incised and coccyx resected, exposing the anterior rectal wall. *s* sacrum, *arb* posterior rectal borders, *arw* anterior rectal wall

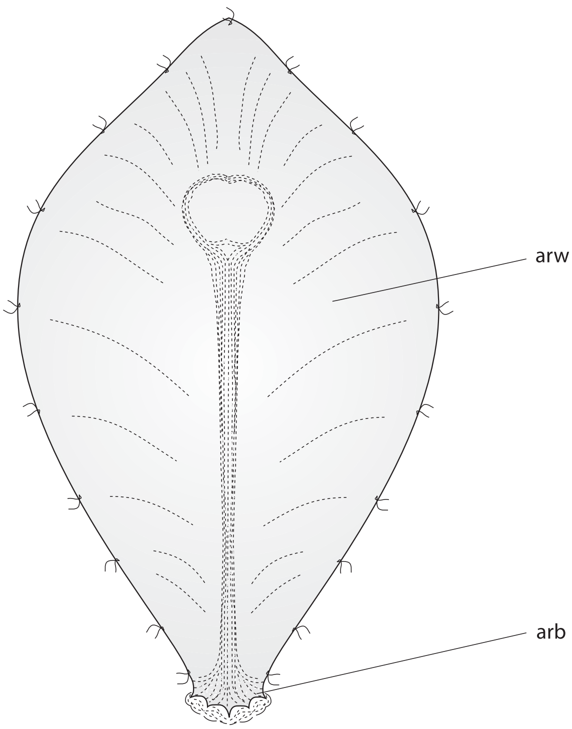
rae. Otherwise, the coccyx is freed from its attachments from the gluteal, ischiococcygeal, and levator ani muscles, structures that are not clearly identified during surgery. The coccyx is removed cutting its articulation with the sacrum using electrocautery or chisel. Mild bleending from the middle sacral artery may be resolved with electrocoagulation.

The incision is further deepened to the posterior wall of the rectum (◻ Fig. 15.4). Dissection around the rectum must be avoided to preserve its innervation [25].

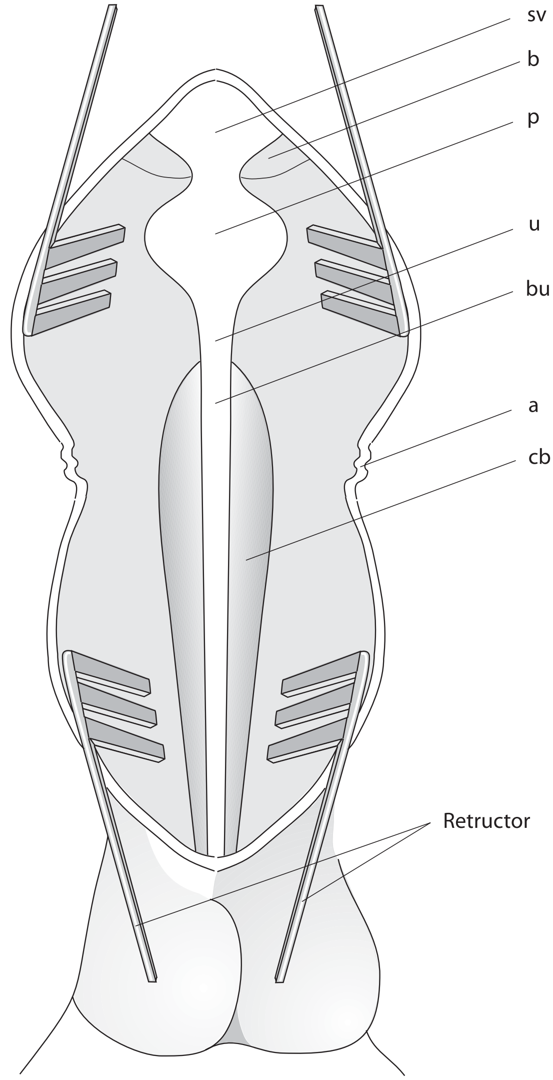
The anus is sectioned posteriorly together with its sphincteric musculature, right in the midline. The anal margins and the sphincteric musculature may be marked with ink or reference tacking stitches to make its proper later realignment easier and safer.

The posterior anal wall incision is extended craniylla, opening the vertically the rectum (◻ Fig. 15.5). Pulling the rectal walls with Allis clamps helps in this maneuver. All the small bleeding vessels are coagulated meticulously with bipolar electrocautery, avoiding rectal wall injury. Separated silk stitches tractioning the opened posterior rectal margins to the skin helps retraction for the further steps (◻ Fig. 15.6). At this point the surgical field is ready for proper correction of rectourethral fistulas (◻ Fig. 15.7). The fistulous tract can be properly dissected and resected, the urethral orifice sutured transversally, and the rectum wall closed in two or three layers. If necessary, a rectal flap may be confectioned to avoid superimposed sutures. Another alternative is to rotate the whole rectum to keep sutures apart. In the most difficult case, after resecting a rectal segment, a pull-through procedure may be done [12]. In patients with previous radiotherapy, the anterior anal and rectal wall may be incised vertically and a gracilis muscle flap interposed between the urethra and the rectum.





■ **Fig. 15.6.** Skin, subcutaneous, posterior rectal wall incised and coccyx resected, exposing the anterior rectal wall. *s* sacrum, *arb* posterior rectal borders, *arw* anterior rectal wall

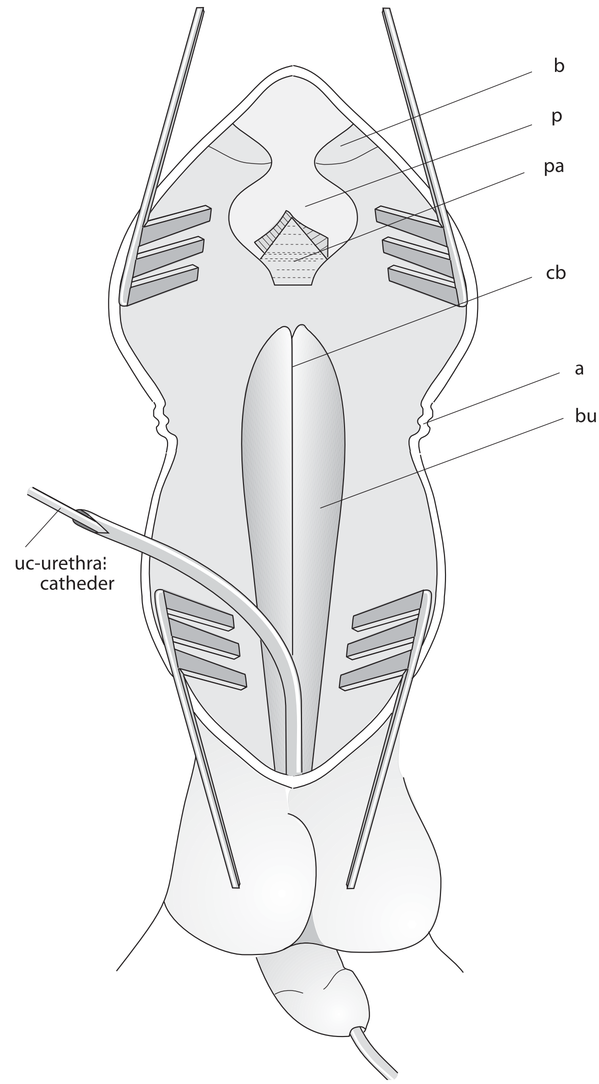


■ **Fig. 15.7.** With the posterior and anterior rectal wall opened, the bladder, seminal vesicles, prostate and urethra are exposed. *b* bladder, *sv* seminal vesicles, *p* prostate, *mu* membranous urethra, *a* anus, *bu* bulbar urethra, *cb* cavernous bodies

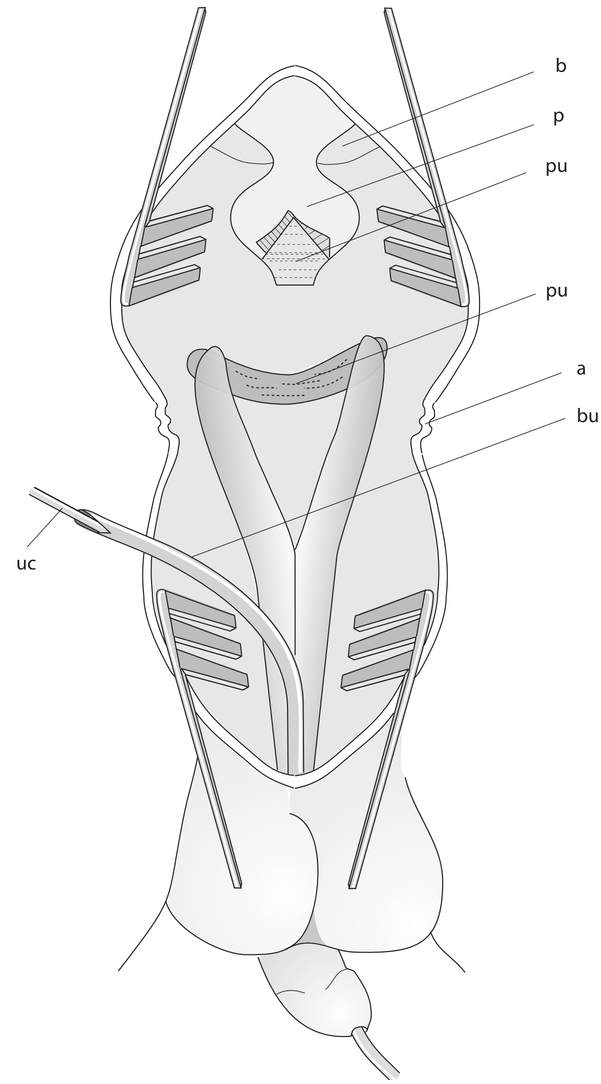
The incision of the anterior wall of the anus is kept right in the midline. Once again, limits of the sphincteric musculature may be marked for further proper identification. The urethra is in close proximity and care must be taken not do damage it. Digital separation of the anterior wall of the rectum from the undermining structures helps its further sagittal section. As with the posterior wall of the rectum, the incision of its anterior wall is carried cranially about 3 cm above the incised sectioned sacrococcygeal articulation.

At this stage the urethral catheter, prostate, bladder, and seminal vesicles may be palpated and the surgical field proper to operate on this structures an müllerian remnants (■ Fig. 15.8). The author will focus on reconstruction of the stenotic posterior urethra.

A small vertical incision in the midline, at the prostate apex, is usually sufficient to identify the end of the proximal stenotic urethra. When necessary, for its precise prior identification, a posterior cystostomy may be of help. With two parallel Allis clamps tractioning the bladder base in a high place, away from the trigone, a 1-cm vertical orifice is made. Repositioning the Allis clamps, grasping the full bladder wall in this hole, facilitates working through it. A curved metal sound may then be introduced through the bladder neck into the posterior urethra to securely work on it.



■ **Fig. 15.8.** The bulbar urethra is separated from the cavernous bodies and the bulbar and prostatic urethra amply spatulated. *b* bladder, *p* prostate, *pu* prostatic urethra, *cb* cavernous bodies, *a* anus, *uc* urethral catheter, *bu* bulbar urethra



■ **Fig. 15.9.** Separation of the cavernous bodies in the and resection of part of the pubic bone shortens the way for the bulbar urethra to reach the prostatic urethra. *b* bladder, *p* prostate, *pu* prostatic urethra, *pb* pubic bone partly resected, *a* anus, *cb* separated cavernous bodies, *bu* bulbar urethra, *uc* urethral catheter

The distal end of the obliterated urethra is felt and opened over the tip of the urethral catheter. After incising the bulbospongiosus muscle in the midline, the whole bulbar urethra may be dissected carefully and mobilized down to the scrotum (■ Fig. 15.9). The scarred tissue of the obliterared membranous urethra is incised in the midline and resected, if necessary.

When the distal urethra does not reach the proximal prostatic urethra, the corpus cavernosum may be separated in the midline and the dissected urethra laid in between them. Should the need arise, the inferior part of the pubic bone may be resected with a chisel to further lessen this gap (■ Fig. 15.10).

To properly prepare the distal prostatic urethra for an ample spatulated further anastomosis, it may be of help to resect a small portion of the lateral lobes of the prostate and invert the urethral mucosa by stitching it to the prostatic capsule (■ Fig. 15.10 and 15.11).

In cases of severe involvement of the prostate with scar from previous trauma or surgery, care must be taken to avoid damaging the bladder neck and causing further incontinence. In the rare instances of trauma with obliteration of the proximal prostatic urethra and bladder neck, all efforts to preserve the distal sphincter are worth trying to maintain continence.

In dealing with the difficult cases where the gap is too long, so that it may be necessary to interpose a tube between the two ends of the urethra, several options are viable through this incision. If a transverse preputial flap tube is planned, it is first harvested with the patient in the lithotomy position and then it is buried in a perineal incision. After quickly suturing the perineal skin, the patient is repositioned for the posterior transsacral approach and the urethroplasty completed. Or a tube may be confectioned from the rectal wall as described by Guzman [26].

When necessary (as in patients complicated with multiple previous surgeries, radiotherapy, local fistulas and sinuses, extensive scarring from local infection, etc.), this acces does not preclude, but facilitates, the use of muscle flaps for reconstruction. This fresh muscular bed may allow the use of free grafts when other alternatives to reconstruct the posterior urethra are not possible [27].

Once the reconstructive urethral procedure is completed, if there is any residual bleeding, a penrose drain may

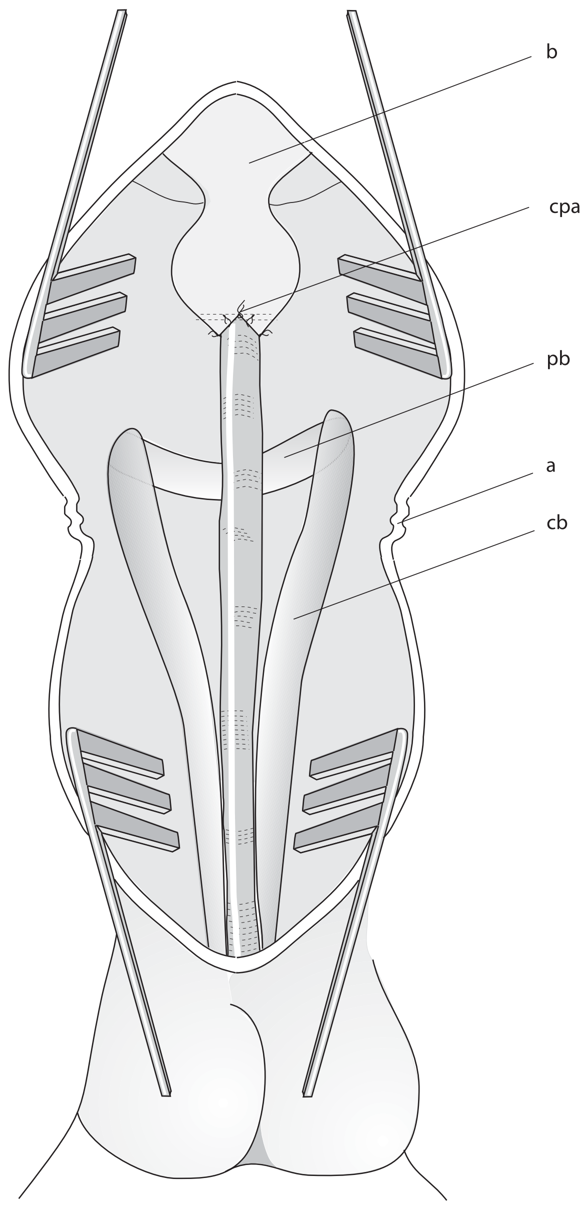


Fig. 15.10. Ample anastomosis without tension of the spatulated bulbar to prostatic urethra. The route that the bulbar urethra follows is shortened by separation of the cavernous bodies and partial resection of the pubic bone. *b* bladder, *upa* urethroprostatic anastomosis, *pb* pubic bone partially resected, *a* anus, *bu* bulbar urethra, *cb* separated cavernous bodies, *uc* urethrovesical Foley catheter

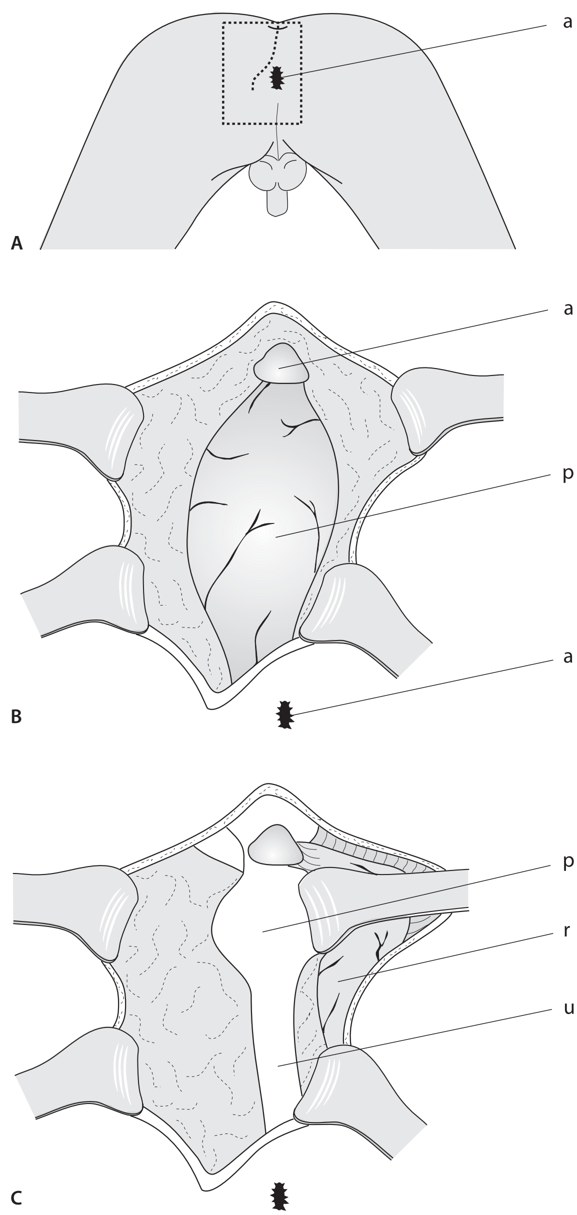


Fig. 15.11. A–C. A Incision for pararectal approach, running from the sacrococcygeal juncture in the midline to the lateral upper side of the anus. **B** Posterior rectal wall exposed by the opened incision. **C** The rectum is retracted to the right side, exposing the bladder neck, prostate and posterior urethra. *a* sacrum, *r* rectum, *a* anus, *p* prostate, *u* urethra

be left for 1 or 2 days. When closing the wound, care is taken to approximate all tissues, avoiding any dead space where blood may be collected.

Closure is started approximating the bulbospongiosus muscle and the subcutaneous perineal tissue with separate absorbable suture. The author uses PDS 3-0 throughout the whole closure but the skin, where Monocryl 5-0 is preferred. Next, the anterior anal sphincteric muscles are carefully rejoined with single stitches. In patients with previous local scar, proper muscular identification may be necessary with an electrical stimulator. The anterior wall of the rectum is closed with running suture, in two layers. Next, the posterior wall is closed in the same way. Meticulous approximation of the posterior muscles of the anal sphincter is done. After closure of the subcutaneous tissue, the skin is sutured.

15.4 Postoperative Care

The skin scar is washed with saline and antibiotic ointment is applied over it for about 7 days.

We leave the suprapubic and the urethral Foley catheters for about 3 weeks. While in the hospital, the bladder is irrigated with saline.

The patient fasts for 3–5 days and then starts a low residual diet. At this time, intake of mineral oil is recommended. During the fasting period, total parenteral nutrition may be instituted, according to the patient's general health and nutritional status.

Pain is not as important as one would predict, probably because operation is entirely accomplished through an incision in the midline raphe. A few patients complain of more prolonged discomfort at the region of the divided end of the sacrum.

15.5 Complications

The main concern, apart from the result of the reconstructive urethral procedure, is the possibility of fecal incontinence. As patients with normal anal sphincters are usually treated, differently from the population of rectal malformations, this complications was not observed by many surgeons experienced with this approach. Special care must be taken in reconstructing the sphincteric muscles if the patient had previous operations in the area. Transitory incontinence of flatus may be referred for about 3 months. Patients may experience difficulty in holding diarrheic feces for a few months.

The author had two patients who presented transitory urethrorectal fistula after urethroplasty, resolved with reinsertion of a Foley which catheter and a more prolonged urethrovesical drainage.

15.6 Author's Comments

One of the reasons posterior urethral reconstruction procedures often present a challenge for the urological surgeon is because the perineal approach offers a restricted space to work in, frequently with bleeding that raises more difficulties. The results of the operation is directly related to the technical quality of the anastomosis performed. The associated perineal with transpubic approach is quite aggressive, may lead to orthopedic complications, hernia formation, and theoretically may predispose to dorsal penile nerve damage.

The best operation to solve posterior urethral stenosis is the first one, when every effort mus be made to obtain an optimal result. Every subsequent procedure becomes more diffivult. The posterior sagittal approach provides optimal visualization and field to work in and better conditions to control bleeding. As it is possible to restrain the dissection in the midline hypothetically, it limits the possibility of causing iatrogenic sexual impotence.

Difficulty may be encountered in deciding when to indicate the access in the case that is not diffulty but would surely benefit from it and the easy one that can well be managed through the perineal route. In this situation, the author prescribes intestinal cleansing should the transrectal approach be necessary and starts the operation through the perineum. Should the need arise, the perineal incision is closed quickly, the patient repositioned and a transrectal approach performed. In some cases, opening only the anterior rectal wall gives the necessary field to perform the procedure adequately.

There is no doubt that this is the best incision to treat high urethrorectal fistulas. It gives an excellent field to perform an adequate closure with a multitude of technical possibilities.

Müllerian remnants may be difficult to remove through other incisions. They adhere to the surrounding tissues and the hole left in the urethra needs proper closure. There is no doubt that this approach gives the best conditions to solve this problem.

The pararectal access preferred by others [15, 18, 21], in the author's opinion, it does not give the same proper surgical field, does not avoid urethrorectal fistula occurrence [21] and, according to experimental studies [25], it may jeopardize the rectal innervation.

According to anatomical studies [28], the rectal sphincter is composed of two groups of muscles that come in contact with one another withouth crossing the midline. Thus, a sagittal posterior approach does not sever anterior and posterior rectal muscles.

It is important for the reconstructive urological surgeon to have this approach in his armamentarium. It gives flexibility in indicating the proper incision for the individual patient and technical malleability in dealing with special situations. This access provides excellent exposure and may change a rather difficult operation into a relatively easy one.

References

1. Kraske P (1885) Verh Dt Ges Chir 14:464
2. Kraske P (1886) Zur exstirpation hochsetzender Mastdarmkrebse (Extirpation of high carcinomas of the bowel) Arch f Klin (Berl) 33:563. Translated in Dis Colon Rectum (1984) 27:499
3. Perry EG, Hinrichs B (1989) A new translation of Professor Dr. P. Kraske's Zur Extirpation. Hochsitzender Mastdarm Krebse. Aust N Z J Surg 59:421-424
4. Kocher T (1874) Die Exstirpation nach vorheriger Excision des Steissbeins. Zbl Chir 1:145–147
5. Mason AY (1974) Trans-sphincteric surgery of the rectum. In Progress in Surgery, Vol. 13, S. Karger, Basel. pp 66–97
6. Mason AY (1975) Malignant tumours of the rectum: local excision. Clins Gastroent. 4:582-593
7. Mason AY (1976) Rectal cancer: the spectrum of selective surgery. Proc R Soc Med 69:237–244
8. Dozois RR (1990) Retrorectal tumours: spectrum of disease, diagnosis and surgical management. Perspect Colon Rectal Sur 3:241–255
9. Pemberton M (1972) The Kraske, sacral or posterior approach to the rectum. Proc R Soc Med 65:663–670
10. Peña A, deVries P (1982) Posterior sagittal anorectoplasty: important technical considerations and new applications. J Pediatr Surg 17:796–811
11. Stephens FD (1953) Imperfurate rectum: a new surgical technique. Med J Austr1. 202:126–132
12. Nathan E, Wiseman NE, Decter A (1982) The Kraske approach to repair of recurrent rectourethral fistula. J Pediatr Surg 17:342
13. Kilpatrick FR, Thomson HR (1962) Postoperative rectoprostatic fistula closure by Kraske's approach. Br J Urol 34:470–476
14. Wood, TW, Middleton RG (1990) Single stage transrectal transsphincteric (modified York-Mason) repair of rectourinary fistulas. Urology 35:27–30
15. Siegel JF, Brock WA, Peña A (1995) Transrectal posterior sagittal approach to prostatic utricle (Müllerian duct cyst). J Urol 153: 785–787
16. Kraeger JA, Jordan WP (1965) Transcoccygeal approach to the seminal vesicles. Am Surg 31:126–132
17. Moussali Flah L, Alpuche JOC, Castro RS (1992) Repair of posttraumatic stenosis of the urethra through a posterior sagittal approach. J Pediatr Surg 27:1465
18. Nikolaev VV, Bizhanova DA (1998) High posttraumatic vaginal stricture combined with urethrovaginal fistula and urethral stricture in girls: reconstruction using a posterior sagittal pararectal approach. J Urol 160:2194–2196
19. Marshall DF (1965) Transcoccygeal prostatectomy. J Maine Med Assoc 56:193–199
20. Grahan, SD Jr (1990) Radical transcoccygeal prostatectomy. In Glenn JF (ed). Urologic Surgery, 4th edn. Harper & Row, Hagerstown, pp 646–653
21. Rigatti P, Da Pozzo LF, Francesca F, Broglia L, Montorsi F, Guazzoni G, Scattoni V (1993) Transcoccygeal radical prostatectomy for localized prostatic cancer. Eur Urol 24 [Suppl]: 29–33
22. Kishev S, Eaton JM JR (1973) Transcoccygeal cystectomy. J Urol 109:835–837
23. Ambrose SS (1977) Transcoccygeal approach 125I prostatic implantation for adenocarcinoma. J Urol 118:211–215
24. Peña A, Filmer B, Bonilla E, Mendez M, Stolar C (1992) Transanorectal approach for the treatment of urogenital sinus: preliminary report. J Pediatr Surg 27:681–685
25. Peña A, Amroch D, Baeza C, Csury L, Rodriguez G (1993) The effects of posterior sagittal approach on rectal function (experimental study), J Pediatr Surg 28:773–778
26. Guzman LF (1999) Neourethra with rectum posterior sagittal approach. In Ehrlich RM, Alter GJ (eds) Reconstructive and plastic surgery of the external genitalia, adult and pediatric. WB Saunders, Philadelphia, pp 101–108
27. Zinman L (1996) Muscle-assisted full-thickness skin graft urethroplasty. In McAninch J (ed) Trauma and reconstructive urology. WB Saunders, Philadelphia, pp 623–630
28. Peña A (1987) Anatomical considerations relevant to fecal continence. Semin Surg Oncol 3:141–145

The Use of Flaps in Urethral Reconstructive Surgery

G.H. Jordan, K.F. Rourke

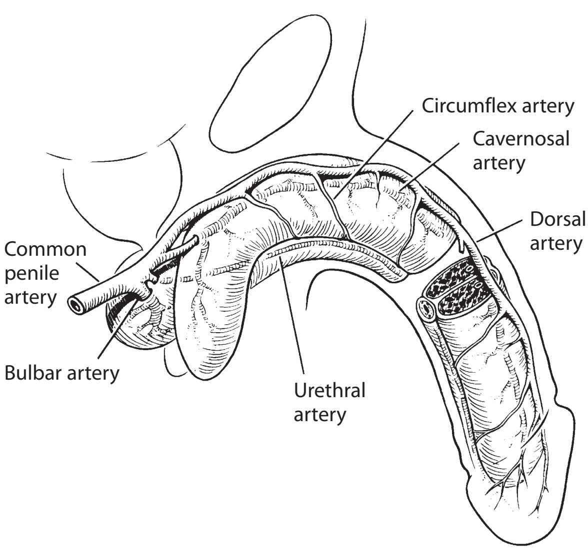
Although excision of a strictured anterior urethral segment with primary spatulated reanastomosis is the best and most durable repair, its application can be limited by the location and length of the stricture. In cases where application of this technique is limited, however (e.g., severely stenotic areas, totally obliterated areas, proximal areas that have been hydrodilated, or areas that require chronic dilation), the surgeon must resort to tissue transfer techniques. This chapter discusses the principles associated with the use of genital skin islands for difficult cases of urethral reconstruction.

16.1 Genital Vascular Supply

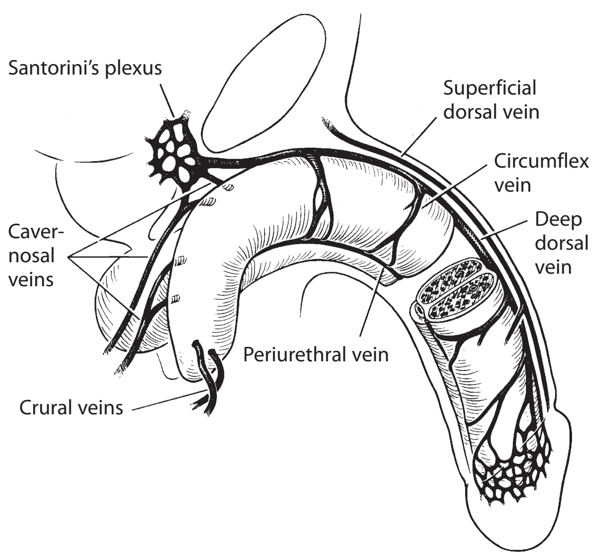
To apply flap technology to urethral reconstruction, the surgeon should have an excellent working knowledge of the vascular anatomy of the areas to be reconstructed and the tissues to be transferred. Although the genital blood supply is described in detail elsewhere in this text, it is selectively re-emphasized in this chapter as it applies to tissue transfer for reconstructive surgery.

The corpus spongiosum has a dual blood supply. The deep internal pudendal artery gives off the common perineal artery, which branches to form the posterior scrotal artery and the lateral perineal artery, and then extends to become the common penile artery. The proximal branches of the common penile artery (i.e., arteries to the bulb and circumflex cavernosal arteries) represent the proximal arterial supply to the corpus spongiosum (◻ Fig. 16.1). The common penile artery bifurcates to become the deep artery of the corpus cavernosum and the dorsal artery of the penis. The dorsal artery extends and arborizes into the erectile tissue of the glans penis, passing in retrograde fashion through the corpus spongiosum. The dorsal artery gives off the circumflex cavernosal arteries; however, those arteries are somewhat unreliable in their distribution. Therefore, arteries of the bulb and circumflex cavernosal arteries provide proximal arterialization, and arborizations of the dorsal artery and cavernosal artery provide a reliable distal arterialization to the corpus spongiosum. Although arterial perforators lie between the ventral corporal cavernosa and corpus spongiosum, they too are not reliable nor constant in distribution. The venous drainage of the corpus spongiosum is predominately via the venous drainage of the glans and other deep structures (◻ Fig. 16.2). The dual vascularity of the corpus spongiosum allows it to be mobilized vigorously either proximally or distally, if both blood supplies are initially intact.

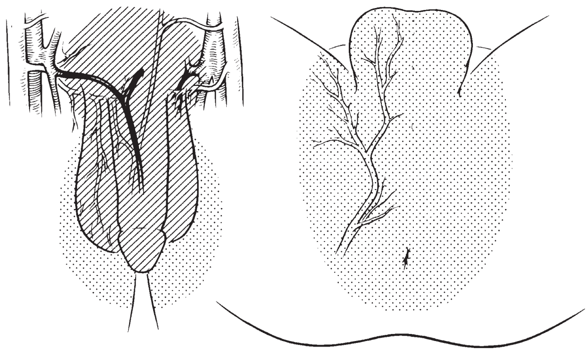
The blood supply to the superficial tissues of the genitalia is based on the superficial external pudendal artery and the posterior scrotal artery (◻ Fig. 16.3). The superficial external pudendal artery is a medial branch of the femoral artery, and arborizes to become fascial plexuses in the dartos fascia of the penis (◻ Fig. 16.4). The posterior scrotal artery, as mentioned, is a branch of the perineal artery and arborizes to become the fascial plexus of the tunica dartos of the scrotum (◻ Fig. 16.5). The superficial and deep plexuses are associated with the fascia, and the fascial septa contain perforators. Because the fascial plexuses are the true blood supply to the genital skin islands, these skin islands can be widely mobilized and aggressively transposed, and with discretion, fascial flaps can be twisted.



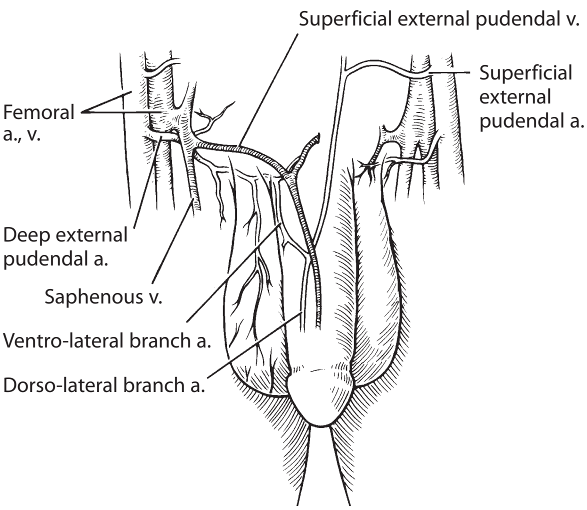
◻ **Fig. 16.1.** The distribution of the common penile artery. Note the dual blood supply to the urethra. Proximal vascularity is supplied by the arteries to the bulb and the circumflex cavernosal arteries. Distally, the blood supply is provided by the arborization of the dorsal artery and perforators from the cavernosal artery. (from [9])



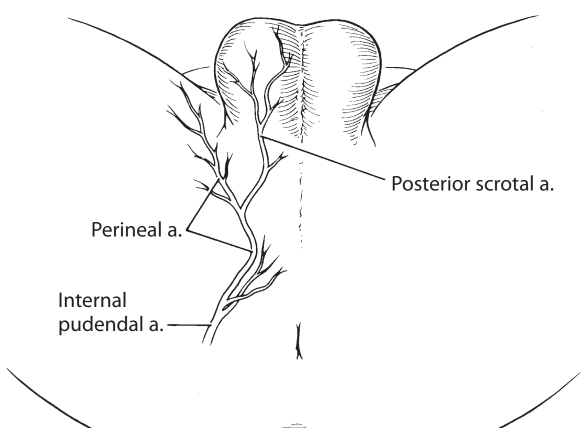
◻ **Fig. 16.2.** The venous drainage patterns of the penis. There are superficial, intermediate, and deep systems of venous drainage. (modified from:[10])



■ **Fig. 16.3.** The superficial fasciocutaneous vascular distribution of the male genitalia and perineum. (from [3])



■ **Fig. 16.4.** The superficial external pudendal artery blood supply. Note that this vessel is a medial branch of the femoral vessel and extends into the dartos fascial system. (from [3])



■ **Fig. 16.5.** The perineal artery/labial-scrotal blood supply. Note this system is a branch of the internal pudendal artery system extending as the posterior scrotal artery into Colles' fascia and tunica dartos. (from [3])

16.2 Principles of Flap Anatomy

Principles that are applicable to all flaps should be considered when contemplating the use of flaps, including the physical characteristics of the flap, the vascular supply to the flap, and the mechanics of elevation of flap transfer to the recipient area.

16.2.1 Physical Characteristics of the Flap

When considering physical characteristics, the surgeon should determine what would be required of the flap. For example, after exenterative surgery, a flap can be transposed into the perineum to provide bulk and vascularity. In contrast, for urethral reconstruction, a skin island is transferred into the urethra to provide a patch. In this instance, the skin should be from an area of natural redundancy, if possible, should be thin and nonhirsute, and must be easily and reliably tailored to avoid the creation of diverticula or sacculations.

16.2.2 Flap Vascularity

Flap vascularity can be classified as random or axial. A random flap has no defined cuticular vascular territory. The vascularity of a random flap varies by location on the body and is not necessarily reproducible between individuals. In contrast, an axial flap has an identifiable vessel in its base and a defined cuticular vascular territory. Furthermore, although axial flaps may contain random areas of vascularity, their cuticular vascular territories are predictable, reliable, and reproducible.

The axial pattern of vascularity applicable to genital skin flaps is the fasciocutaneous pattern. A fasciocutaneous blood supply is similar to a musculocutaneous blood supply in that both have identifiable vessels that vascularize the deep structures, and secondary perforators that supply blood flow to the skin (■ Fig. 16.6). This is in contrast to a direct cuticular pattern of vascularity in which the identifiable vessel is superficial to the fascia, and seems to have the vascularity of the overlying adipose and skin as its only purpose.

16.2.3 Mechanics of Elevation and Flap Transfer

The term most frequently used with regard to genital skin flaps for urethral reconstruction is »island flap.« Although technically an island flap is one that is elevated on dangling vessels, this is not the case with island flaps used for urethral reconstruction; island flaps used for urethral reconstruction islands are elevated on the fascia

A

B

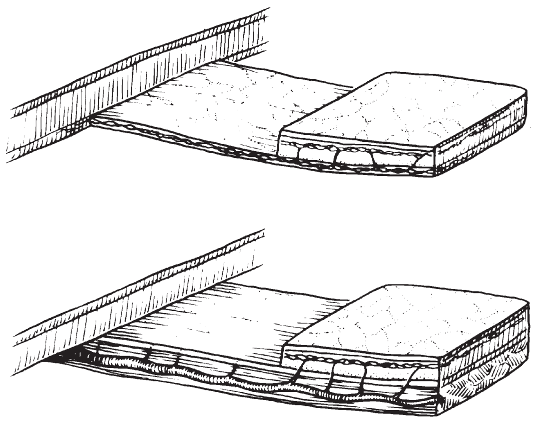


Fig. 16.6A, B. Representation of a skin island flap elevated on the **A** fascial blood supply or **B** the musculocutaneous blood supply. These are correctly termed fascial flaps or muscle flaps that carry the overlying skin islands or paddles. (from [11])

and are properly termed skin islands or skin paddles. To clarify, the fascia can be viewed as the flap and the skin that is carried, as a passenger. Thus, while maintaining its vascularity, a skin island can be oriented on the facial flap as required by the surgeon, providing many options for pedicle mechanics.

If a skin island is carried on a fascial flap that is dorsally oriented (i.e., the base of the flap is dorsal to the penis), then the fascial flap is reliable; however, it is efficiently transferred only to the area of the penile shaft and requires extensive mobilization to allow transfer to the perineum. In fact, such a skin island can only be carried with great difficulty to the level of the proximal bulbous or membranous urethra. Therefore, for many cases of anterior urethral reconstruction, a dorsally based flap is inefficient.

Alternatively, a fascial flap can be oriented ventrally, implying that the fascial base is left intact on the ventral surface of the penis and extends down into the scrotum. Because the arborizations of the superficial external pudendal arteries pass onto the shaft of the penis from the lateral aspect, it is necessary to preserve that aspect of the flap's base. These pedicles can be reliably and extensively mobilized, and skin islands oriented on them can be transferred to the apex of the prostate, if required. Thus, a ventrally oriented pedicle is extremely efficient for the purposes of anterior urethral reconstruction.

Alternatively, the tunica dartos can serve as the fascial flap. However, although it is useful for carrying scrotal skin islands, it is relatively inefficient. Whereas the pedicle is efficient for carrying the island to the bulbous urethra, it is sometimes difficult to carry the skin island to the proximal anterior urethra, and it is virtually impossible to carry it onto the penile shaft. It cannot be emphasized enough that if one is to use scrotal skin islands, they must be from a nonhirsute scrotal donor area.

16.3 Surgical Procedure

16.3.1 Preoperative Evaluation and Preparation

Evaluation, including antegrade and retrograde urethrograms and limited urethroscopy, reveal the area to be reconstructed. The patient is assessed for presence of nonhirsute genital skin. If none is found, epilation of genital skin can be performed over several sessions if no other source of donor tissue is felt appropriate. Donor sites with redundant nonhirsute genital skin are most convenient for urethral reconstruction. In cases where the redundancy is dorsal on the penis, a skin island can be transversely oriented and mobilized on the dorsal dartos fascia [1]. The skin island can be mobilized as a ventral longitudinal island if the redundancy is on the ventrum of the penis. A ventral longitudinal island can either be vigorously mobilized on a ventrolateral-oriented dartos fascial flap for transposition to the perineum, or less vigorously mobilized, transposed, and inverted into a pendulous urethral stricture defect. Ventral islands can be oriented transversely or longitudinally, and longer skin islands can be mobilized by orienting the island both ventrally and transversely at the distal end (i.e., hockey stick orientation), allowing for islands as long as 7–9 cm. The islands can also be oriented circumferentially when the penile skin has a general redundancy. These »circular skin islands« are mobilized on the entire penile dartos fascia and are most efficiently transferred when they are based ventrally with a dorsal split in the pedicle, and can allow for islands up to 15 cm long.

Combining stricture excision with either a graft or skin island onlay (i.e., augmented anastomosis) can be beneficial in treating difficult, narrow-caliber, nearly obliterating segments. This is a three-step technique, involving excision of the obliterating segment, performing a roof or floor strip urethral anastomosis, and filling the remaining urethrotomy defect with either a graft or skin island onlay.

Some patients have relatively large nonhirsute areas of the scrotal skin that can be elevated on the tunica dartos of the scrotum. This skin island must be stretched due to a significant muscular component to the tunica dartos; however, with proper tailoring the development of a diverticulum can be avoided. This flap is best used when it is laterally based; and when properly oriented, it is reliable and has been used extensively with good results in select centers.

Improved functional and cosmetic results have been achieved in reconstruction of the fossa navicularis using skin islands oriented on the penile dartos fascia. Important considerations in the design of these islands include the location of hair on the penile shaft and the mechanics of flap transfer (i.e., transposition vs advancement).

A flap procedure that can be used as an alternative to a staged STSG when nonhirsute skin is unavailable is the epilated midline genital skin island. Like the STSG, this procedure should be considered a staged procedure, with the epilations performed as the initial stage or stages. Epilation can be accomplished using either a narrow-gauge needle and monopolar cautery or with epilation needles and machines. The interval between epilations should be 6–8 weeks, and urethral reconstruction should not be performed until 10–12 weeks after the last epilation. The stricture repair involves elevation of a midline skin island based on the dartos fascia of the penis and tunica dartos of the scrotum. Meticulous tailoring of the scrotal portion of the island is important, as in the nonhirsute scrotal skin island. In the past, we used epilated islands for long-segment strictures associated with balanitis xerotica obliterans (BXO). The result in these patients were not as good as in the non-BXO population

16.3.2 Surgical Technique

The patient is placed supine and a suprapubic catheter is placed. For many flaps, the patient is left supine for elevation of the flap and then placed into an exaggerated lithotomy position. Before shaving, the area of the skin island is carefully marked. Elevating the flap with the patient flat helps to limit the time in lithotomy and therefore, decrease the morbidity of the lithotomy position.

16.3.2.1 Generalities of Using Nonhirsute or Epilated Skin Island Onlays

A lambda-shaped incision is marked on the perineum and created to expose the corpus spongiosum. The dissection is directed to detach the bulb from the perineal body without interfering with the proximal blood supply, and the corpus spongiosum is detached from the corpora cavernosa.

The distal extent of the stricture is identified using cystoscopy, and then the corpus spongiosum and urethra are transected. The obstructing urethral segment or extensively fibrotic corpus spongiosum can be excised. The distal urethra is then dorsally spatulated through the wide-caliber stricture segment until a normal-caliber urethra is measured by bougienage and the proximal urethra is dorsally spatulated to normal tissue (Fig. 16.7).

A ventrally based strip (floor strip) anastomosis is temporally approximated to allow accurate measurement of the urethrotomy defect, and the island is carefully tailored, stretching the skin to avoid redundancy. If using a scrotal island, it is elevated on the tunica dartos fascia, and also preserving the midline septal vasculature, if possible. The flap is then transposed with onlay (without tension) to the area of reconstruction, and the proximal urethra is spatulated into normal tissue. (Fig. 16.8).

The onlay on the distal portion of the urethra is then completed, and three apex sutures are used to approximate it to the proximal spatulation. The strip anastomosis is

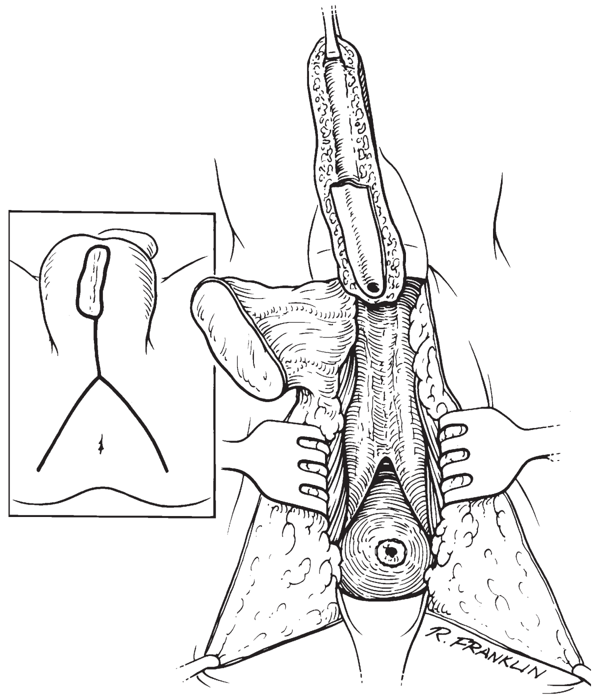


Fig. 16.7. Scrotal island flap is outlined and the lambda incision is created but not encroaching onto the flap (*inset*). The diagram shows the scrotal island elevated, urethra divided, severe disease segment excised, and the remaining anterior urethra spatulated. (from [3].)

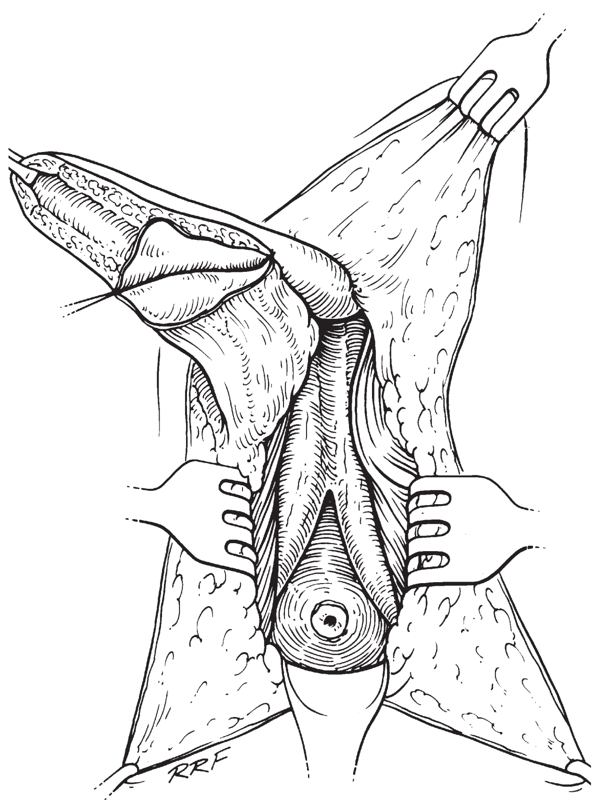


Fig. 16.8. Placement of the skin island dorsally as an onlay. (from [3])

completed without tension and a urethral catheter is introduced through the area of reconstruction (Fig. 16.9).

The wound is closed anatomically. A small suction drain is placed opposite the flap pedicle to drain the space under the musculature and a larger suction drain is placed in the subcutaneous space. The drains are extended out opposite the flap pedicle. The principles of the augmented anastomosis, as mentioned, involve excision of the severely stenotic segment, creation of a widely spatulated floor-strip anastomosis, and completion by a dorsally placed onlay of nonhirsute scrotal skin (Fig. 16.10).

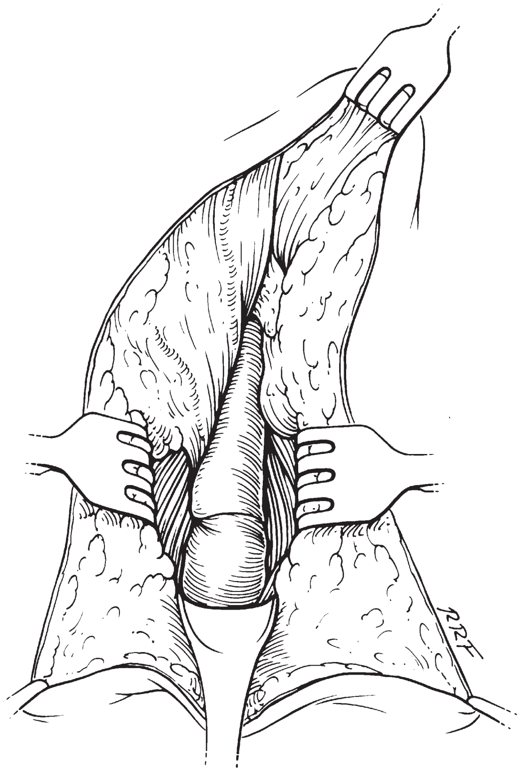


Fig. 16.9. The augmented anastomosis, with dorsal flap placement and floor strip anastomosis. (from [3])

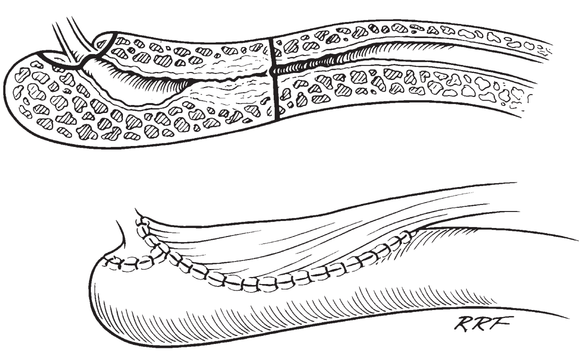


Fig. 16.10. The completed repair with excision of stenotic segment, floor strip anastomosis, and flap onlay dorsally. (from [3])

16.3.2.2 Generalities of Using Penile Skin Islands

With the patient in a supine position, the nonhirsute penile skin is marked, and the penile skin island is measured and mobilized on a broad ventrally based pedicle of dartos fascia (Fig. 16.11).

With Buck's fascia on the deep surface, the fascia can be sufficiently elevated to allow transfer to the level of the proximal anterior urethra. The dissection is carried adjacent to the corpus spongiosum into the perineum, permitting the flap to be transposed into that space (Fig. 16.12). The incision is closed and covered with a Bioclusive dressing.

The patient is then carefully placed in an exaggerated lithotomy position, the corpus spongiosum is exposed via a perineal incision, and the dissection is advanced under the scrotum to expose the flap (Fig. 16.13). The flap is transposed into the perineum and extended to test its reach to the proximal anterior urethra or membranous urethra without tension. Detachment of the bulbospongiosum from the perineal body can be performed with preservation of the proximal blood supply. The corpus spongiosum is detached from the triangular ligament and corpora cavernosa, to expose the full length of the stricture.

Based on the preoperative evaluation, the urethra can be transected at the proximal bulb to expose the proximal margin of a narrow caliber segment (Fig. 16.14)

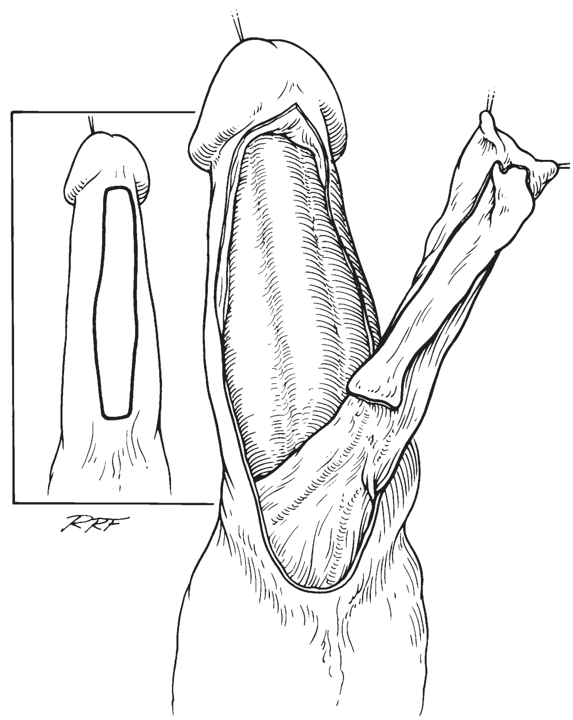


Fig. 16.11. A longitudinal ventral skin island is outlined, elevated, and mobilized on a broad ventrally oriented dartos fascial flap. The patient is left in a flat, supine position for this dissection. (from [3])

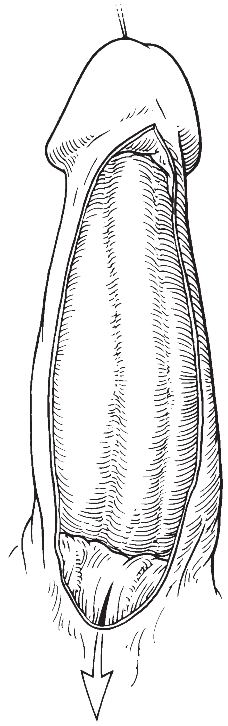


Fig. 16.12. The flap is transposed to the perineum through the plane superior to the corpus spongiosum while the patient is flat and supine. (from [3])

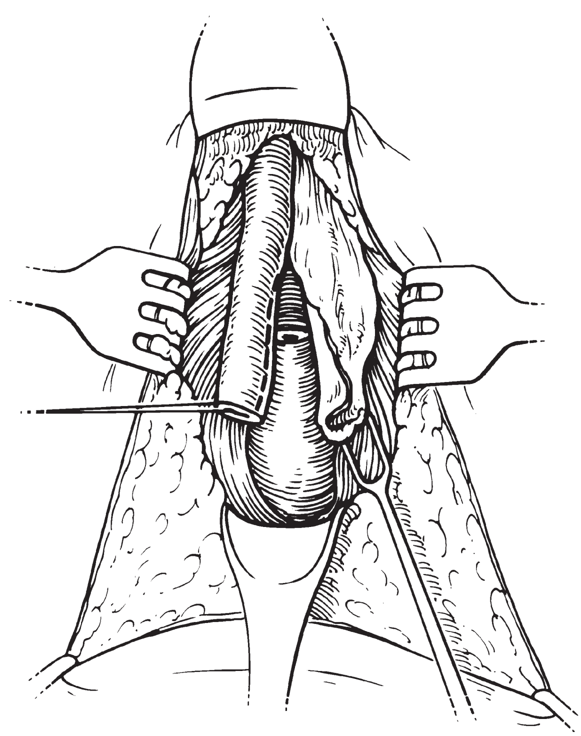


Fig. 16.14. The corpus spongiosum is divided and the severely stenotic segment is excised. (from [3])

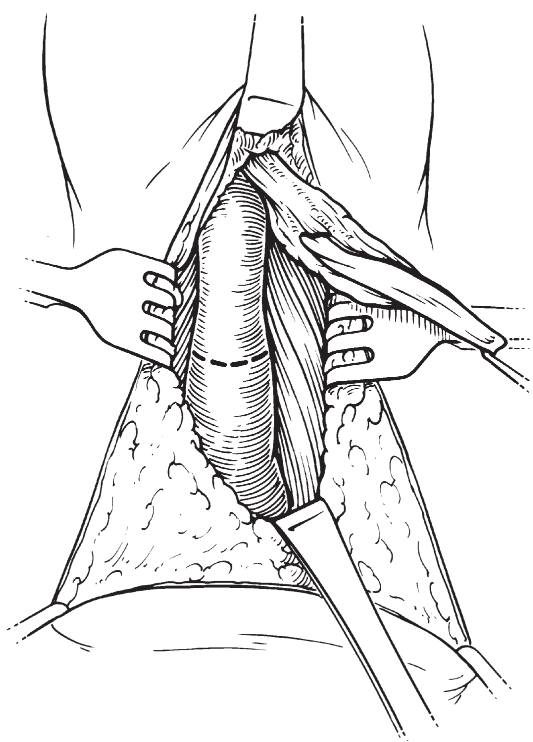


Fig. 16.13. Perineal dissection has been completed and the flap has been allowed into the wound. Note the area of stricture has been identified. The patient has been placed in the exaggerated lithotomy position. (from [3])

or through the narrowest or most fibrotic area. After the narrow-caliber segment is excised, the strictured urethra that remains is distally spatulated until bougienage and endoscopy reveal normal tissues. The urethrotomy defect is measured, and the intracrural space is developed to allow a strip anastomosis without tension.

The penile skin island is tailored to achieve a lumen of approximately 28 Fr and the onlay is placed into the proximal spatulation using interrupted and running small sutures (Fig. 16.15). The ventrally based (floor-strip) anastomosis is completed using combined one- and two-layer techniques (Fig. 16.16). A 14-Fr stenting catheter is passed, and the wound is closed and drained as in the epilated scrotal skin island onlay (Fig. 16.17).

16.3.3 Postoperative Course

Bed rest is recommended for 1–2 days postoperatively depending on edema, and then ambulation is allowed. Drains are removed as drainage permits. On postoperative day 21–28, a contrast voiding trial will reveal healing and patency. At 6 months, an endoscopy showing an open, well-healed repair and good voiding indicate early success. The literature is clear, however, that these patients need lifelong follow-up as a slow constant deterioration in success is the rule.

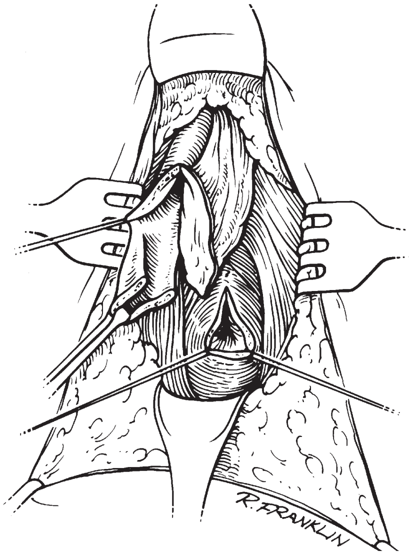


Fig. 16.15. After dorsal spatulation of the urethra, the flap onlay is placed dorsally. (from [3])

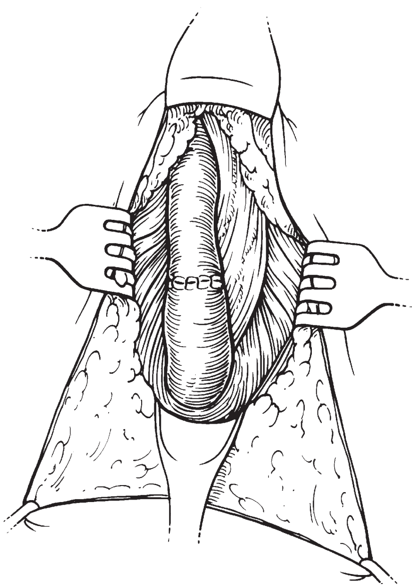


Fig. 16.16. The augmented anastomosis is complete. Closed suction drains are then placed and the wound is closed. (from [3])

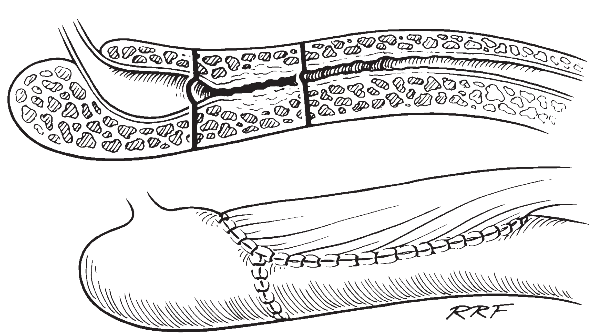


Fig. 16.17. An illustration of the repair and its principles. (from [3])

16.4 Conclusions

Primary spatulated reanastomosis represents the most durable repair for urethral reconstruction; however, its application can be limited by length or location of urethral disease. Genital skin islands are versatile, and can be used alone, combined with other flaps or combined with excision of a portion of the urethra. If possible, tubularization of these flaps should be avoided, as it decreases both the immediate and long-term success rate. Adherence to principles of tissue transfer can result in excellent success rates in appropriately selected patients. The resurgence of graft techniques has significantly altered the requirement for the use of these flaps; flap techniques are now reserved for the most complicated of cases.

References

1. Duckett JW (1981) The island flap technique for hypospadias repair. Urol Clin North Am 8:503–511
2. Jordan GH (1999) Penile reconstruction, phallic construction, and urethral reconstruction. Urol Clin North Am 26:1–13
3. Jordan GH, Stack RS (1997) General concepts concerning the use of genital skin islands for anterior urethral reconstruction: reconstruction for urethral strictures. Atlas Urol Clin North Am 5:23
4. McAninch JW (1993) Reconstruction of extensive urethral strictures: circular fasciocutaneous penile flap. J Urol 149:488–491
5. Orandi A (1968) One-stage urethroplasty. Br J Urol 40:717–719
6. Orandi A (1972) One-stage urethroplasty: 4-year follow up. J Urol 107: 977–980
7. Quartey JKM (1983) One-stage penile/preputial island flap urethroplasty for urethral stricture. J Urol 134: 284–287
8. Webster GD, Robertsen CN (1985) The vascularized skin island urethroplasty: its role in urethral stricture management. J Urol 133:31–33
9. Horton CE, Stecker JF, Jordan GH (1990) Management of erectile dysfunction, genital reconstruction following trauma and transsexualism. In McCarthy JG, May JW Jr., Littler JW (eds) Plastic surgery, vol 6, WB Saunders, Philadelphia, pp 4213–4245
10. Jordan GH (1992) Urethral surgery and stricture disease. In Droller MJ (ed) Surgical management of urologic disease: an anatomic approach. Mosby-Yearbook, St. Louis, p 817
11. Jordan, GH (1992) Principles of plastic surgery. In Droller MJ (ed) Surgical management of urologic disease: an anatomic approach. Mosby-Yearbook, St. Louis, p 1227

Reconstruction of the Fossa Navicularis

G.H. Jordan, K.F. Rourke

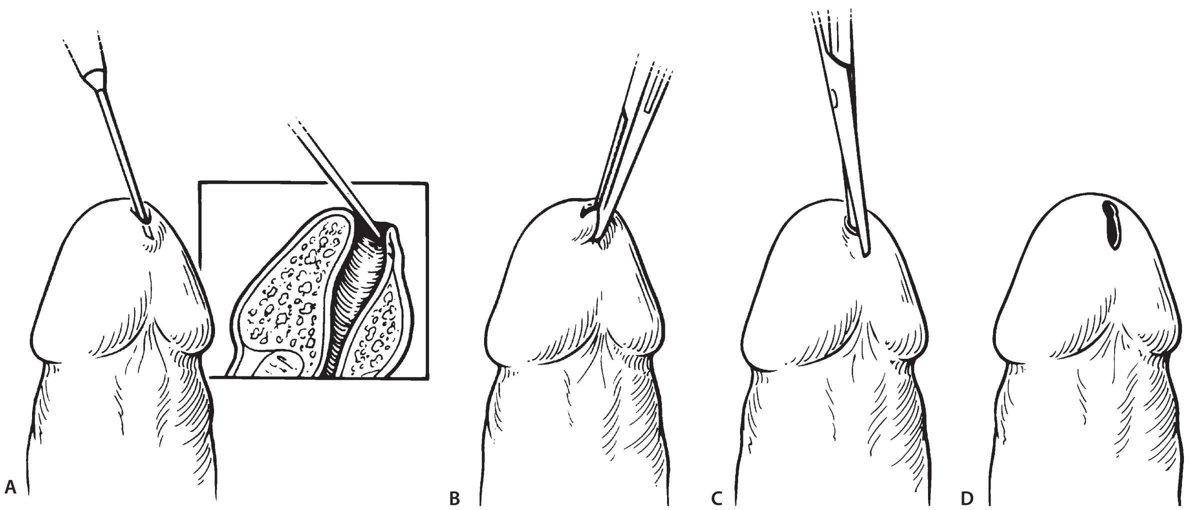
17.1 Reconstruction of Acquired Meatal Stenosis and Strictures of the Fossa Navicularis

Transurethral resection procedures and early balanitis xerotica obliterans (BXO) have been associated with isolated strictures of the meatus and fossa navicularis. In addition, anatomical anomalies or sequelae of ammoniacal meatitis/balanitis can cause meatal stenosis in children. The choice of procedure for repair of acquired meatal stenosis is dependent on the anatomy of the stenosis and the penile skin. This chapter describes several procedures for reconstruction of the meatus and fossa navicularis using vascularized skin islands.

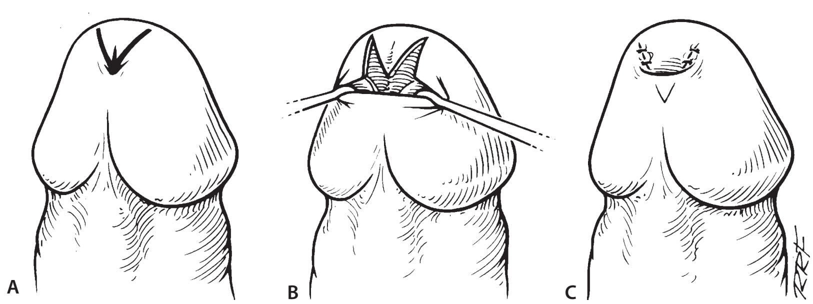
17.2 Reconstruction of Childhood Meatal Stenosis

Childhood meatal stenosis is usually the result of »fusion« of the meatus following irritation of the tip of the glans in the infant or young child in diapers. Also known as ammoniacal meatitis, this condition is more frequent in the circumcised child. If identified acutely, parent education about the nature of the condition, more frequent diaper changes, and meatal dilations using a child/infant meatal dilator or tip of an ophthalmic antibiotic tube may allow resolution before meatal stenosis develops. The application of a topical steroid to the affected area and on the dilator is also helpful.

When the condition advances, ventral fusion can occur. Ventral fusion can be readily managed with either a ventral meatotomy (◘ Fig. 17.1) or a dorsal Y-V flap procedure (◘ Fig. 17.2). A Y-V flap procedure is performed by elevation of a V flap from the dorsal glans tissue, creation of an incision through the stenotic area, and advancement of the V flap into the incision to widen the area of the stenosis. The Y-V flap procedure exchanges the redundancy of the dorsal glans tissue for the paucity of tissue at the stenotic meatus or distal fossa. It has been argued that this procedure is preferred over a ventral meatotomy, which could create a retrusive meatus. In our opinion, a ventral meatotomy provides better functional and cosmetic results as the desired slit



◘ **Fig. 17.1A–D.** Ventral meatotomy as applied to ammoniacal meatal stenosis. **A** Local anesthetic is instilled into the obstructing tissue. **B** The ventral diaphragm of tissue is compressed with a small hemostat. **C** An incision is created through the tissue. **D** The creation of the ventral meatotomy. It is important to keep the skin edges separated during healing. (From [9])



◘ **Fig. 17.2A–C.** Y-V advancement for meatal stenosis. **A** A V-flap is outlined immediately dorsal to the stenosis. **B** The area of stenosis is incised. **C** The flap is advanced into the incision. (From [11]) configuration of the meatus is often lost with the dorsal Y-V flap procedure.

17.2.1 Isolated Stricture of the Fossa Navicularis Following Transurethral Resection of the Prostate

Patients who present with an isolated meatal fossa stricture following transurethral resection of the prostate generally gain little from repetitive dilations; however, reliable reconstruction of the meatus and fossa navicularis with nearly perfect functional and cosmetic results can be accomplished using several surgical techniques.

17.2.1.1 Y-V flap Procedures

Flap procedures for repair of true fossa navicularis strictures founded on the Y-V principle were described by Cohney [1] and Blandy [2]. Cohney's procedure uses a ventral transverse peninsula flap, usually with random vascularity. The flap is transposed and interdigitated into the meatotomy, creating a retrusive meatus with a »dog ear« at the transposition site (◘ Fig. 17.3B). Blandy's modification creates a vertical skin peninsula flap on the midline of the penile shaft that is usually elevated with random vascularity and advanced into the meatotomy (◘ Fig. 17.3A). Although elevation with the fascial blood supply intact and elimination the »dog ear« are theoretic improvements over the Cohney procedure, the Blandy modification still leaves the patient with a coronal or distal shaft meatus. The functional results of both of these techniques are adequate when stenosis is confined to the fossa navicularis; however, both have been criticized due to their suboptimal cosmetic results.

A modification of Blandy's procedure has been described by Brannen [3]. This procedure involves elevation of a peninsula flap based on the dartos fascial blood supply with aggressive advancement into the meatotomy defect (◘ Fig. 17.3C). Although the design of the longer flap was intended to place the meatus closer to the tip of the glans, most patients are left with a retrusive meatus and the unsightly appearance of shaft skin advanced into the ventral glans. Thus, in most cases, this modification yields neither a functional nor cosmetic improvement over Cohney's or Blandy's original flap designs.

Brannen's procedure was then modified by DeSy, who used a longitudinal skin island mobilized on the dartos fascia and aggressively advanced it into the meatotomy defect by inverting the skin island (◘ Fig. 17.3D). Mobilized on a dartos fascial pedicle with the ventral glans fused ventrally over the dartos fascial strip, this procedure also requires a lengthy advancement of the midline dartos fascia. However, DeSy has reported excellent functional and cosmetic results [4].

17.2.2.2 Resurfacing of Fossa Navicularis

Devine reported a procedure he termed resurfacing the fossa navicularis, applicable to only short strictures confined to the intraglanular urethra [5]. This procedure involves excision of the strictured area with placement of a penile skin graft (◘ Fig. 17.3E). As an alternative, a tubed buccal mucosa graft could be used in lieu of a skin graft.

17.2.2.3 Transverse Ventral Penile Skin Island

One of the authors of this chapter (GHJ) has described a procedure for reconstruction of the meatus and fossa navicularis that was intended primarily for strictures confined to the fossa navicularis [6], but can be used for structures up to 4.5 cm in length. Initially, a wide urethrostomy is created through the stenotic meatus and fossa down to the level of the normal urethra. The technique then involves elevation of a transverse ventral penile skin island on a broad ventral dartos fascial pedicle. The skin island is transposed and inverted into the meatotomy defect. Although the broad dartos pedicle allows vigorous mobilization of the ventral fascial pedicle, it requires more aggressive dissection of the lateral glans flaps to assure a tension-free ventral glans fusion. The surgical technique for this procedure is described in detail below.

Evaluation with retrograde and voiding contrast medium and urethroscopy is performed in all surgical candidates. Urethroscopy is usually performed with a small, rigid pediatric cystopanendoscope. For patients in whom this is not possible but in whom contrast studies have indicated that the stenotic process is confined to the fossa, endoscopy is performed through the area of stenosis immediately after the urethrotomy is complete, to assure the surgeon that the stricture does not extend into the more proximal urethra.

The surgical approach is generally through the patient's existing circumcision incision; in patients who have not been circumcised, it is via a partially circumcising incision on the ventral surface of the penis. The ventral penile skin and dartos fascia are elevated in the plane immediately superficial to the superficial lamina of Buck's fascia and, in some cases, the ventral aspect of Buck's fascia can be mobilized and included as the flap's deep layer. A grooved director is passed through the stricture and an external urethrotomy is made through the stricture in the fossa and extended approximately 1–1.5 cm into the normal urethra (◘ Fig. 17.4).

The normal urethra is identified by bougienage and endoscopy. The dimensions of the remaining glanular epithelial strip are measured and a transverse skin island is outlined on the ventral penile skin and tailored to produce a 28- to 30-Fr neofossa navicularis. The island is elevated to preserve the dartos fascial pedicle by incising

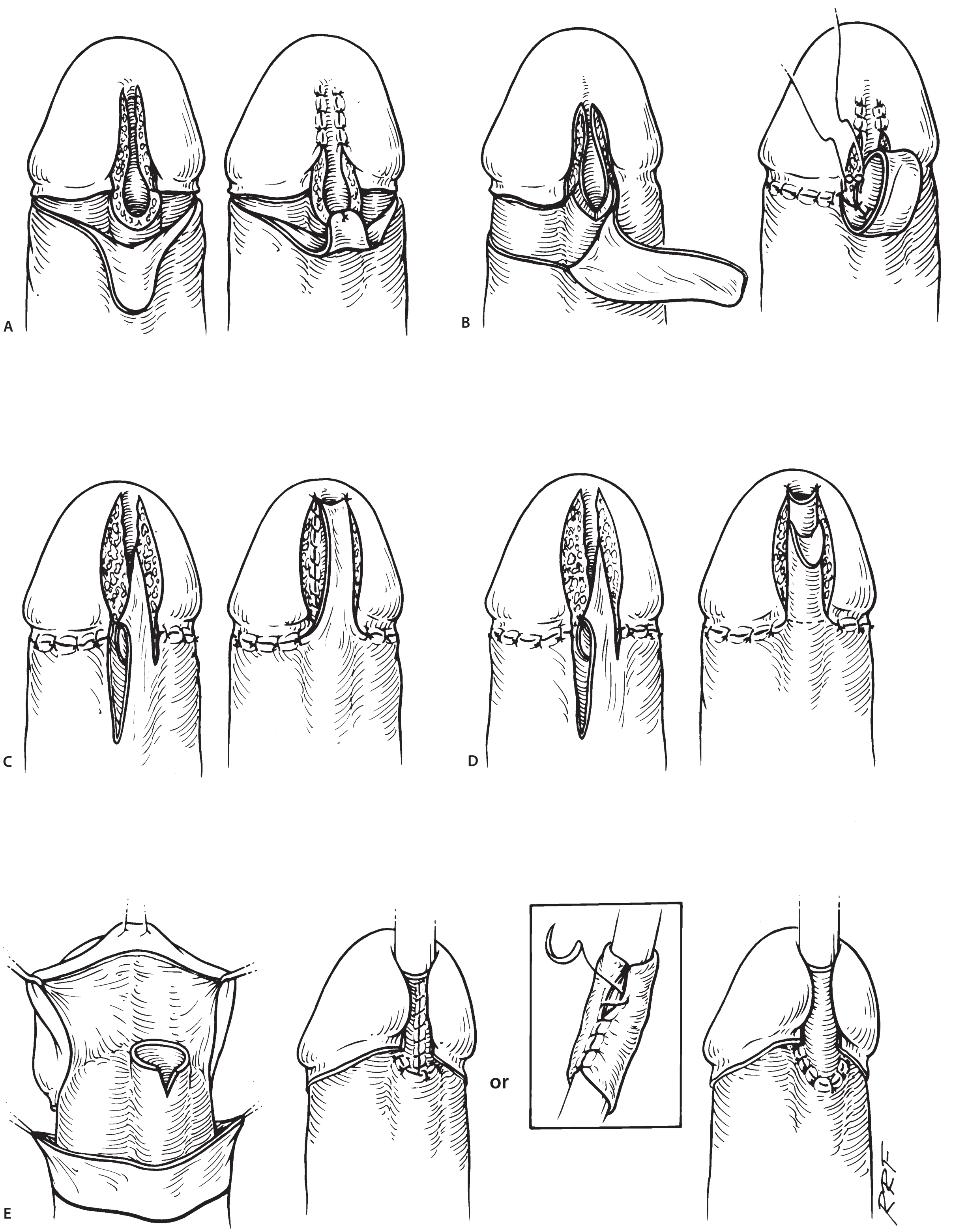
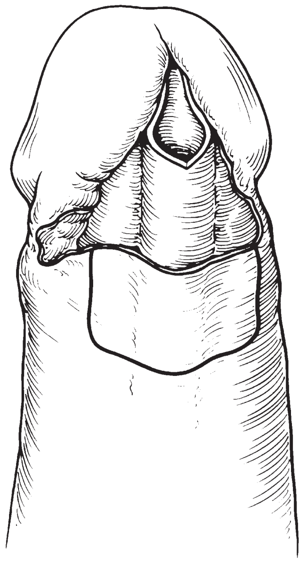


Fig. 17.3A–E. Techniques for correction of strictures of the urethral meatus and fossa navicularis. **A** Technique as described by Blandy. This utilizes a mid-line skin peninsula flap advanced into a meatotomy defect but creates a retrusive meatus. **B** Cohney's technique (creation of a ventral transverse skin flap). **C** Brannen's modification utilizing a more aggressive advancement of a mid-line dartos-based peninsula flap. Note that penile skin is advanced onto the ventral glans. **D** DeSy's technique. A longitudinal skin island is mobilized on dartos fascia, aggressively advanced, and inverted into a meatotomy. The ventral glans is then fused over the repair. **E** Resurfacing of the fossa navicularis as described by Devine. (From[10])

the skin alone. The ventral penile skin is dissected from the fascial pedicle in the plane between the superficial fascial plexus and the deep subdermal plexus of the skin (■ Fig. 17.5). With the skin island oriented transversely, the broad dartos fascial pedicle is created from the entire penile ventrum, and elevation of the fascial flap should be sufficient for a tension-free flap transposition.

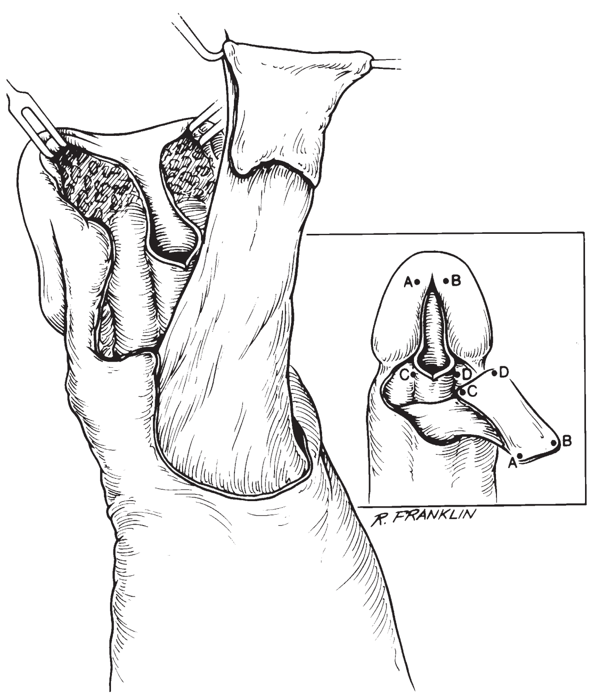


■ **Fig. 17.4.** The ventral transverse skin island as described by Jordan. A urethrostomy defect is created to the level of normal urethra. The dimensions of the skin island is outlined transversely on the ventral penile skin. (From [11])

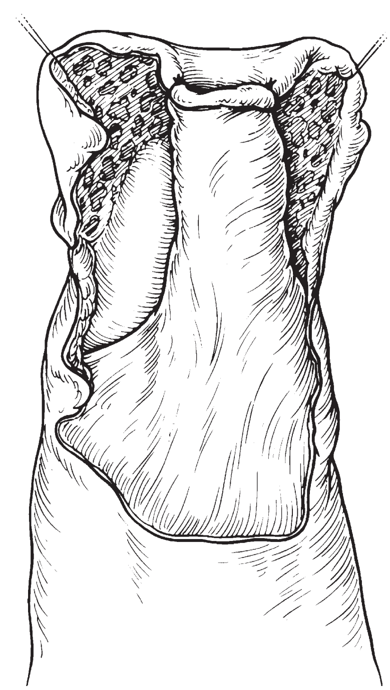
The lateral glans flaps are dissected in the relatively avascular plane between the tips of the corpora cavernosa and the glanular spongy erectile tissue. The small amount of bleeding that occurs during this dissection is easily controlled with bipolar electrocautery forceps and injection of the glans with diluted epinephrine. Tension or narrowing of the urethra of the glans caused by ventral fusion is avoided by wide elevation of the glans flaps, and the appearance of the glans after fusion is normal in most patients.

The skin island is transposed and inverted into the external urethrotomy defect without requiring aggressive advancement of the ventral dartos fascia after elevation (■ Fig. 17.6). Flap transposition permits mechanically efficient mobilization of the fascia. The onlay is secured with tacking sutures (# 5-0 PDS with knots inside the urethral lumen) and a running subepithelial suture (#6-0 PDS).

The glans is closed ventrally over the neofossa with a #28-Fr sound through the area of reconstruction after the patch onlay is complete. A deep layer of #4-0 or #5-0 monofilament absorbable suture and small (usually #6-0) PGA sutures are used to bring the skin into everted apposition is used for glans closure. The sound is replaced with a small urethral stent. Suprapubic diversion was performed early in our series; however, some of our patients currently are diverted by placing a feeding



■ **Fig. 17.5.** The lateral glans wings are dissected. The skin island is then elevated on dartos fascia, transposed and inverted into the remaining dorsal midline strip (From [11])



■ **Fig. 17.6.** The skin island is sutured into the defect. Note the glans wings have not been fused ventrally yet (From [11])

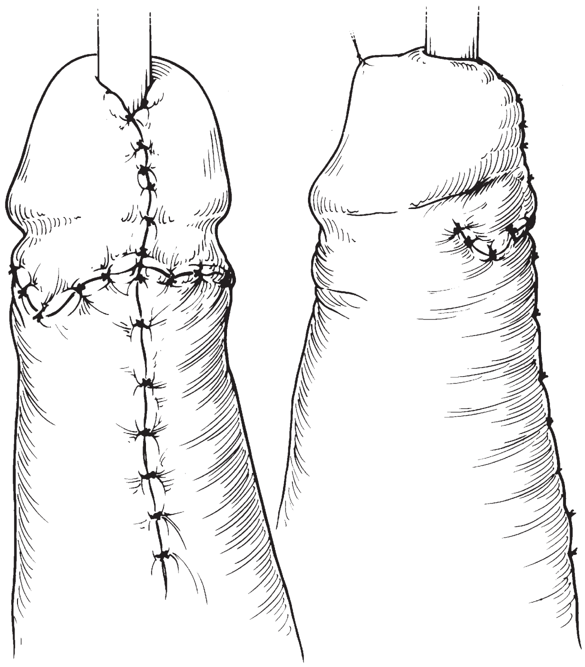


Fig. 17.7. The appearance of the glans when re-fused ventrally with the flap harvest site closed (From [11])

tube through a splent, to allow voiding (through the splent) on the 3rd postoperative day. The flap donor site is closed by transposition of the preputial skin into the defect and development of Burrow's triangles to excise the small »dog ears« at the corners of the closure (Fig. 17.7).

17.2.3 Stricture Associated with Early Balanitis Xerotica Obliterans

Although BXO in children is normally seen with a redundant prepuce, phimosis and balanitis, it has been suggested that BXO begins as a perimeatal process. In patients with BXO who present early in the disease course with a meatal or fossa stricture, high intraurethral pressures appear to be generated during voiding, which leads to intravasation of urine into the glands of Littre. This intravasation may cause inflammation and microabscess formation, ultimately leading to a progressive and severe urethral stricture. It has been our experience that panurethral stricture disease is avoided if early aggressive reconstruction is offered to these patients while the stricture process is confined to the meatus or distal fossa navicularis.

While the meatus and fossa are generally the site of greatest functional limitation in BXO, the glanular skin is also a problem. Most patients will respond to topical steroids up to three times daily for 6–8 weeks, tapered to once daily. Generally after patients are reduced to a once daily regimen, they begin to use it on an as-needed regimen. In addition, BXO-associated inflammation seems to respond favorably to daily doxycycline. However, dermatologists commonly regard BXO as a premalignant condition, and a biopsy is therefore recommended in patients with BXO, who do not respond as expected to treatments, as squamous cell carcinoma may present with what appears to be severe BXO of the glans.

In addition to the one-staged procedures described above for strictures of the fossa navicularis, some surgeons prefer a staged approach for reconstruction of the fossa navicularis in BXO. Devine's procedure (i.e., resurfacing of the fossa navicularis) has been used for BXO, and when there is concern that the BXO would recur involving the graft, a tubed buccal mucosa graft could be used alternately. Another application would be to place a buccal graft open as a first stage followed by a second stage in which the graft is tubed [7].

17.3 Stricture of the Fossa Navicularis with Redundancy of Dorsal Penile Skin

Occasionally a patient will present with stenosis of the fossa navicularis or distal urethral stricture disease, who has redundant skin on the dorsum of the penis. This can be reconstructed using a transverse skin island elevated on the dorsal dartos fascia from the redundant dorsal skin, with the deep dissection in the layer immediately superficial to the outer lamina of Buck's fascia [8].

To produce a tension-free fusion of the glans around the neomeatus and neofossa navicularis, the dorsal transverse island procedure requires wide elevation of the lateral glans flaps similar to the other techniques described above. Some patients, particularly those who have undergone multiple procedures, do not have enough redundancy to elevate a dorsal transverse island without torsion. However, in most cases the torsion resolves over time, and leaving some torsion in exchange for a good functional result is generally acceptable. If the surgeon suspects in advance that this might occur, the patient should be informed before the surgery is performed.

17.4 Results

Several procedures for reconstruction of true strictures of the fossa navicularis provide excellent aesthetic and functional results. The largest series of patients in which a single technique has been used for reconstruction of the fossa navicularis was reported by DeSy, using a longitudinally oriented skin island mobilized on the dartos fascia. The ventral transverse island technique has also been used in large numbers by several reconstructive surgeons, including the author, with excellent results.

17

References

1. Cohney BC (1963) A penile flap procedure for the relief of meatal strictures. Br J Urol 35:182
2. Blandy JP, Tresidder GV (1967) Meatoplasty. Br J Urol 39:623
3. Brannen GE (1976) Meatal reconstruction. J Urol 116:319–321
4. DeSy WA (1984) Aesthetic repair of meatal stricture. J Urol 132:678–679
5. Devine CJ Jr (1986) Surgery of the urethra. In Walsh PC, Gittes RF, Perlmutter AD et al (eds) Campbell's Urology, edn 5. WB Saunders, Philadelphia, p 2853
6. Jordan GH (1987) Reconstruction of the fossa navicularis. J Urol 138:102–104
7. Venn SN, Mundy AR (1998) Urethroplasty for balanitis xerotica obliterans. Br J Urol 81:735–737
8. Duckett JW (1981) The island flap technique for hypospadias repair. Urol Clin North Am 8:503–511
9. Jordan GH, Schlossberg SM (2002) Surgery of the penis and urethra. In Campbell's Urology, 8^{th} Edn. Vol 4, Chap. 110, Saunders, Philadelphia
10. Jordan GH (1987) Management of anterior urethral stricture disease. problems in urology, Vol 1. Philadelphia, JB Lippincott
11. Jordan GH (1999) Reconstruction of the meatus-fossa navicularis using flap techniques. In: Schreiter F, Bartsch (eds) Plastic-Reconstructive Surgery in Urology. George Thieme, Stuttgart, 1999

Penile Circular Fasciocutaneous Flaps for Complex Anterior Urethral Strictures

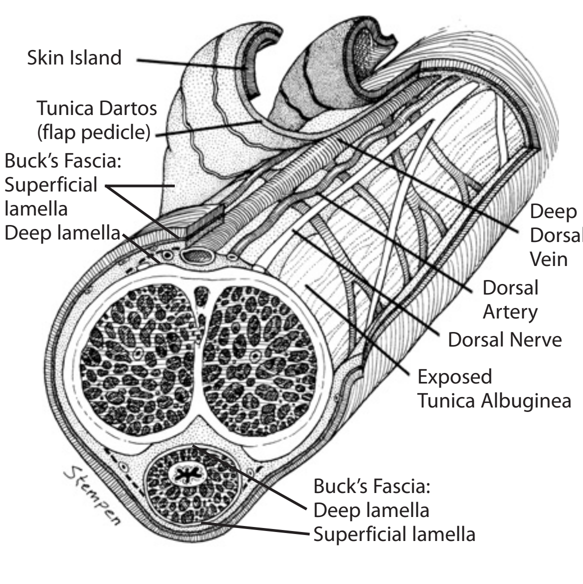
K.J. Carney, J.W. McAninch

Surgical reconstruction of complex anterior urethral strictures, 2.5–6 cm long, frequently requires tissue-transfer techniques [1–8]. The most successful are full-thickness free grafts (genital skin, bladder mucosa, or buccal mucosa) or pedicle-based flaps that carry a skin island. Of the latter, the penile circular fasciocutaneous flap, first described by McAninch in 1993 [9], produces excellent cosmetic and functional results [10]. It is ideal for reconstruction of the distal (pendulous) urethra, where the decreased substance of the corpus spongiosum may jeopardize graft viability.

A circumferential island of hairless distal foreskin (or loose penile skin in the circumcised patient) is mobilized on its vascular pedicle. The flap reliably provides a skin island approximately 13–15 cm long. We have not encountered any cases in which the donor site could not be closed primarily, even in circumcised patients.

18.1 Penile Fascial Anatomy

For proper surgical development of fasciocutaneous penile flaps, a thorough knowledge of penile anatomy and the relationships of the penile fasciae is critical (see ▫ Fig. 18.1). Anatomically, the corpora cavernosa and corpus spongiosum are invested by both a deep fascial layer (classically referred to as Buck's fascia) and a superficial layer of loose areolar tissue known as the dartos fascia. The term »fasciocutaneous flap« refers to the use of Buck's fascia as the primary supporting fascia of the tunica dartos vascular pedicle as it passes to the island of penile skin [9].



▫ **Fig. 18.1.** Anatomy of CFF. Buck's fascia is the transporting fascia for the island pedicle. (From [19, p. 47])

Buck's fascia is a well-defined fascial layer that is closely adherent to the tunica albuginea. Despite this intimate association, a definite plane of cleavage exists between the two, permitting separation and mobilization. Buck's fascia acts as the supporting layer, providing the foundation for the circular fasciocutaneous penile flap. Dorsally, the deep dorsal vein, dorsal arteries, and dorsal nerves lie in a groove just deep to the superficial lamina of Buck's fascia. The circumflex vessels branch from the dorsal vasculature and lie just deep to Buck's fascia over the lateral aspect of the penile shaft. Ventrally and dorsally, Buck's fascia separates into superficial and deep lamellae that diverge to surround the corpus spongiosum and neurovascular structures in envelope fashion. Only the superficial lamella is elevated with the fasciocutaneous flap.

The superficial dartos fascia is a thin, membranous layer of loose subdermal tissue devoid of fat, which lies immediately beneath the skin. It is of utmost importance to preserve this layer, which must be reflected with the penile skin to preserve the delicate subdermal vascular plexus and prevent subsequent skin necrosis.

Deep to the dartos fascia and superficial to Buck's fascia lies the tunica dartos. This layer of areolar tissue moves freely over Buck's fascia, is devoid of fat, and is continuous with the membranous layer (Scarpa's fascia) of the anterior abdominal wall fascia, the dartos tunic of the scrotum, and Colles' fascia of the perineum. A rich supply of superficial blood vessels, nerves, and lymphatics runs within the tunica dartos fascia. This is best perceived as a conduit containing the vascular pedicle [11].

Quartey has described the microcirculation of the penile skin and its relevance to reconstructive surgery of the genital tract [5, 12]. Briefly, the arterial blood supply is derived from the superficial (superior) and deep (inferior) external pudendal arteries, which are medial branches arising from the femoral artery. These arteries descend inferiorly and enter the base of the penis as the dorsolateral and ventrolateral axial penile arteries to form an arterial network within the tunica dartos fascia (▫ Fig. 18.2). Branches from the axial penile arteries then pass superficially to form the subdermal plexus, which nourishes the penile skin (▫ Fig. 18.3). Along the penile shaft, the connections between the subcutaneous and subdermal arterial plexuses are so fine that the skin and dartos fascia can usually be dissected off the tunica dartos with little bleeding.

The venous drainage of the penile skin is highly variable. In general, venous blood from the penile skin drains into a subdermal venous plexus that in turn empties into several tributaries at the penile base (▫ Fig. 18.4). The deep and superficial (subcutaneous) dorsal veins originate from the retrobalanic venous plexus, which lies in a hollow posterior to the glans penis and distal to the termination of the corpora cavernosa (▫ Fig. 18.5). Usually no large connections exist between the subdermal venous plexus and the subcutaneous veins.

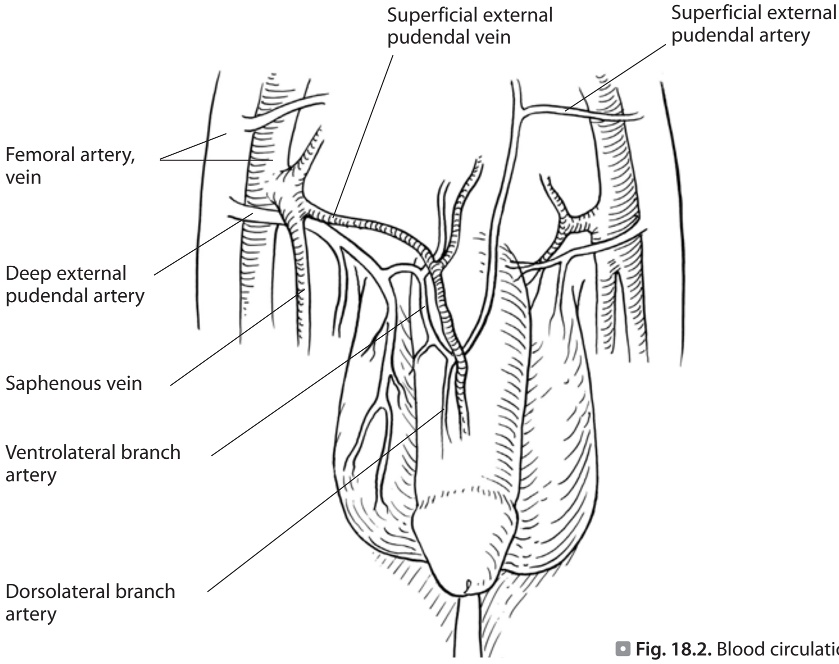


Fig. 18.2. Blood circulation of the penile skin.

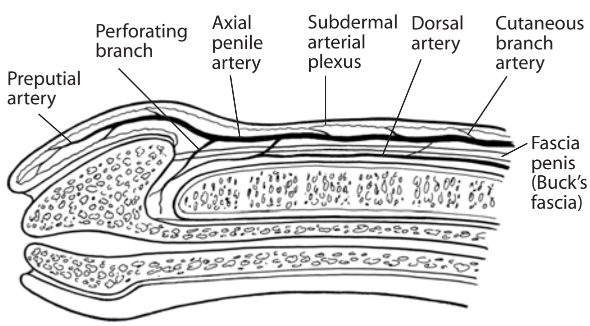


Fig. 18.3. Axial penile arteries from the subdermal plexus to nourish the penile skin

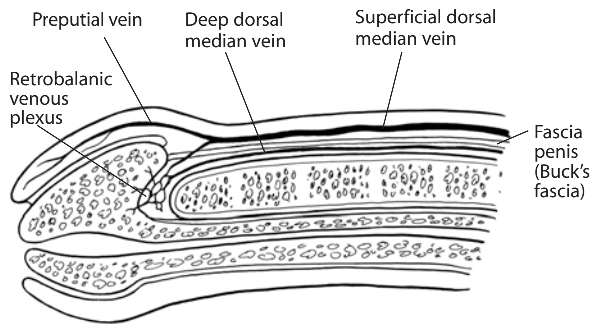


Fig. 18.4. The venous drainage of the penile skin: superficial dorsal medium vein arising directly from the deep dorsal median vein

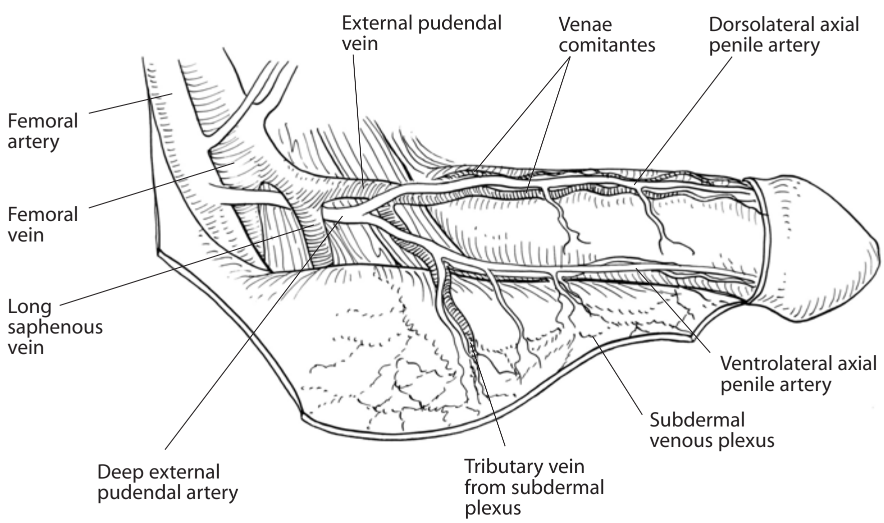


Fig. 18.5. Superficial venous drainage of the penis and penile skin

18.2 Flap Anatomy

The following principles must be borne in mind: (a) morbidity and coverage of the donor site; (c) flap vascularity; (c) physical characteristics of the flap; and (d) the mechanics of flap elevation and transfer to the recipient site [11].

For circular fasciocutaneous penile flaps, the donor site is the distal penile shaft (or foreskin in uncircumcised patients). In this location, the skin is highly elastic, richly vascularized, flexible, and devoid of hair. Nearly all patients, including those circumcised, have adequate preputial redundancy to permit circumferential flap harvesting up to 2.5 cm wide without compromising primary closure or functional results.

Flap vascularity is random or axial: a random flap has no identifiable vessel at its base, and its survival depends on the dermal and intradermal plexuses and length-to-width ratio [13]; axial flaps have an identifiable vessel at their base and, therefore, a well-defined and reproducible vascular territory (Fig. 18.6). Genital skin flaps are axial. The identifiable vessel (the axial penile artery) is located within the tunica dartos fascia, which acts as a conduit and contains the vascular pedicle. However, one should not visualize the vascularity of genital fasciocutaneous flaps as a single axial vessel, but rather as a blood supply based on an axial vessel that includes immediate, wide arborizations [14]. As the blood supply is located within the tunica dartos, this constitutes the flap and the overlying skin is best referred to as a skin island. Secondary perforator vessels are present that supply flow to the skin island (Fig. 18.3). In summary, the circular fasciocutaneous penile flap is an axial flap that carries a skin island, *not* an island flap.

Desirable physical characteristics for genital flaps used in anterior urethral reconstruction include thin, nonhirsute tissue that is easily tailored, as redundancy can lead to the formation of diverticula. Genital skin is a must. Hair in the urethra will result in eczema, calciferous deposits on the hair shaft, and infection, which promotes stricture recurrence [9].

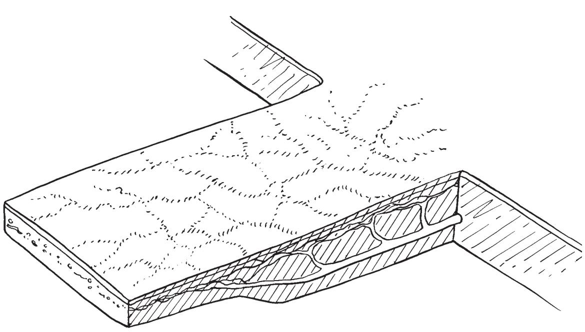


Fig. 18.6. Axial flap with a well-defined arterial blood supply

The mechanics of flap elevation and transfer entail getting the flap to the recipient site with its blood supply intact. As noted above, the fascia is the flap and the skin island is merely a passenger. This is an important concept because fascial flaps with skin islands can endure some twisting without vascular compromise, allowing them to be oriented in many different directions at the recipient site.

All the above criteria are met by the circular fasciocutaneous penile flap. It reliably provides adequate length (usually 13–15 cm) of hairless genital skin that can be used throughout the entire anterior urethra. The abundant vascularity of the tunica dartos fascia allows the skin island to be reliably tailored and oriented at the recipient site, without compromising vascularity. The skin island can be used as a single unit for long complex strictures, or divided and applied in two separate areas for multiple strictures.

18.3 Patient Selection

Successful outcome begins with appropriate patient selection. Numerous factors must be considered: patient age, stricture location and length, degree of spongiofibrosis, prior urethroplasty, the presence of penile skin diseases such as balanitis xerotica obliterans, presence or absence of foreskin, and distribution of hair along the penile shaft.

18.4 Preoperative Preparation

Stricture length and characteristics should be well delineated. In addition to preoperative retrograde urethrography and voiding cystourethrography, we have found preoperative sonourethrography to be useful for precise determination of stricture length and degree of spongiofibrosis [15].

Patients are generally admitted on the morning of surgery. All are given appropriate preoperative antibiotics; we prefer IV ampicillin (1 g) and gentamicin (5 mg/kg). Procedures are performed under general anesthesia, and we rarely use adjuvant epidural anesthesia.

18.5 Patient Positioning

Proper patient positioning cannot be overemphasized. It is imperative both for gaining adequate surgical exposure and for preventing postoperative neuromuscular complications [16–18]. To avoid prolonged placement in the exaggerated lithotomy position, we begin with all patients supine for flap harvest. Patients with strictures involving only the pendulous urethra may remain supine or in a low dorsal lithotomy position; those with more proximal strictures are converted to the exaggerated lithotomy position.

An inflatable bean bag overlapped by a gel mattress pad is positioned beneath the patient. Before induction of general anesthesia, thigh-length TED antiembolism stockings and sequential pneumatic compression devices (Kendall) are placed on each lower extremity. Foam egg-crate heel protectors and padded stirrup straps, which wrap around the plantar surface of the foot at the level of the arch and around the posterior distal lower leg, are applied. The dorsum of the foot must be sufficiently padded with foam to prevent compression of the dorsal cutaneous nerves. The gluteal clefts are positioned just beyond the table's edge. The bean bag is positioned so that the caudal edge extends 8–10 in. beyond the gluteal clefts. This configuration allows the caudal-most aspect of the bean bag to be »rolled under« the sacrum, which will align the perineum nearly parallel to the floor. Candy-cane stirrups are used to suspend the lower extremities high in the air. To avoid excessive stretch on the sciatic nerve, one must ensure that the bean bag lifts and rotates the perineum into the proper position, *not* the suspended lower extremities. The legs should be suspended high enough to avoid acute angulation at the knee joints.

18.6 Flap Harvest

As noted above, we harvest the flap with the patient supine. This decreases urethral blood loss from the incised corpus spongiosum and lessens time spent in the exaggerated lithotomy position, decreasing the risk of associated complications.

Optical magnification should be used throughout the procedure. A 2-0 silk stay suture is placed in the midsagittal plane of the glans penis just above the urethral meatus to provide stretch and permit manipulation. To avoid disturbing the natural hair pattern, the penile shaft should not be shaved before the flap area is marked. As the circular fasciocutaneous flap is harvested from the distal aspect of the penile shaft or foreskin, this usually assures hairlessness. The proximal penile skin is placed on light stretch and the lines of incision are marked with calipers: the distal line (brilliant green dye) is approximately 5 mm proximal to the coronal sulcus, with a second line approximately 17–20 mm proximal to the first (Fig. 18.7). Flap width varies according to the amount of tissue needed to produce a final urethral lumen approximately 26 Fr in diameter. For onlay procedures, a 17- to 20-mm flap width is adequate. To prevent pseudodiverticulum formation, we rarely develop skin flaps more than 20 mm wide for onlay reconstruction. However, when complete urethral replacement is necessary, we harvest a 25-mm-wide flap to allow for tubularization.

As the ink tends to fade with manipulation, we initially score both lines of incision lightly with a #15 scalpel blade. Dissection is then begun by deepening the distal incision on the lateral aspect of the penile shaft down to the superficial lamina of Buck's fascia, thus avoiding the ventrally positioned urethra and dorsal neurovascular structures. As noted above (see »Penile Fascial Anatomy«), a definite avascular plane of cleavage exists between Buck's fascia and the tunica albuginea. Once this plane has been correctly identified, the dissection is carried circumferentially. The dorsal penile neurovascular complex and tunica albuginea are exposed and preserved immediately beneath the plane of dissection. Injury to the former must be avoided to prevent anesthesia in the glans and distal foreskin. The superficial lamina of Buck's fascia is elevated with the pedicle flap, thereby supplying its foundation. As the flap is elevated proximally, it is helpful to lift it with skin hooks (for better delineation of the avascular plane of dissection) and to angulate the scissors in the direction of the penile shaft. This dissection is carried to the base of the penis. Care is taken to ensure precise hemostasis with bipolar cautery.

Attention is now directed to the proximal incision line. This is deepened only through the thin (subdermal) dartos fascial layer. The delicate dartos fascia is thus elevated with the penile skin along the entire shaft of the penis, which protects the subdermal vascular plexus and, thereby, assures skin survival (Fig. 18.8).

Once each plane of dissection has been extended down to the penile base near the suspensory ligament, the flap is divided in the midventral plane (to avoid the abundant network of superficial dorsal veins) back to the penoscrotal junction, thereby converting the circular configuration of the skin island into a longitudinal strip (Figs. 18.9, 18.10). In most patients this is 13–15 cm long. Stay sutures are placed at each end. The well-vascularized pedicle flap, with its skin island, is then transposed to one side of the penis for passage through the scrotum and to the area of repair. Penile tethering is avoided by freeing the flap adequately from the proximal shaft until it reaches into the perineum without tension. Although division in the midventral plane leaves the flap based dorsally, it avoids

Fig. 18.7.

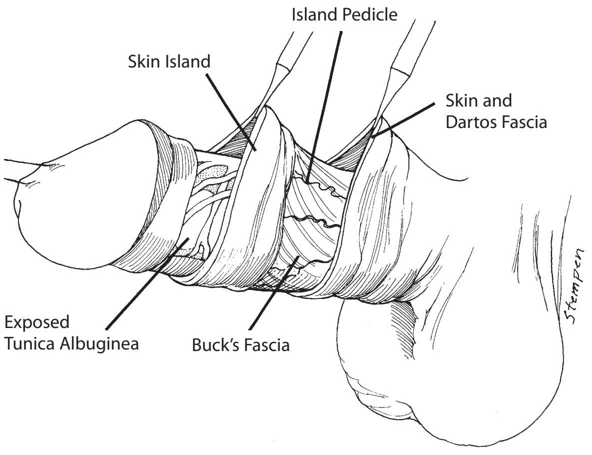


Fig. 18.8. The delicate dartos fascia is mobilized with the skin. (From [19])

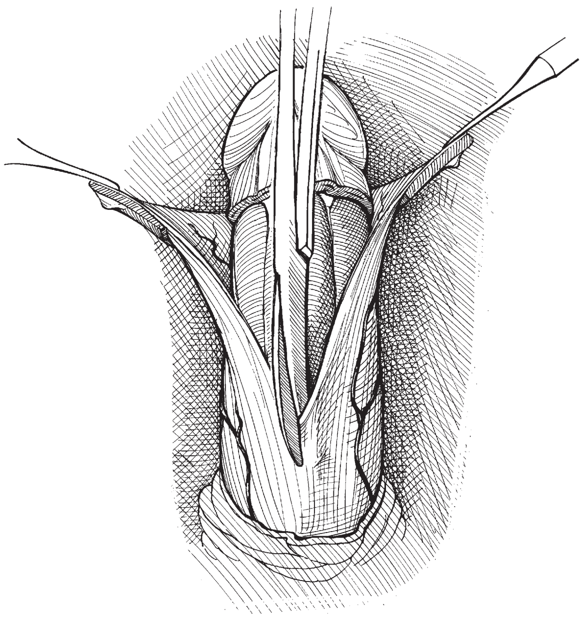


Fig. 18.9. Mobilizing the flap. The flap is incised ventrally. (From [19, p 50])

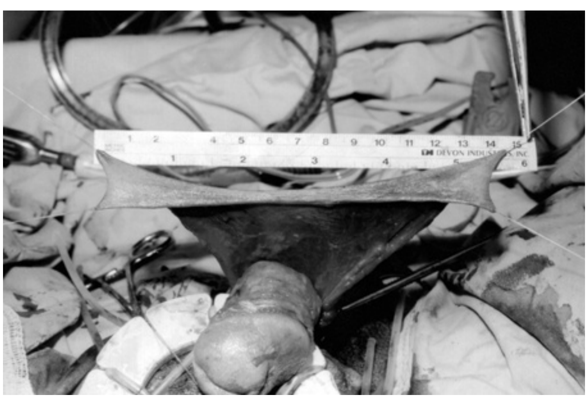


Fig. 18.10.

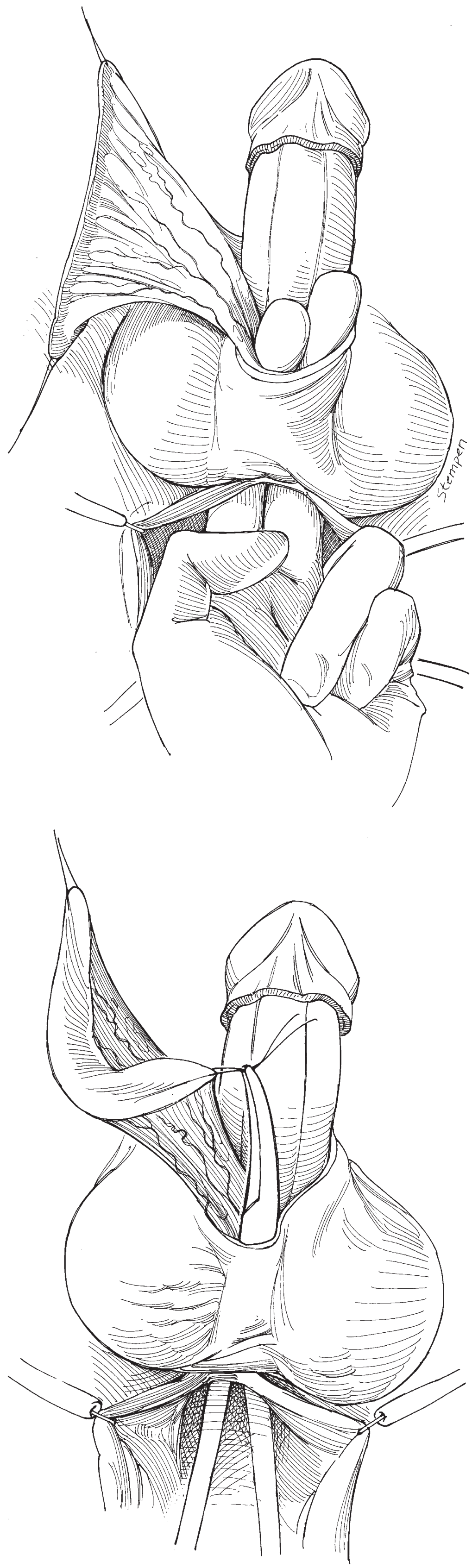
the superficial dorsal vasculature and has presented no problems in obtaining adequate flap length to reach deep into the perineum. (Note that in the dictation report, one *must* document the direction toward which the flap was transposed so that injury to the pedicle can be avoided if reoperation is necessary.)

18.7 Stricture Exposure

Distal strictures can be repaired through the circumcision incision. Bulbar or membranous strictures, however, require repositioning patients into a high lithotomy position, as described above.

A midline incision is made in the perineum along the line of the median raphe. The incision is deepened through the superficial Colles' fascia down to the bulbospongiosus muscle. We prefer the Scott retractor with accompanying skin hooks to provide adequate exposure and facilitate dissection. The bulbospongiosus muscle is sharply divided in the midline with Metzenbaum scissors and reflected laterally, exposing the corpus spongiosum, which can be grasped with DeBakey forceps and manipulated to either side during dissection. Passage of a 20-Fr red rubber urethral catheter will identify the distal-most aspect of the stricture. Stay sutures of 4-0 Dexon are placed in the corpus spongiosum at the 3 and 9 o'clock positions to provide exposure and retraction. The corpus spongiosum and urethra are entered on the ventral surface just distal to the stricture, and the entire length of abnormal urethra is sharply incised in the ventral midline, extending at least 1 cm into normal urethra. Often passage of a small-caliber feeding tube will help delineate the lumen as the stricture is incised. Additional full-thickness stay sutures of 4-0 Dexon are placed in the incised edges of spongiosum along the length of the stricture, to facilitate exposure. The urethra distal to the stricture is dilated with a 26-Fr Acorn bougie à boule; proximally, a 28- Fr or 30-rF bougie à boule is passed into the bladder to ensure that the complete length of stricture has been lysed and to rule out additional unsuspected strictured areas. We then pass a 19-Fr rigid cystoscope into the proximal urethra and bladder to identify anatomic landmarks and rule out bladder pathology.

A tunnel that will allow passage of two fingers is created bluntly and sharply under the scrotum from the penile shaft to the perineum. The previously placed stay suture at one end of the flap is grasped and passed through this scrotal tunnel into the perineal incision near the region of the bulb (Fig. 18.11). As the axial blood supply is located within the fascia, and the skin is merely carried as a passenger (a fascial flap with a skin island), this configuration can endure some degree of rotational twisting without vascular compromise. Nonetheless, tension and rotation should be minimized.



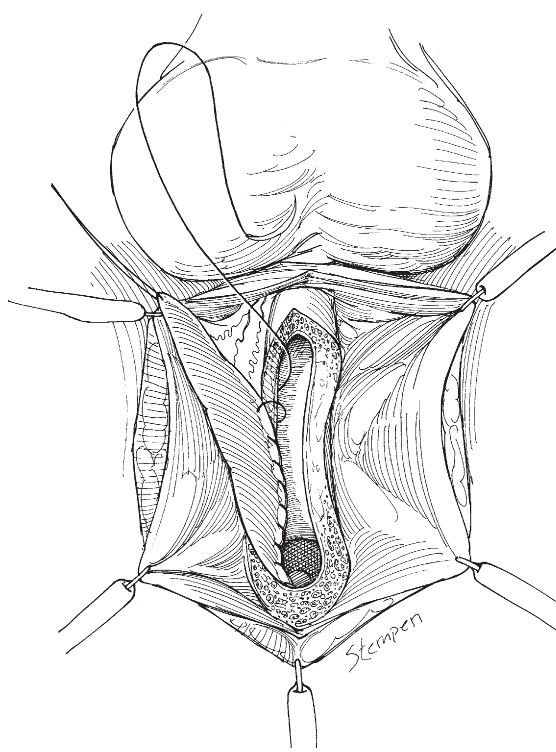
A

B

■ **Fig. 18.11A, B.** Flap mobilization for bulbar strictures. (From [19, p 55])

18.8 Anastomosis

Although the skin island can be fashioned into a complete tube and used for replacement urethroplasty, we prefer to maintain the urethral plate and use the flap for onlay reconstruction whenever possible. The length of the urethral defect is measured, and the skin island is tailored accordingly. It should face the lysed urethra. Two running, double-armed, monofilament, absorbable (polyglyconate [Maxon], poliglecaprone [Monocryl] or polydioxanone [PDS]) 5-0 or 6-0 sutures are placed at the apices. Knots are tied on the outside of the urethral lumen. The flap can be temporarily tacked along the urethral margin with interrupted suture of 5-0 chromic to stabilize it. Suturing begins at the proximal apex of lysed stricture; the back wall is the first side sutured (i.e., the side toward which the pedicle was passed) (■ Fig. 18.12). The suture (which was tied with the knot on the outside) is then passed back through the spongiosal tissue into the urethral lumen, and a running, water-tight, urethral anastomosis is performed along one side, approximating the edge of skin island to the urethral mucosa margin. Billowing and bunching of the flap can be avoided by lightly stretching the skin island with delicate jeweller's forceps while precisely placing the sutures in the skin edge. One should avoid grasping the suture with forceps to prevent weakening it during the anastomosis. The suture is tied at the distal apex of lysed urethra.



■ **Fig. 18.12.** When the flap is straightened and its apex is tailored, the ipsilateral back wall anastomosis is completed first. (From [19, p 56])

A second running suture is begun at the distal apex and run proximally to complete the anastomosis. Width of the skin island can be reduced in areas by trimming as needed to produce a smooth contour approximately 26 Fr. A 16-Fr 100% silicone catheter is inserted before completing the second anastomotic line. As completion nears, redundant skin is excised and the skin island tailored near the distal apex. Caution should be exercised to ensure that only the skin island is tailored, thereby preserving the pedicle flap. To avoid excess bulk, the pedicle flap can be loosely tacked along the penile shaft with interrupted sutures.

Complex strictures that exceed the length of the skin island can be managed by combining other forms of tissue transfer with the flap. In such cases, the flap should be placed in the pendulous portion of the urethra and the free graft should be placed in the bulbar urethra, thereby taking advantage of the abundant corpus spongiosum to provide vascular support for the graft tissue.

If bleeding from the spongiosal edge is troublesome, the opened spongiosum can be sutured along its edge with running absorbable suture, but formal spongioplasty is avoided to prevent pressure on the pedicle. A small TLS suction drain can be placed beneath the bulbospongiosus muscle before closure and brought out through a separate stab incision. The bulbospongiosus muscle is reapproximated in the midline with interrupted Dexon suture, and Colles' fascia is reapproximated in like manner. The perineal skin incision is closed with interrupted 4-0 chromic suture. The skin over the penile shaft is reduced and closed in standard fashion as for circumcision.

18.9 Postoperative Care

The incisions are dressed with Xeroform, followed by fluff gauze. A scrotal supporter is used to hold the dressing in place and to ensure gentle compression and immobilization, reducing edema without compromising blood supply. Circumferential compression bandages to the penile shaft are avoided. Suprapubic urinary diversion is typically not performed. A 16-Fr 100% silicone catheter is used as a stent and to divert the urine for at least 3 weeks. The Foley is secured to the lower abdominal wall with a Cath-Secure to maintain the penis in the anatomic position, thereby avoiding undue pressure on the ventrally positioned flap. On postoperative day 1, diet is advanced and ambulation permitted. Patients are usually discharged after 48–72 h. Suppressive doses of oral antibiotics are maintained until the catheter is removed. Voiding cystourethrography is performed at catheter removal. Patients are followed with flow rate measurement and urethrography at 3 and 12 months.

18

References

1. Devine PC, Sakati LA, Poutasse EF, Devine CJ Jr (1968) One-stage urethroplasty: repair of strictures with free full thickness patch of skin. J Urol 99:191
2. Morey AF, McAninch JW (1996) When and how to use buccal mucosa grafts in adult bulbar urethroplasty. Urology 48:194
3. Mundy AR, Stephenson TP (1988) Pedicled preputial patch urethroplasty. Br J Urol 61:48
4. Orandi A (1972) One-stage urethroplasty: 4 year followup. J Urol 107:977
5. Quartey JKM (1985) One-stage penile/preputial island flap urethroplasty for urethral stricture. J Urol 134:474
6. De la Rosette JJM, de Vris JDM, Lock MTWT, Debruyne FMJ (1991) Urethroplasty using the pedicled island technique in complicated strictures. J Urol 146:40
7. Wessells H, Morey AF, McAninch JW (1996) Combined tissue transfer techniques in the single stage reconstruction of complex anterior urethral strictures. J Urol 155:502A
8. Yachia D (1988) Pedicled scrotal skin advancement for one-stage anterior urethral reconstruction in circumcised patients. J Urol 139:1007
9. McAninch JW (1993) Reconstruction of extensive urethral strictures: circular fasciocutaneous penile flap. J Urol 149:488
10. McAninch JW, Morey AF (1998) Penile circular fasciocutaneous skin flap in 1-stage reconstruction of complex anterior urethral strictures. J Urol 159:1209
11. Jordan GH, Stack RS (1997) General concepts concerning the use of genital skin islands for anterior urethral reconstruction. Atlas Urol Clin N Am 5:23
12. Quartey JKM (1997) Microcirculation of the penile and scrotal skin. Atlas Urol Clin N Am 5:23
13. Jordan GH (1996) Use of flaps and grafts. In: Traumatic and reconstructive urology. WB Saunders, Philadelphia, pp 71–85
14. Jordan GH (1998) Anterior urethral reconstruction: concepts and concerns. Cont Urol, 10:81
15. Morey AF, McAninch JW (1996) Ultrasound evaluation of the male urethra for assessment of urethral stricture. J Clin Ultrasound 24:473
16. Angermeier KW, Jordan GH (1994) Complications of the exaggerated lithotomy position: a review of 177 cases. J Urol 151:866
17. Moses TA, Kreder KJ, Thrasher JB (1994) Compartment syndrome: an unusual complication of the lithotomy position. Urology 43:746
18. Peters P, Baker SR, Leopold PW, Taub NA, Burnand KG (1994) Compartment syndrome following prolonged pelvic surgery. Brit J Surg 81:1128
19. Morey AF, McAninch JW (1997) Penile circular fasciocutaneous flap urethroplasty. Atlas Urol Clin North Am 5:49

Selective Use of the Perineal Artery Fasciocutaneous Flap (Singapore) in Urethral Reconstruction

L. Zinman

Complex bulbar and bulbomembranous strictures that are compromised by extensive periurethral fibrosis with avascular tissue beds, prior radiation, perineal decubitis, pelvic fracture, distraction defects greater than 6 cm or extensive perineal trauma present a surgical challenge that will not often respond to traditional genital flaps and grafts. These patients with such demanding urethral pathology are candidates for a number of local peninsular or free flaps from the thigh and forearm that can combine the resolution of a urethral stricture, need for supporting skin cover and the filling of soft tissue defects. The gracilis myocutaneous flap has been the most widely used for perineal reconstruction, but has the disadvantage of an unpredictable skin vasculature and an extremely bulky cutaneous island for urethral substitution.

We first brought attention to the perineal artery fasciocutaneous flap in male urethral reconstruction and urethral replacement in 1997, where it was employed in nine patients with high-risk, complex (bulbomembranous) urethral stricture management [1]. This flap provided a reliable skin island substitution onlay that could be readily transferred into the proximal bulb and posterior urethra with minimal donor site morbidity.

The perineal artery flap belongs to a class of axial fasciocutaneous constructs that are ubiquitous and have extended the role of thigh flaps in pelvic and perineal reconstruction. It is often referred to as the Singapore Flap since its boundaries were anatomically defined by the Singapore surgeons, Wee and Joseph in 1989 [2].

Basics of the Fasciocutaneous Flap

The perineal artery or Singapore flap belongs to a group of tissue segments referred to as axial fasciocutaneous flaps first described by Ponten [3] in 1981 for lower leg reconstruction and subsequently classified by Cormack and Lamberty, who defined their vascular anatomy and the variation of fascial and skin components. The flap consists of a unit of skin, subcutaneous tissue, and a well-developed fascial undersurface that acts as a vehicle or trellis for supporting that circulation and its arborizing plexi and perforators. These well-defined composites of transferable tissue are supplied by a circulation that consists of three vascular patterns. Their common anatomic feature is the inclusion of a deep fascial floor that preserves the interconnecting vascular network arising from septocutaneous, musculocutaneous, or direct cutaneous arterial trunk sources. These vessels form a fasciocutaneous plexus that may be found at the subfascial, suprafascial, subcutaneous, or subdermal levels and ultimately arborizes and provides sustenance to the skin. The suprafascial component of the flap circulation is regarded as the major blood supply to these axial skin flaps regardless of the type of vascular anatomy. These anatomic and vascular characteristics permit reliable, predictable flaps that can be raised by simple dissections with minimal blood loss and no loss of function. Fasciocutaneous flaps are a significant advance in flap design and were developed because a myocutaneous flap is not often available, not expendable, or is too bulky. They do not possess the superior immunologic qualities seen with muscle and musculocutaneous flaps, but have the advantages of less bulk, ease of elevation and are thinner and more expeditiously used for smaller defects such as those involving the urethra and vagina.

The Singapore medial thigh flap is an example of a Cormack Type B fasciocutaneous flap with a single septocutaneous perforator that permits it to be used as a hinged or island flap with consistently predictable measurements.

History of Singapore Flaps

The primary impetus for the development of the perineal artery flap was the need for reliable, one-stage, sensate vaginoplasty for acquired and congenital absence of the vagina [5]. The concept was first applied for vaginal reconstruction in two patients with congenital adrenal hyperplasia and vaginal atresia by Morton in 1986 [6]. Cadaveric injection studies by Hagerty et al. [7] first identified the perineal branch of the internal pudendal artery as the vascular basis for the flap and defined the medial border as the groin crease. In 1989, Wee and Joseph [2] established the definitive boundaries (cutaneous vascular territory) and the design of the pudendal flap as well as its neurovascular anatomy. Injection studies showed that the internal pudendal artery supplies the perineum by its first branch, the inferior rectal. The perineal artery, its second branch, then courses lateral to the labia majora in women and the scrotum in men. The scrotal branches anastomose with branches of the deep external pudendal artery as well as the medial circumflex femoral artery and obturator artery over the proximal adductors. By arborizing with the deep external pudendal artery and the random subdermal circulation, the distal limit of the flap reaches the medial border of the femoral triangle (Fig. 2). The deep fascia and epimysium over the adductors were noted to be an integral part of this reliable flap. Giraldo et al. [8], using a 3×10-cm flap, confirmed that the surface landmarks, with the center on the inguinal fold, were a reliable reflection of the flap circulation and that the deep external pudendal vessels could be cut at the superior apex without loss of skin. The first account of the use of a pudendal perineal artery-based flap in reconstruction of a post-traumatic urethral stricture was in a patient with gender dysphoria, reported by Tzarnas et al. [9] in 1994. Subsequent clinical reports have confirmed the value of this approach to complex proximal urethral stricture disease [10].

Flap Design and Elevation

The perineal artery medial thigh flap is a vertically oriented composite of skin, subcutaneous tissue, deep fascia, and adductor epimysium that measures 15×6 cm, with its proximal base in the male located at the level of the mid perineum 3 cm distal to the anal margin (Fig. 19.1). The medial border is the crease of the groin lateral to the edge of the scrotum. Wee and Joseph [6] described the maximal safe dimensions of the flap as less than 6 cm in width from the base and 15 cm in length reaching the femoral triangle, including some random circulation at the distal point. The vascular basis of this flap is the superficial perineal artery, which is centered just medial to the groin crease with branches going to the scrotum and skin of the thigh. These vessels interconnect with branches of the deep external pudendal artery and the medial circumflex femoral artery, which arises directly from the profunda femoralis. A connection to the anterior branch of the obdurator artery exists near the proximal region of the adductor muscle (Fig. 19.2).

The innervation of the proximal flap is supplied by branches of the pudendal nerve and perineal rami of the posterior cutaneous nerve of the thigh, which create a partially sensate structure.

This flap is elevated with the patient in the exaggerated lithotomy position and the thigh abducted using well-padded Direct OR stirrups. The lower abdomen, genitalia, perineum, and both thighs are prepared and exposed. The proximal and distal limits of the urethral stricture are marked on the skin surface, and the margins of the flap are outlined carefully with an indelible skin scribe. The initial incisions are made in parallel vertical lines and deepened down to the fascia on both sides, raising the epimysium with the fascia and suturing them to the dermis to prevent shearing injury to the segmental vessels. The flap is lifted until the proximal transverse margin is reached. The vascularity of the distal edge is confirmed by de-epithelializing a 1-cm area of the distal margin to identify a bleeding dermis. This step is followed by intravenous injection of two ampoules of fluorescein dye and examined with a Wood's light. The tissue bridge between the base of the flap and the urethral exposure is divided rather than attempt tunneling during transfer of the flap. This will prevent a compression effect and potential compromise of flap circulation. This technique provides ease of transfer of the somewhat tenuous distal island to the deep proximal urethra and release of tension on the closure of the donor wound site.

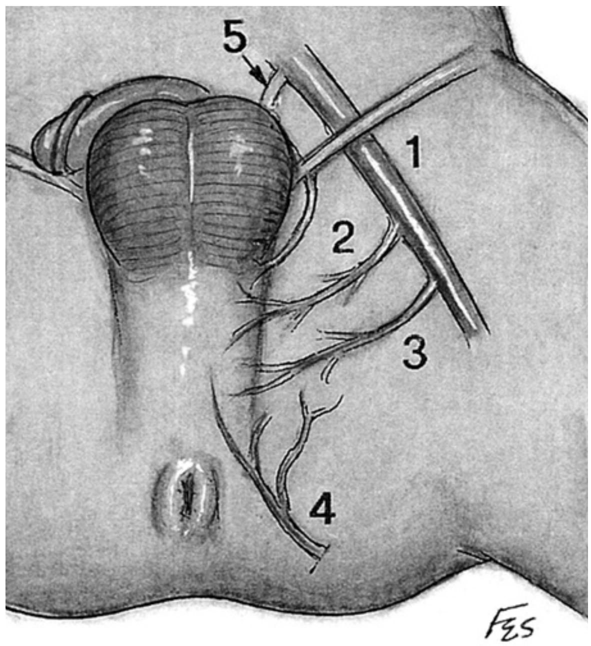


Fig. 19.2. Vascular basis of the medial thigh perineal artery fasciocutaneous flap centers around perineal artery (*4*), which arises proximally from an internal pudendal artery. This courses lateral to the scrotum and arborizes with branches from the deep external pudendal (*2*), medial circumflex (*3*), femoral (*1*),and obturator (*5*), which arises from common and profunda femoralis

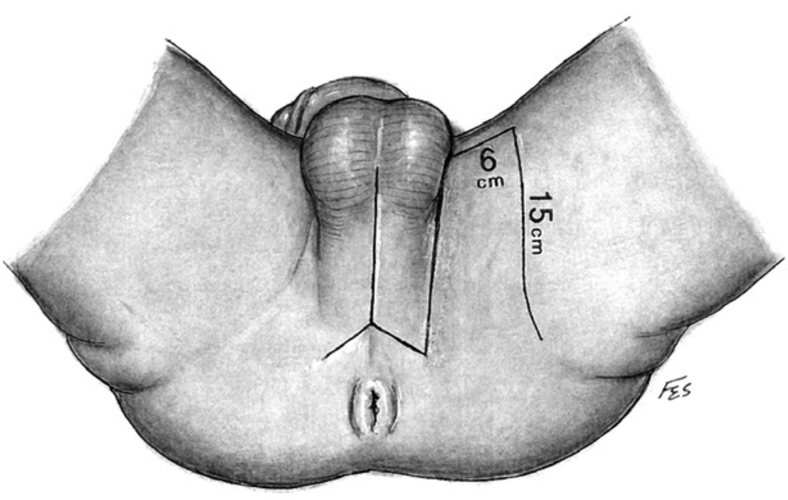


Fig. 19.1. Medial thigh flap measurements are consistently 15×6 cm, with the proximal base located at the level of the mid-perineum. The medial border is the crease lateral to the edge of the scrotum. The distal border is the mid-femoral triangle

Urethral Reconstruction

Four different variations of the Singapore fasciocutaneous flap transfer have been used in the management of a group of high-risk, complex proximal strictures. The selection of application has been based on length and proximal extent of the stricture, the pressure of an intact urethral roof, the absence of a segment of bulbomembranous urethra or co-morbid features of radiation, prior perineal and genital surgery or decubiti.

Most patients managed by this flap require an onlay patch designed in a traverse direction and rotated with a slight twist to a caudal position. This island onlay augment is performed in a ventral position and optimally combined with partial excision of the narrowest point followed by a »roof strip« anastomosis (◘ Fig. 19.3).

Technique of Onlay Patch Urethroplasty

The urethra is exposed with the patient in the dorsolithotomy position and both thighs draped into the operative field. A retrograde bougienage will readily define the distal limits of the stricture, while a #5 Fogarty balloon distended with 1 ml of saline will identify the proximal limit. An inverted Y-incision that extends to the midscrotal raphe permits access to the relevant portion of the urethra and will allow a proper entry site for the flap (◘ Fig. 19.1). The bulbocavernosus muscle is divided in the midline and separated from the corpus spongiosum. The spongiosum is mobilized if partial excision is contemplated from the suspensory to the triangular ligament, avoiding the neurovascular pedicle to the muscle and the bulbar arteries.

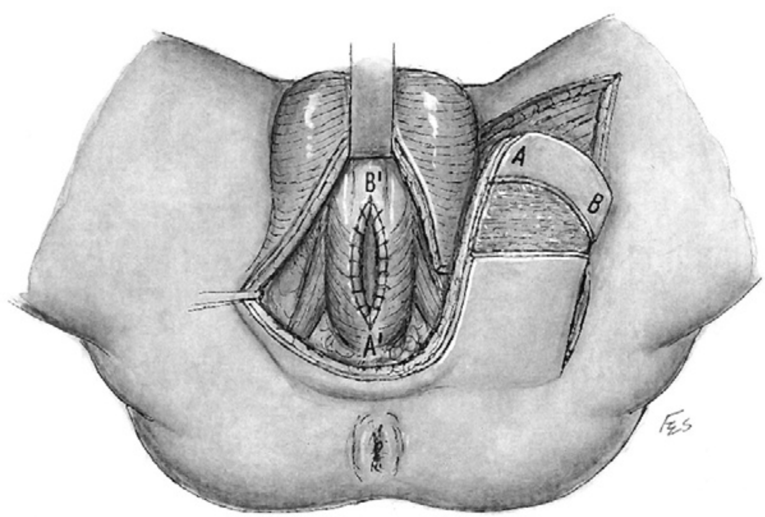
A urethrotomy (stricturotomy) is started distally on the ventral surface of the bulbar urethra and extended proximally to the palpable intraurethral balloon across the apex of the prostatic urethra if necessary (◘ Fig. 19.3).

A running locked hemostatic suture of 5-0 chromic catgut is used to approximate the adventitia to the urethral edge, thus controlling the bleeding spongiosa edge while permitting more precise fixation of the flap onlay.

When segments of the urethra are too narrow and fibrotic for a uniform onlay, partial resection with a roof strip anastomosis is performed utilizing interrupted 4-0 Monocryl sutures and fixing the mobilized spongiosa to the ventral side of the corpora cavernosa. The urethrotomy must extend to 2–3 cm of normal, healthy, uninvolved urethra at the proximal and distal limits of the disease. Reluctance to perform an aggressive urethrotomy accounts for most recurrent strictures since nonobstructive cryptic spongiofibrosis can be difficult to define without incising the spongiosa. The length and width of the prepared urethrotomy are measured with an indwelling 24-F catheter as a sizing template for the proximal urethral lumen. If the stricture extends across the sphincter, a series of 4-0 Monocryl sutures are placed in the proximal apex of the urethrotomy in preparation for the onlay or tube island flap. A suprapubic cystotomy is established at this point.

Attention is then directed to the perineal artery flap retrieval, which then needs to be elevated with a secure circulation and a well-perfused distal margin. A 6- to 8-cm by 2-cm transverse island is outlined around the edge of the flap (◘ Fig. 3). A 3-cm-wide strip of skin just proximal to the island is de-epithelialized, leaving a thin layer of dermis to prevent ischemic injury to the transverse island. The flap is rotated medially and inferiorly and the island patch is sutured over the urethrotomy defect by inserting the previously placed apical sutures into the proximal edge of the skin island (◘ Fig. 19.4). Two running sutures of 4-0 Monocryl are used to complete the onlay repair. These are reinforced with widely spaced, interrupted sutures of 5-0 Vicryl and a #16 silastic catheter is inserted.

The donor site and perineal incision are closed by advancing the lateral thigh wound edge toward the



◘ **Fig. 19.3.** A bulbomembranous urethrotomy is performed and then managed by a horizontal or transverse onlay patch scrotum, covering the proximal perineum and urethral reconstruction with the pudendal flap and transferring the scrotal bridge laterally (◘ Fig. 19.5).

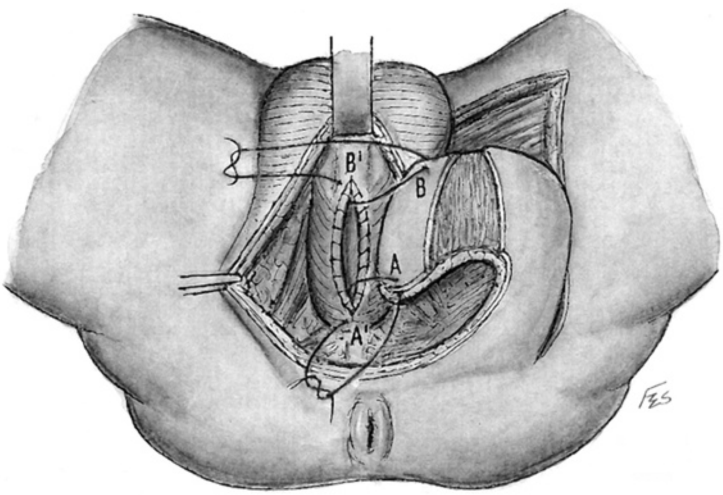
A small, round Jackson-Pratt suction drain that exits through the thigh incision is inserted for 4 days. The urethral catheter is removed in 10 days and the suprapubic diverting cystotomy in 3 weeks pending normal results on voiding cystourethrogram. A retrograde urethrogram is obtained every 3–6 months and repeat uroflows are checked every 4 months for 2 years.

Techniques of Tube Flaps Urethral Replacement

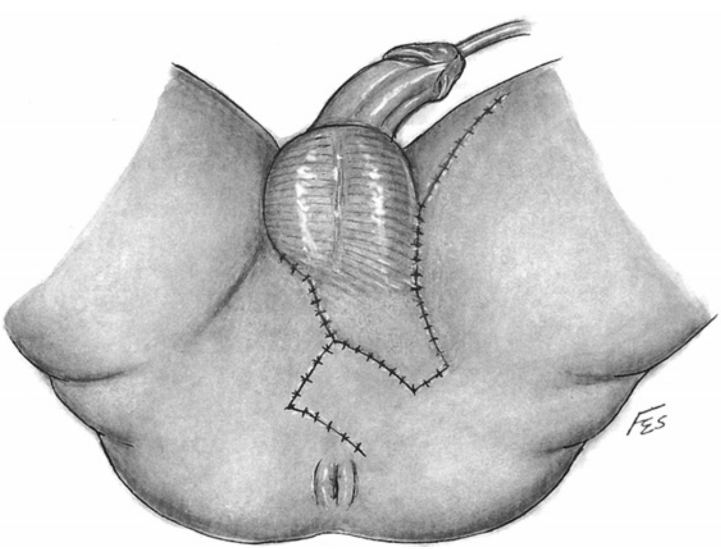
Pelvic fractures or perineal injuries can produce long defects from the apex of the prostate to the mid bulbar urethra that cannot be bridged by standard anastomotic techniques because of a very lengthy defect, vascular compromise of the anterior urethra, or prior anterior urethral surgery and associated spongiofibrosis that interferes with retrograde blood flow. This will require the uncommon use of a circumferential one- or two-stage tube flap design as a salvage procedure to restore the proximal urethral lumen. The perineum is exposed with the patient in the lithotomy position and the sacrum elevated by wedge or gel-pack pillow. The bulbomembranous and prostatic apex is explored through an inverted Y-incision, dividing the central tendon and bulbocavernosus muscle in the midline.

The crura of the corpora cavernosa are separated in the midline by dividing the intercrural membrane to achieve access to the prostatic lumen. The membranous and prostatic apical urethra are spatulated ventrally along with the distal bulbous urethral stump. The segment of obliterated urethra and periurethral fibrous tissue between the two openings is excised.

The perineal artery flap is raised and its length extended to the maximum point of viability. A central distal island of skin is measured to fit the size of the defect and marked with a skin scribe to a width of 3–3.5 cm and



◘ **Fig. 19.4.** The flap is rotated medially and inferiorly, and the island of skin is applied to the urethrotomy defect and closed with running sutures of 4-0 polydioxanone reinforced with interrupted 5-0 polyglactin 910 (Vicryl)



◘ **Fig. 19.5.** Closure of the thigh wounds of the donor site and perineum a length of 6–8 cm. The skin margin surrounding the demarcated island flap is de-epithelialized, leaving a telltale bleeding dermis while preserving the circulation to the potential island tube flap (Fig. 19.6). The proximal margin is de-epithelialized for a minimum of 3 cm.

The skin strip island (*1*) is tabularized around a #22 F catheter (*2*), and the edge is closely initially with a few well-spaced interrupted sutures of 4-0 Monocryl (*3*) followed by running subcuticular sutures of 5–0 Monocryl (*4*) (Fig. 19.7).

The distal stoma of the tube flap is coapted to the proximal prostatic apex with closely placed 4-0 Monocryl tied on the outside of the lumen. The proximal tube stoma is brought to the bulbous urethral lumen after mobilizing the corpora spongiosa to the penoscrotal junction and completing the distal anastomosis with interrupted 4-0 Monocryl (Fig. 19.8).

The wounds are closed in layers by advancing the thigh margins of the incision medially and the proximal portions of the flap as a posterior cover (Fig. 5).

Perineal Artery

Multistage Flap Urethroplasty

A recurrent bulbomembranous stricture that has undergone prior failed procedures, or radiation with extensive periurethral fibrosa and loss of adequate scrotal or perineal skin cover can be salvaged by transferring the Singapore flap to the proximal spatulated urethrostomy. This technique can be accomplished by bringing the tapered distal flap margin to the apex of the ventral urethrotomy, thus delaying the definitive urethral reconstruction by an initial marsupialization procedure (Fig. 19.9). The flap is elevated after the urethra is prepared and rotated to the urethral margin. The proximal part of the flap is concomitantly used as a wound cover while the nonhirsute scrotal edge is sutured to the distal urethral edge (Fig. 19.10). A 20-F silastic catheter is placed thru the proximal stoma for bladder drainage for 12 days and evaluation continues periodically by bougie calibration (Fig. 19.11).

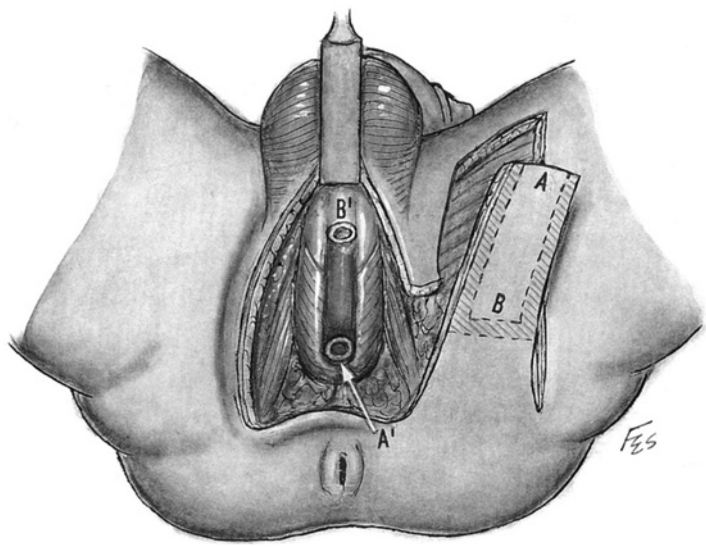


Fig. 19.6. The island of skin is measured and demarcated in preparation for a tubed flap to bridge a long defect that cannot be repaired by standard anastomotic techniques

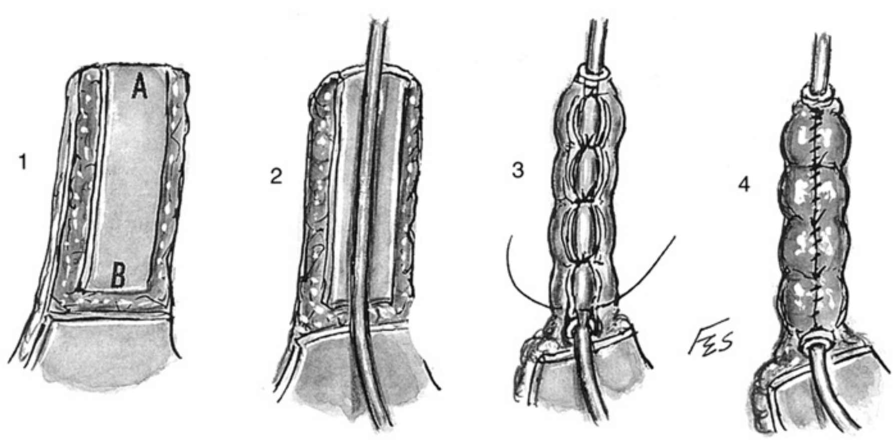
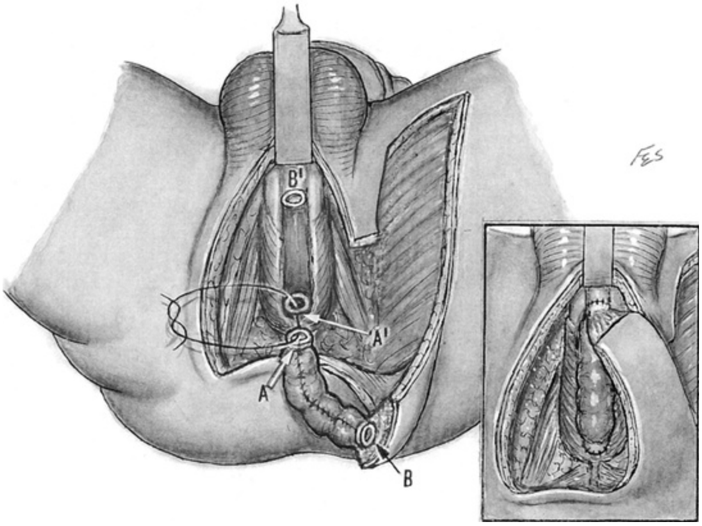
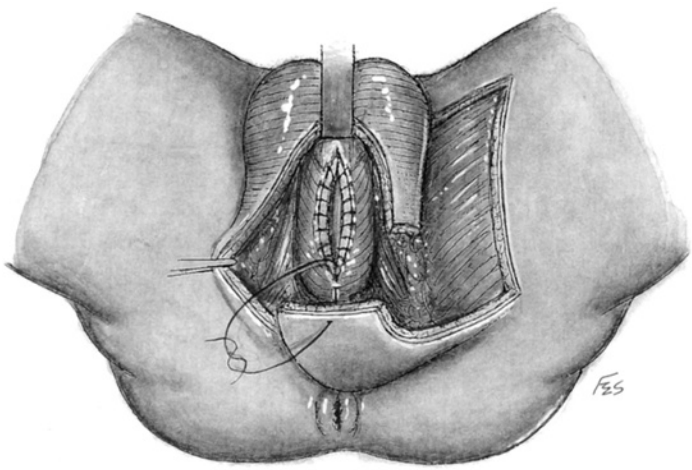


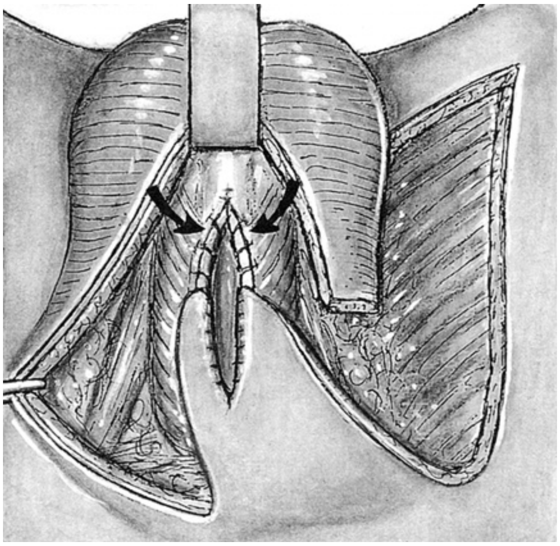
Fig. 19.7. An island is tubularized



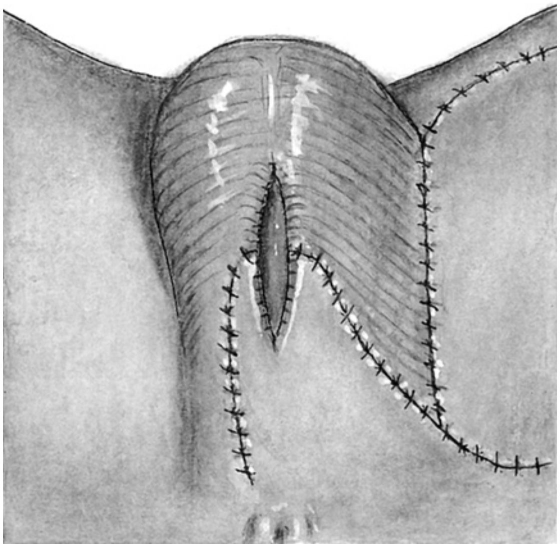
■ **Fig. 19.8.** The distal stoma of tube flap is sutured to the proximal apex with interrupted 3-0 Vicryl sutures



■ **Fig. 19.9.** A pudendal thigh flap is transferred to the proximal urethrotomy edge as a marsupialization first-stage procedure



■ **Fig. 19.10.** The flap used as perineal wound cover



■ **Fig. 19.11.** Completed first stage is monitored periodically by bougie calibration. The second stage is performed only when the two stomas are proved stable

Clinical Experience

From 1992 to the present, 13 patients ranging in age from 29 to 72 years have undergone urethral reconstruction using a perineal artery fasciocutaneous flap. The length of the stricture varied from 3 to 12 cm and follow-up ranges from 1 to 10 years. These strictures were located uniformly in the proximal bulbomembranous and prostatomembranous urethra. Seven patients underwent an onlay island patch flap. Five of these were referred after several prior failed repairs, and two patients had been treated with radiation therapy for carcinoma of the prostate. Two of these patients required combined addition of a buccal graft onlay. Four patients underwent one-stage tube flap proximal urethral interposition for post-traumatic 6- to 8-cm urethral gaps. One of these was restrictured and underwent a multistage marsupialization procedure without a second stage. Two patients have been managed by a first-stage procedure, one for a radiation stricture and a distal urethrectomy, and one for an extensive stricture with transmembranous component that worsened with massive perineal fibrosis after 12 prior failed attempts at reconstruction.

There were no fistulas, diverticula, or problems with wound healing. Two patients experienced a transient anterior compartment syndrome, and two patients required drainage and antibiotics for a donor-site wound infection. A hematoma developed in one flap under its medial border, but no loss of skin or the onlay island was encountered.

Conclusion

The Singapore or perineal artery flap is a medial thigh sensate, axial-patterned fasciocutaneous flap based on the terminal branches of the internal pudendal artery. It is a reliable extragenital skin flap that has the potential of salvaging a subset of complex proximal bulbomembranous and prostatomembranous strictures and urethral segmental loss that are not suitable for grafts or genital flaps. It is a thin, pliable flap that is simple in design and easy to harvest with consistent, well-defined borders. It is frequently nonhirsute with a robust, reliable pedicle, and it is transferred readily to the proximal urethra without tension. The donor site creates no significant morbidity of skin loss or deformity and lends itself to primary closure without the need for covering skin grafts. Patients with proximal urethral radiation strictures after therapy for prostate, urethral, and rectal carcinoma are candidates for repair with this easily elevated flap since the radiation does not preclude its use.

References

1 Zinman L (1997) Perineal artery axial fasciocutaneous flap in urethral reconstruction. Atlas of Urol Clinics North Am 5:91–107
2. Wee JTK, Joseph VT (1989) A new technique of vaginal reconstruction using a neurovascular pudendal thigh flap: a preliminary report. Plast Reconstr Surg 83:701–709
3. Ponten B (1981) The fasciocutaneous flap: its use in soft tissue defects of the lower leg. Brit J Plast Surg 34:215–220
4. Cormack GC, Lamberty BG (1984) A classification of fasciocutaneous flaps according to their patterns of vascularization. Brit J.Plast Surg 37:80–87
5. Goldwyn RM (1977) History of attempts to form a vagina. Plast Reconstr Surg 59:319–329
6. Morton KE, Davies D, Dewhurst J (1986) The use of the fasciocutaneous flap in vaginal reconstruction. Br J Obstet Gynecol 93:970–973
7. Hagerty RC, Vaughn TR, Lutz MIJ (1988) The perineal artery axial flap in reconstruction of the vagina. Plast Reconst Surg 82:344–345
8. Giraldo R, Solano A, Mora MJ (1996) The Milaga flap for vaginoplasty in the Mayer-Rokitansk-Kuster-Hauser syndrome: experience and early term results. Plast Reconst Surg 98:305–312
9. Tzarnas CD, Raezer OM, Castillo OA (1994) A unique fasciocutaneous flap for posterior urethral repair. Urology 43:379–381
10. Monstrey S, Blondel P, Van Lanphy TK, Verpaele A, Tonnard P Matton G (2001) The versatility of the pudendal thigh fasciocutaneous flap used as an island flap. Plast Reconst Surg 107:719–725

Anterior Urethral Stricture Repair and Reconstruction in Hypospadias Cripples

*F. Schreiter, B. Schönberger**

* Professor Schönberger has died since this chapter was completed.

20.1 Introduction

Anterior urethral strictures may involve the Fossa navicularis, the pars pendulans of the urethra, and part of the bulbar urethra. This strictures can be caused by inflammatory disease, including lichen sclerosis or balanitis xerotica obliterans (BXO) of the corpus spongiosum (1), traumatic scarring after a blunt trauma or traumatic catheterization, long-term indwelling catheter treatment, and forced bougienage, as well as congenital anomalies (hypospadias, epispadias), and hypospadias resulting from multiple previous reconstructions. The use of scrotal or genital skin can lead to hair-growing, inflammation, stone formations, and diverticula.

Since the use of buccal mucosa [8] was included in urethral stricture repair, the tendency has clearly gone from pedicle flap procedures [4–7] to a one-stage free graft repair.

Free preputial grafts of the inner sheet of the foreskin – a moist full-thickness skin graft lacking of hair follicles – seems to provide similar good long-term results. [2] The easy handling of the harvesting and transfer of the grafts that are free of hair may be the greatest advantage.

Hypospadia patients (Fig. 20.1A, B) or patients who have undergone multiple previous procedures of urethral reconstruction develop severe scarring and present an operative challenge. The problems develop from the absence of healthy tissue that can be used for urethral reconstruction. In those cases, a two-stage procedure is recommended, which can either be performed by using buccal mucosa in a two-stage procedure [3] or using a free split skin graft, the so-called two-stage mesh graft procedure [7].

20.2 Patient Preparation for Surgery

The day before surgery, a complete bowel preparation should be performed. A special liquid diet is favorable. On the day of surgery, the genital area and the perineum are shaved.

20.3 Instruments

Fine surgical instruments are used as well as magnifying glasses 1:2.5–3.5; dilatation set up to 30 Fr; Bipolar electrocoagulation; submucosal injection (adrenaline 1:100,000); Scott retractor; cystoscope; suture material 4-0 to 6-0 absorbable; and nonadhesive wound dressing.

Fig. 20.1A, B. Hypospadia patients having undergone multiple surgical reconstructions (lack of skin and hair, and stone formations)

20.4 Surgical Procedures According to the Type of Stricture – Step by Step

20.4.1 One-Stage Meatoplasty

20.4.1.1 Buccal Mucosa or Foreskin Graft Urethroplasty

Indications include short meatal stricture within the glans penis or hypospadia meatal stenosis.

- Meatal stricture (Fig. 20.2A)
- The stricture is fully opened (Fig. 20.2B)
- A buccal mucosa graft (if available) is harvested from the lower lip or the cheek. If foreskin is available it can be harvested from the inner sheet as well (Fig. 20.2C).
- The graft is sutured to the left rim of the opened navicular fossa.
- The graft is rotated over the urethral plate and sutured to the right rim of the glandular urethra with the mucosal or epithelial surface looking to the urethra (Fig. 20.2D).
- The glans is closed over the graft and a 20-Fr catheter or silicon stent is left in place for 10 days (Fig. 20.2e).

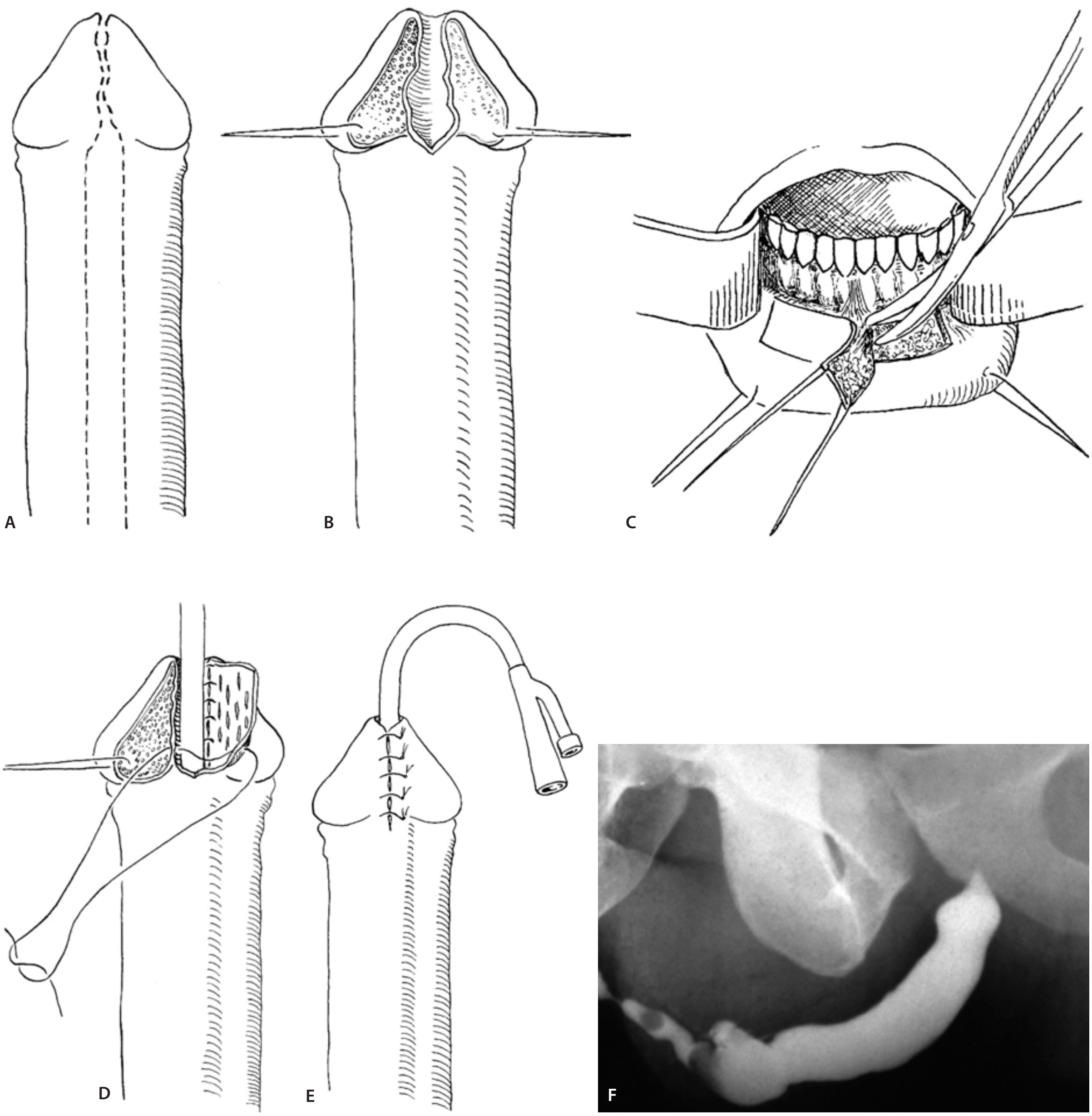


Fig. 20.2. **A** Meatal stricture. **B** Opening of the meatal stricture until the healthy spongious tissue is reached. **C** Harvesting of buccal mucosa. **D** Suturing the graft to the urethral rim on both sides. **E** The glans is closed over the graft.

20.4.2 Pedicled Flap Urethroplasty (Jordan)

The flip-flap technique (Jordan flap) gives excellent cosmetic and functional results. This technique is used for meatal strictures extending beyond the glans penis (▫ Fig. 20.3).

- The flap is prepared crosswise on the ventral side of the distal penile shaft (▫ Fig. 20.3A).
- Open the stricture until healthy tissue of the corpus spongiosum is reached (▫ Fig. 20.3B).
- The pedicle has to be prepared as long as the flap can be rotated 90 degrees (▫ Fig. 20.3C).
- The rotated flap is sutured to rim of the urethral plate (▫ Fig. 20.3D).
- The penile shaft skin is sutured over the Jordan flap using a asymmetric penile skin flap (Bayars) (▫ Fig. 20.3E).
- Or, if possible, the edges of the glans are sutured over the Jordan flap (▫ Fig. 20.3F).

20.4.3 Pedicled Penile Flap Urethroplasty (Quartey-Orandi-Devine)

This technique is recommended in patients with extended penile strictures with or without stricture of the fossa navicularis. Enough penile skin has to be available. This technique is especially used for patients who wish to avoid harvesting of buccal mucosa and in circumcised patients. A transverse penile skin flap can be prepared with a long vascularized pedicle that can be rotated 90 degrees and can also be pulled through underneath the scrotum to reach the bulbar urethra (Quarty-technique). A longitudinal penile flap (Orandi-Devine) is easy to prepare with a short pedicle that allows the flap to be rotated with its epithelial surface to the marsupialized urethral plate.

20.4.3.1 The Quartey Technique

- Midline incision in the raphe of the penis and degloving the penile skin. (▫ Fig. 20.4A).
- Transverse dissection of the penile flap (▫ Fig. 20.4B).
- Careful dissection of the tunica dartos pedicle between the two layers of penile skin vessels (▫ Fig. 20.4C).
- Splitting of the strictured urethra (▫ Fig. 20.4D).
- Trimming of the flap to the length of the stricture and suturing first to the left rim of the stricture and thereafter to the right side of the stricture over a 20-Fr indwelling catheter (▫ Fig. 20.4E).
- Covering of all suture lines with the tissue of the tunica dartos (▫ Fig. 4F).
- The penis is covered with the outer penile skin (▫ Fig. 20.4G).
- For repair of bulbar strictures, the long pedicled flap is pulled through the under side of the scrotum (▫ Fig. 20.5A, B)
- The flap is sutured to both rims of the opened urethral stricture using a running 5-0 resorbable suture material (▫ Fig. 20.5C).
- The tissue of the pedicle (tunica dartos) is used to cover the sutures of the flap to prevent fistulae (▫ Fig. 20.5D).
- Covering the bulbocavernosus muscle and closure of the wound (▫ Fig. 20.5E).

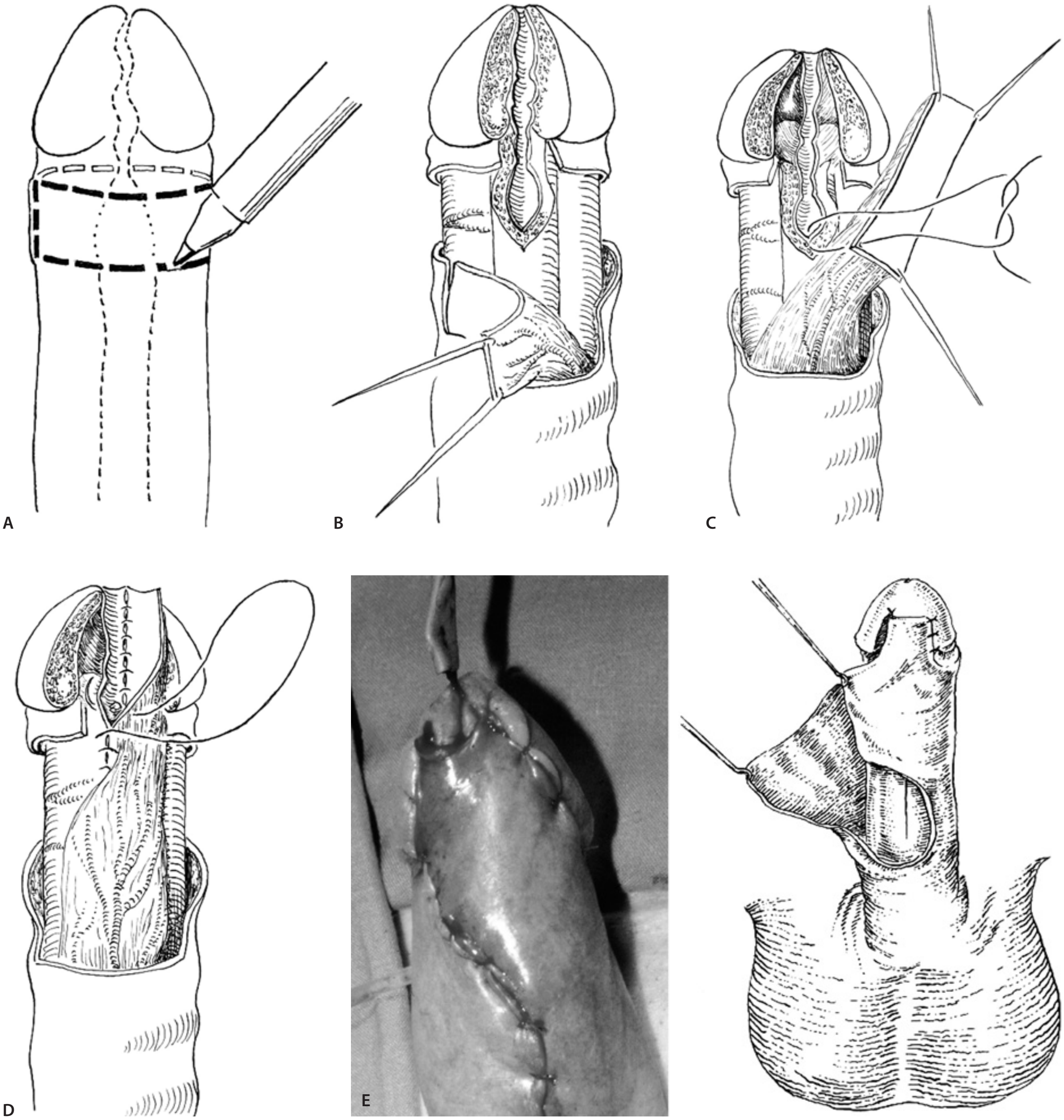
20.4.3.2 The Orandi-Devine technique

- Peritomy of the flap in the middle of the penile shaft. For long strictures the flap can be lengthened by cutting the flap further on subcoronarially. (▫ Fig. 20.6A).
- A short pedicle is prepared so that the rotation of the flap is without tension (▫ Fig. 20.6B).
- The flap is rotated and sutured to the rim of the strictured urethra on both sides (▫ Fig. 20.6C, D).
- The tunica dartos is sutured over the flap to cover all suture lines and prevent fistulae (▫ Fig. 20.6D).
- The skin is covered over the flap. Sometimes a rotated Byars flap is necessary to reconstruct the skin (▫ Fig. 20.6E).

20.4.4 Dorsal Buccal Mucosa Graft (Barbagli)

This technique is suggested for repairing of penile urethral strictures only in patients with normal corpus spongiosum of the urethra In anterior strictures, it is seldom used)

- Total stripping of the penile skin including the tunica dartos (▫ Fig. 20.7A).
- Ventral opening of the corpus spongiosum to the healthy tissue. Incision of the urethral plate in the midline dorsally and mobilization of the lateral wings of the urethral plate (▫ Fig. 20.7B).
- The gap of the urethral plate is covered using a buccal mucosa or free preputial graft using 6-0 interrupted resorbable sutures. (▫ Fig. 20.7C).
- Over a 20-Fr catheter, the corpus spongiosus is sutured (▫ Fig. 20.7D).
- The glans and the penile skin are closed covering the urethra with the dartos tissue underlying the penile skin. (▫ Fig. 20.7E).



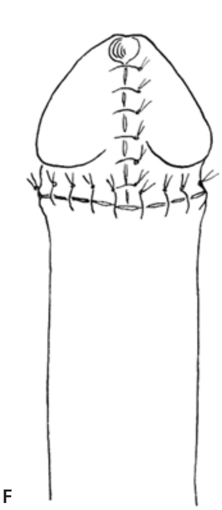
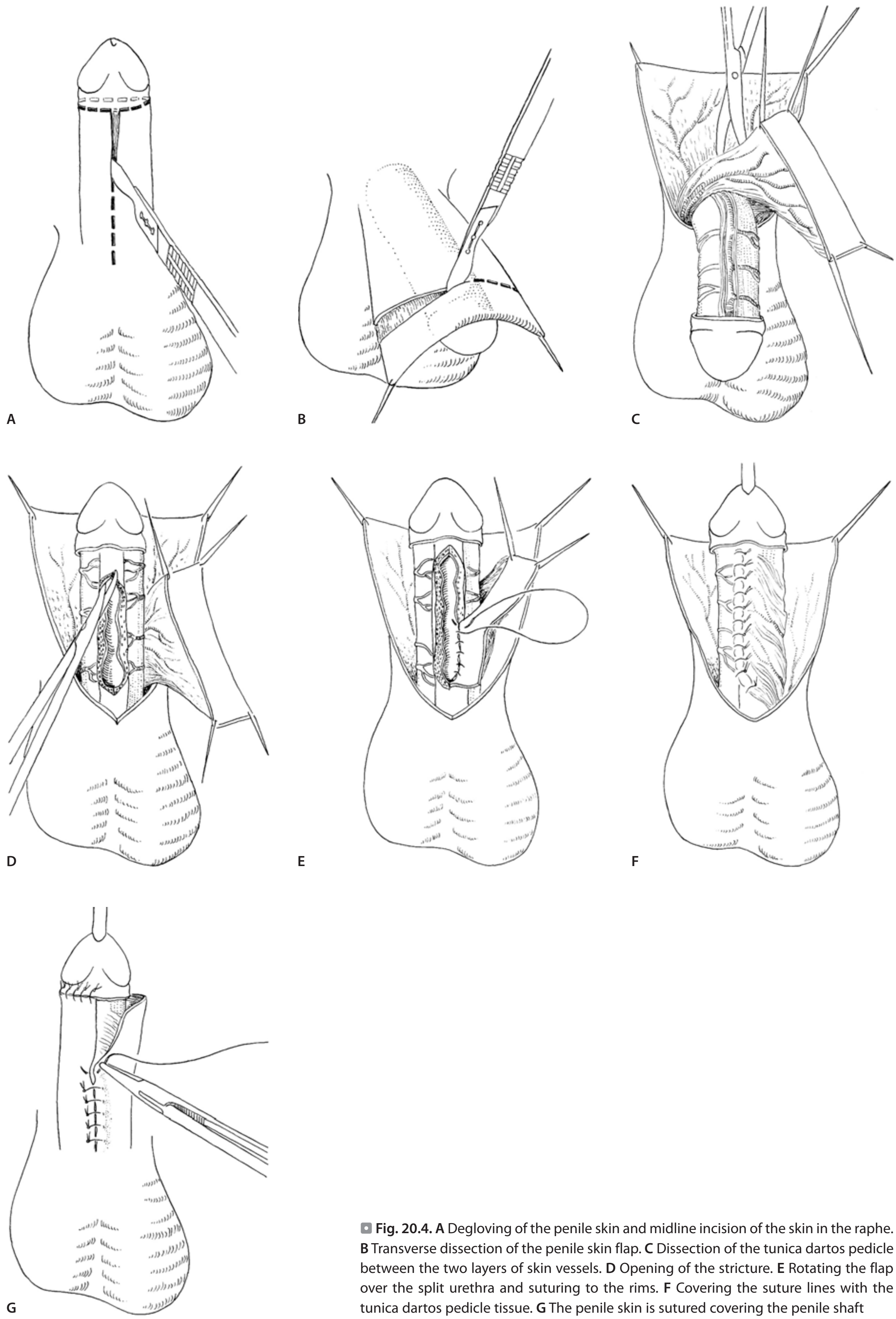


Fig. 20.3A–F. Anterior stricture including the meatal part of the urethra. **A** Meatal plasty (Jordan). Preparation of a broad-based pedicled penile skin flap. **B** The skin island flap is elevated with a long pedicle. **C** The stricture is opened. **D** The flap is rotated and sutured to the rim of the urethra. **E** The penile skin and the glans is closed over the urethra using a Bayars flap. **F** If possible, the edges of the glans are covered over the flap and the skin sutured to the rim of the prepuce



■ **Fig. 20.4. A** Degloving of the penile skin and midline incision of the skin in the raphe. **B** Transverse dissection of the penile skin flap. **C** Dissection of the tunica dartos pedicle between the two layers of skin vessels. **D** Opening of the stricture. **E** Rotating the flap over the split urethra and suturing to the rims. **F** Covering the suture lines with the tunica dartos pedicle tissue. **G** The penile skin is sutured covering the penile shaft

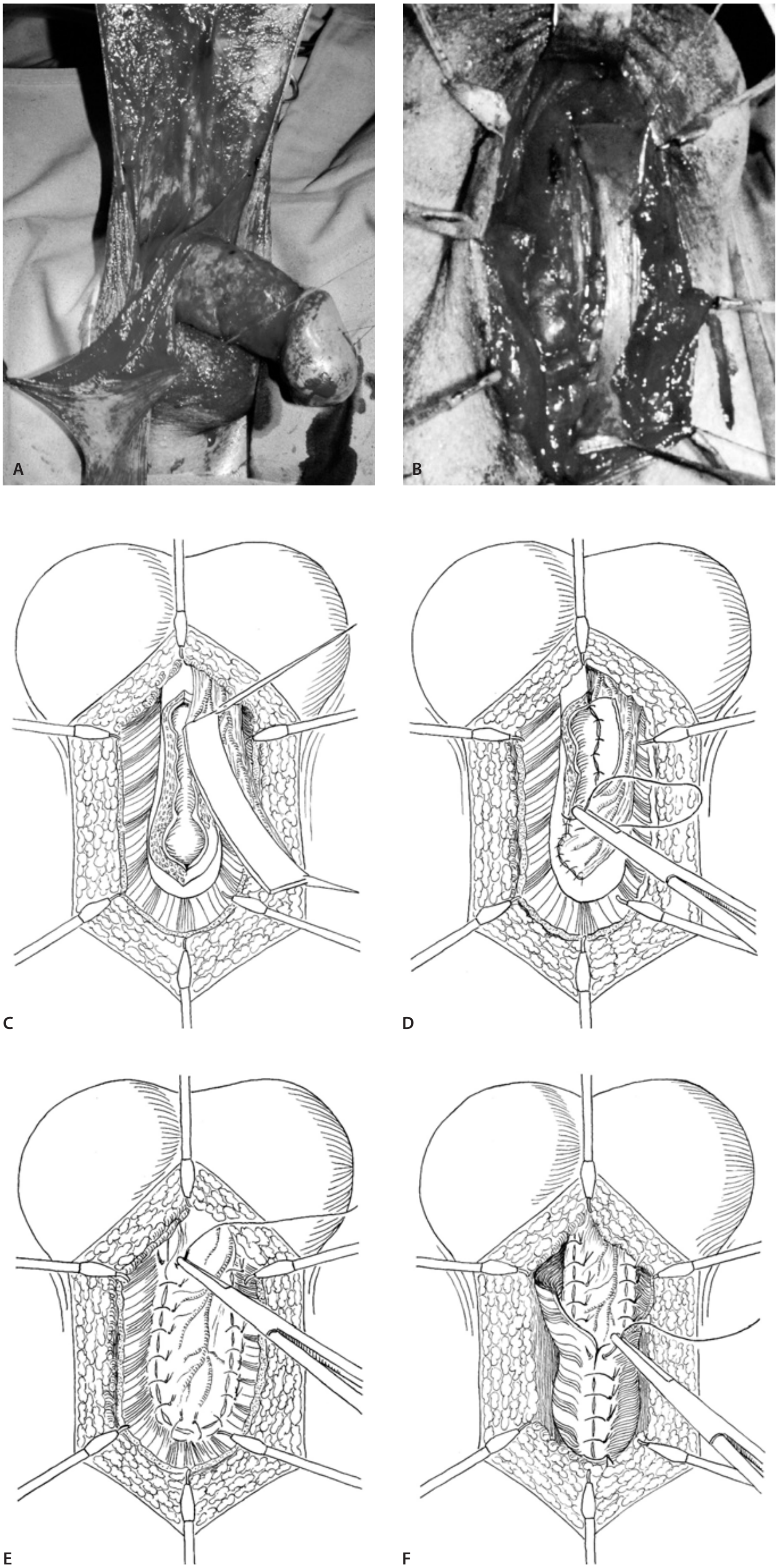
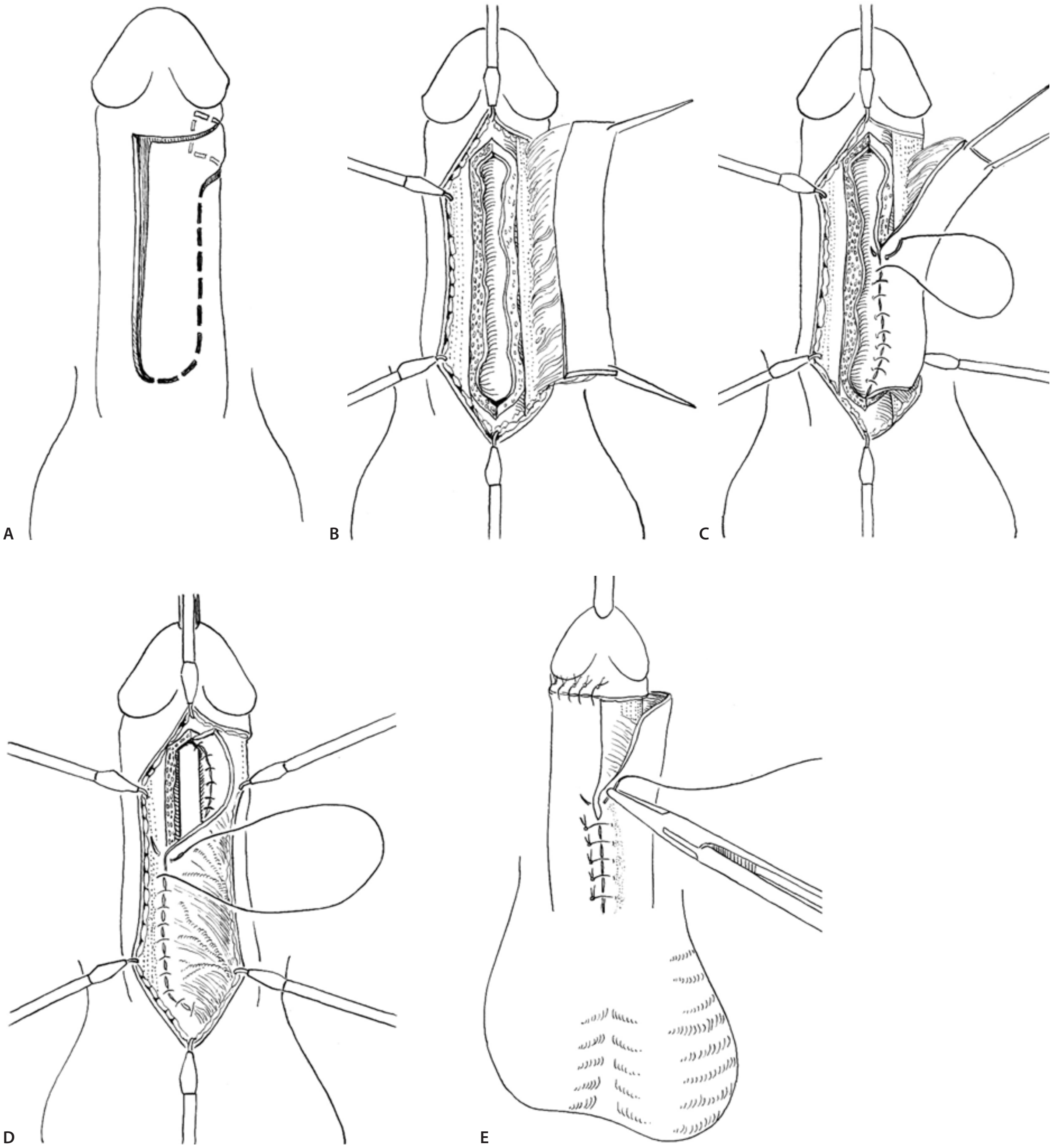


Fig. 20.5. A, B, C Bulbar stricture repair. Pull the flap through the undermined scrotum. **D** Suturing the flap to the rim of the opened stricture. **E** Covering suture lines with tunica dartos of the pedicle. **F** Urethra is covered by using the bulcocavernous muscle



■ **Fig. 20.6. A** Preparing a long penile skin flap, occasionally extended subcorneally. **B** Dissection of a short pedicle. **C** Rotating and suturing the flap to the rim of the urethra. **D** Covering the suture lines with tunica dartos. **E** Covering the penile skin over the flap

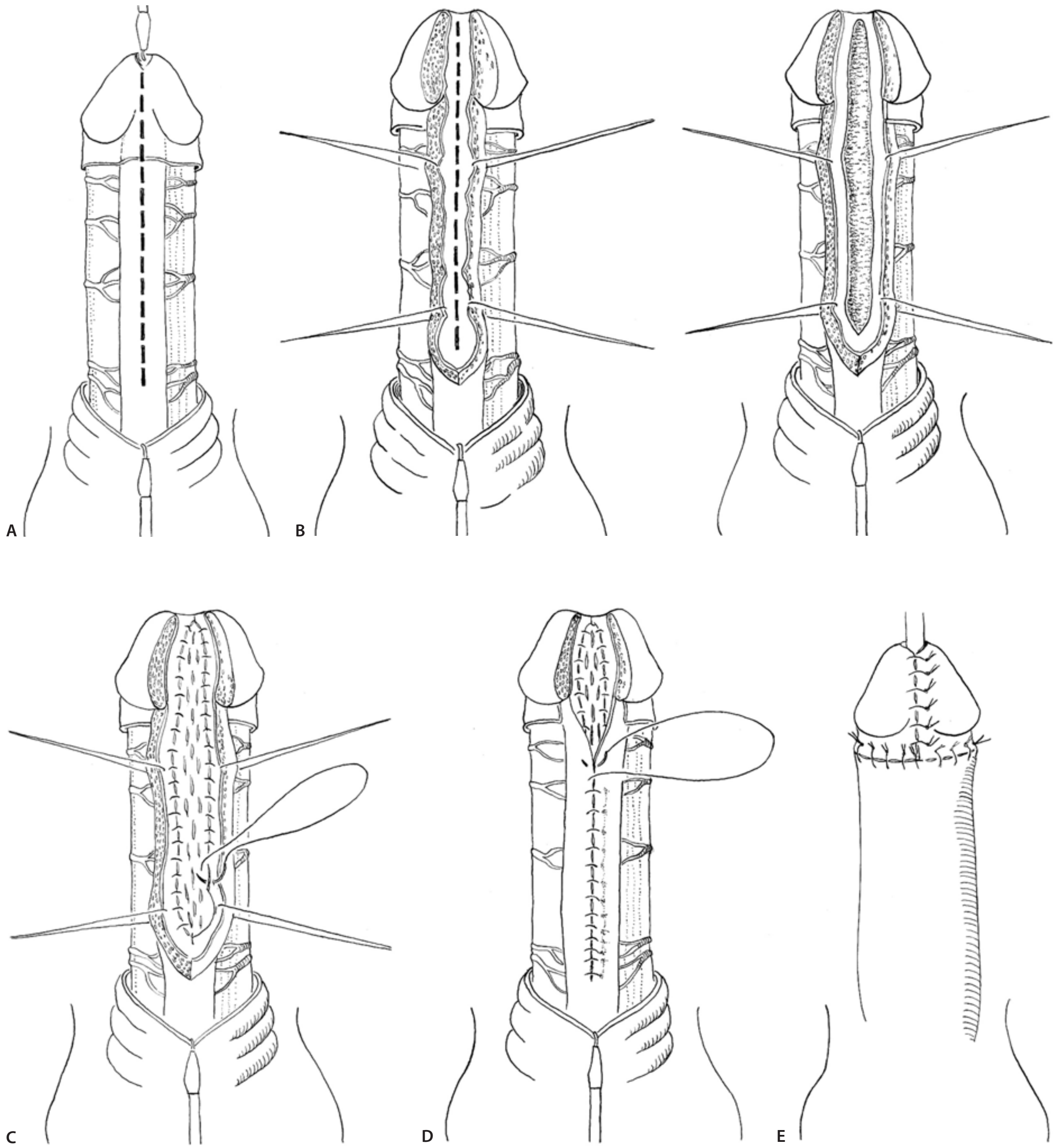


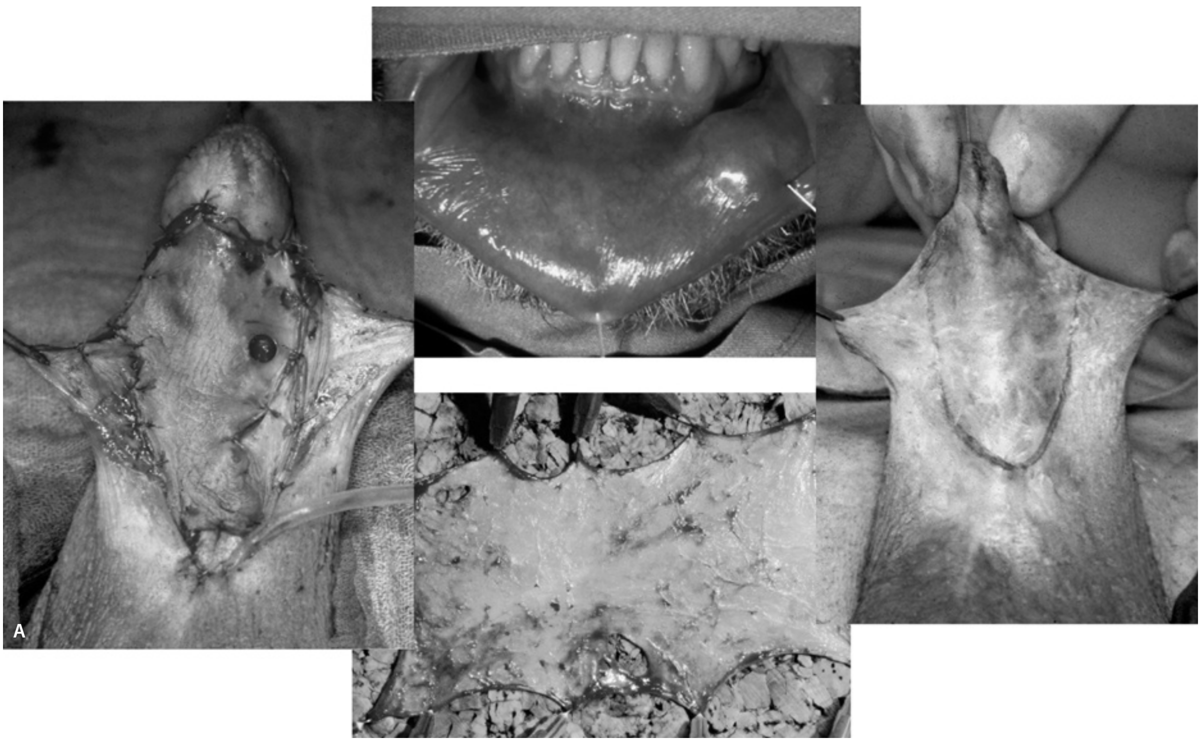
Fig. 20.7. A Degloving of the penile skin. The *dotted line* shows midline incision of the corpus spongiosum. **B** Opening of the urethra and incision of the urethral plate. **C** Suturing the graft into the split dorsal wall of the urethral plate. **D** Closing of the urethra. **E** Covering the urethra with the penile skin

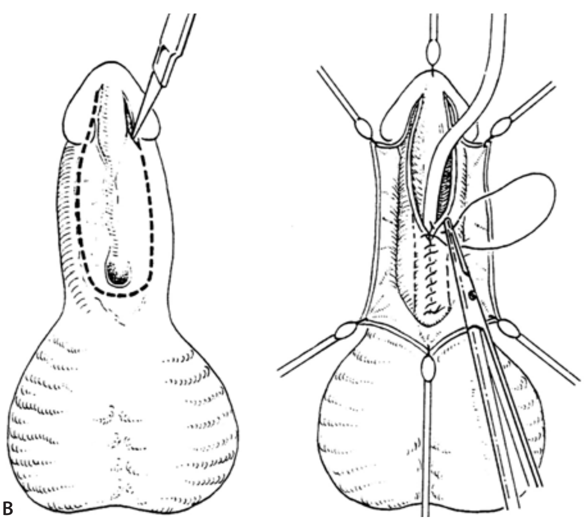
20.4.5 Two-Stage Buccal Mucosa Graft (Brakka)

This technique is recommended in patients with hypospadia features and strictures based on Lichen sclerosis (BXO) where the urethral plate is absent or has to be removed completely. With this technique, a complete replacement of the urethra is possible. In very long defects, the harvesting of buccal mucosa may be limited to the length of the stricture.

The two-stage mesh graft procedure may be become reasonable.

- In the first stage, the urethral plate is removed up to healthy tissue.
- A buccal mucosa graft is sutured into the defect covering the Buck fascia of the corpora cavernosa. The graft is fixed to the rim of the healthy penile skin.
- After 3–6 months, the first stage the graft is healed and stable (◘ Fig. 20.8A).
- A peritomy of the graft has to be done, the skin laterally and slightly mobilized and the neourethra sutured using 5-0 resorbable monophilic suture material (◘ Fig. 20.8B).
- The mobilized penile skin is sutured over the neourethra.
- No catheter is necessary; suprapubic urinary diversion is recommended.





◘ **Fig. 20.8. A** Removal of the urethral plate and grafting the defect with buccal mucosa. **B** Reconstruction of the neourethra from the graft

20.4.6 Dorsal Onlay Graft Urethroplasty (Barbagli)

This technique is recommended for rather short and bulbar strictures or strictures near the bulbar area of all origins. The advantage of this technique is a stable widening of the strictured urethra and the lack of diverticula formation.

- A midline perineoscrotal incision is made. The bulbocavernous muscle is split.
- The strictured part of the urethra is mobilized (Fig. 20.9A).
- The mobilized urethra is rotated 180 degrees (Fig. 20.9B).
- The stricture is opened dorsally (Fig. 20.9C).
- A buccal mucosa graft or a prepuce graft is trimmed to the length of the stricture and sutured to the Buck fascia of the corpora cavernosa (Fig. 20.9D).
- The rim of the opened urethra is sutured splayed and quilted to the rim of the graft using 6-0 resorbable suture material (Fig. 20.9E).

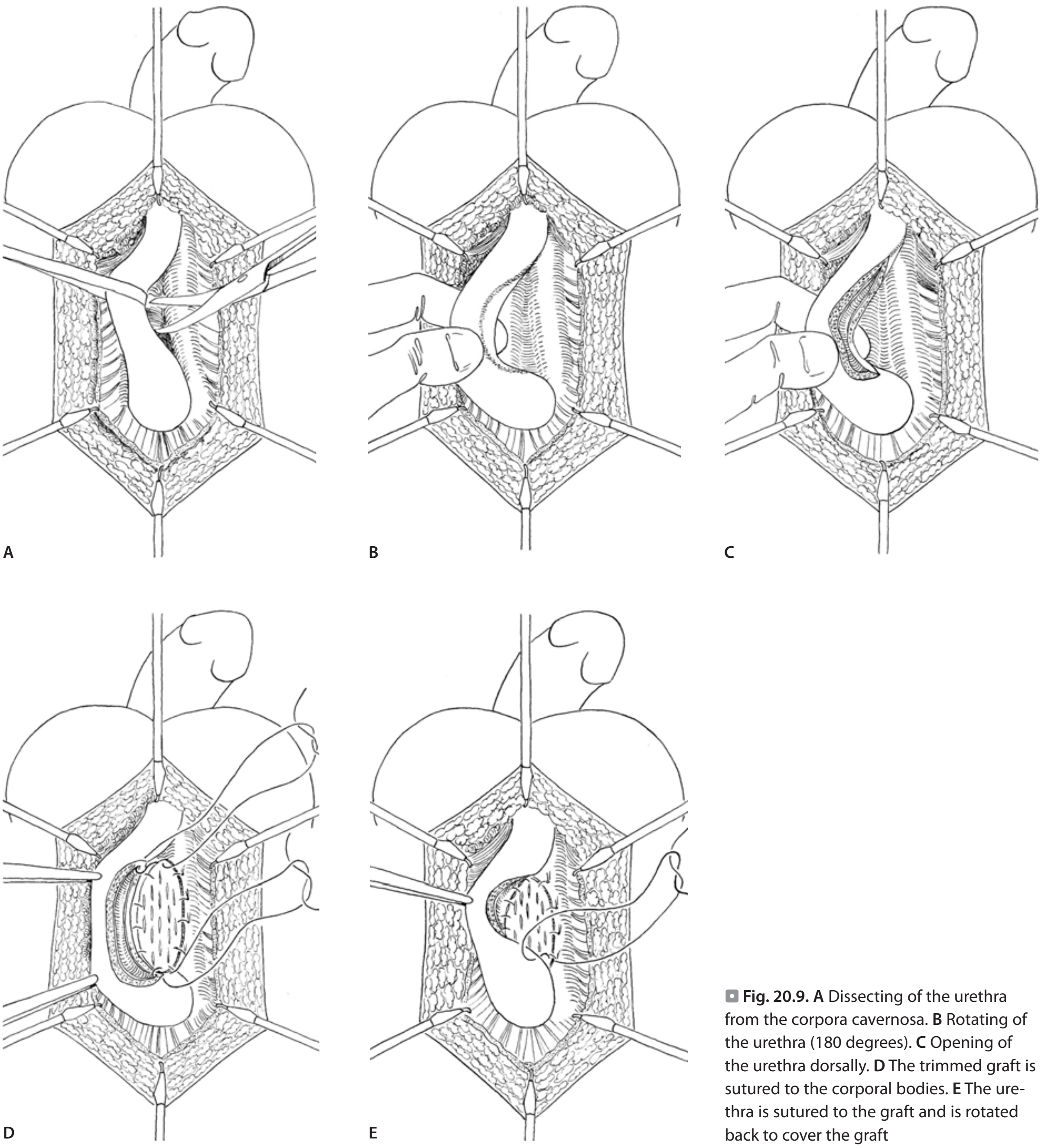


Fig. 20.9. A Dissecting of the urethra from the corpora cavernosa. **B** Rotating of the urethra (180 degrees). **C** Opening of the urethra dorsally. **D** The trimmed graft is sutured to the corporal bodies. **E** The urethra is sutured to the graft and is rotated back to cover the graft

20.4.7 Dorsal Augmented Anastomotic Urethroplasty

This procedure is indicated for strictures in the bulbar or penile urethra that are too long for simple anastomotic repair.

- A penile or perineoscrotal incision is made and the bulbocavernous muscle split. The beginning of the stricture is located using a bougie (Fig. 20.10A).
- The urethra is mobilized and dissected totally. The urethra edges are freed from the corporal bodies (Fig. 20.10B).
- The urethral stumps are spatulated (Fig. 20.10C).
- A buccal mucosa graft or prepuce skin graft is sutured to the rim of the spatulated distal stump and fixed to the corporal bodies (Fig. 20.10D).
- The distal spatulated stump is rotated 180 degrees to cover the graft and the spatulated distal stump and sutured using 6-0 resorbable suture material (Fig. 20.10E).
- At the end of the procedure, the grafted area is covered entirely by the urethra. A 20-Fr catheter is left for 3 weeks (Fig. 20.10F).

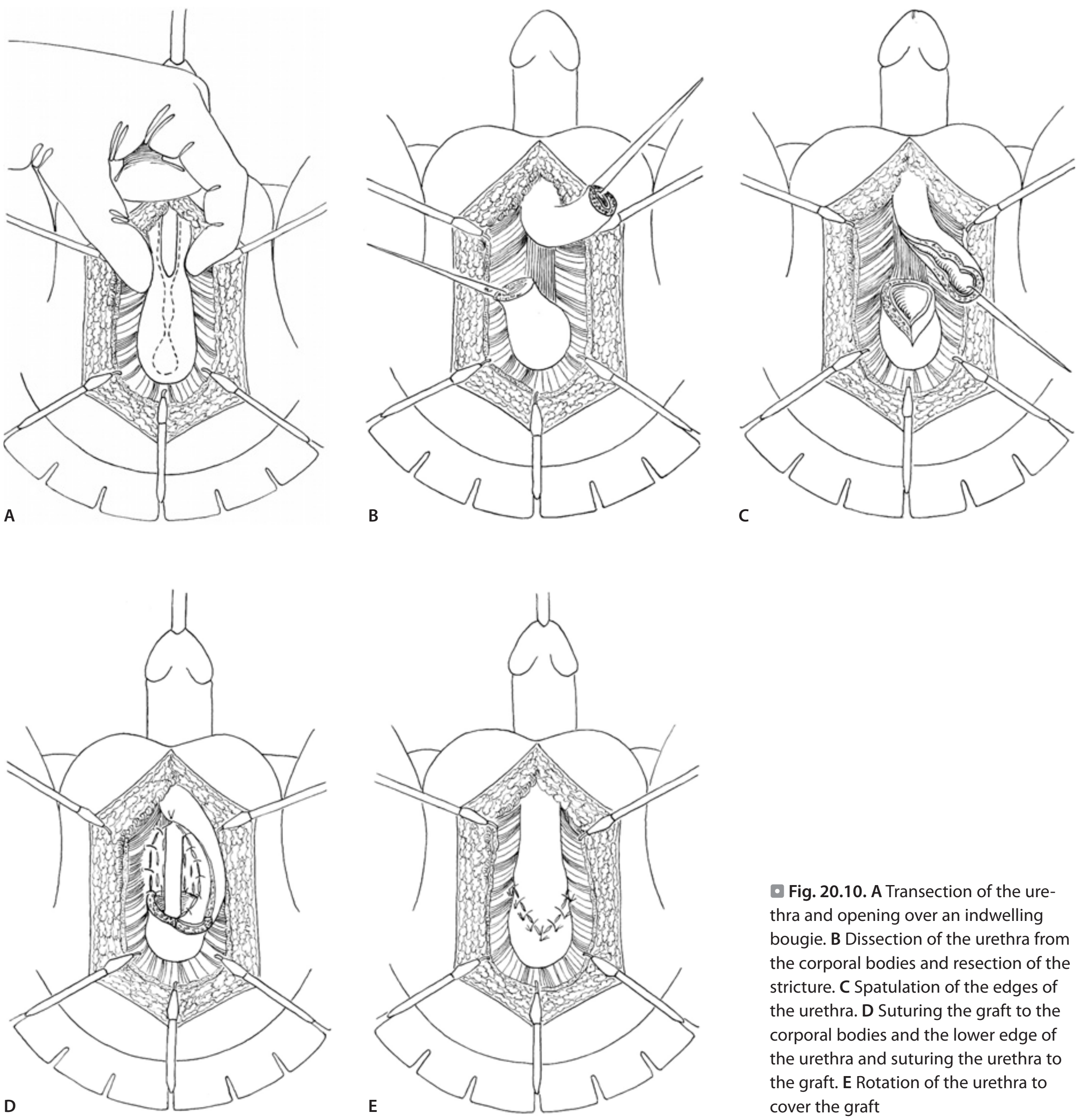


Fig. 20.10. A Transection of the urethra and opening over an indwelling bougie. **B** Dissection of the urethra from the corporal bodies and resection of the stricture. **C** Spatulation of the edges of the urethra. **D** Suturing the graft to the corporal bodies and the lower edge of the urethra and suturing the urethra to the graft. **E** Rotation of the urethra to cover the graft

20.5 Tips and Tricks

To prevent major complications the following tips and tricks should be observed:

- Use fine or microsurgical instruments.
- Use magnifying glasses.
- Always prepare the stricture until healthy tissue of the corpora spongiosus is reached.
- Mobilize the urethra widely over the length of the stricture. This is most important in anastomotic repair.
- Do not underestimate the length of the stricture. In urethrograms they look shorter than they are. Use additional diagnostic procedures such as combined MCU and retrograde urethrogram as well as ultrasound using a 10-MHz probe. Ultrasound is the best method to visualize the length of the spongiofibrosis.
- Put the patient in the right position on the operating table: the lithotomy position for all bulbar strictures and the flat position for distal strictures. Be aware that sometimes the patient's position must be changed in cases where there is a change from a distal procedure to a proximal part of the urethra.
- Take into account free transplanted graft shrinkage, which can be as much as 30%.
- Take special care for the dressing. The dressing should be removable easily (fatty gauze or other nonadhesive wound dressing).
- Do not remove the dressing before the 5th day. In two-stage procedures, dressings should not be removed before the 10th day.

In postoperative care, the recommendations below should be followed:

- Keep urine sterile during the early postoperative period.
- Avoid moving the patient.
- Remove dressing gently and carefully.
- Remove catheter or suprapubic tube not before the urethra is watertight as shown in a retrograde urethrogram or voiding micturition cystogram.

20.6 Possible Complications

In general, penile urethroplasties more than anastomotic reconstructions are intrinsically susceptible to complications such as hematoma, infections, or fistula, and especially in enlarged flap procedures they are susceptible to disturbances of blood circulation of the outer skin. Following the shrinkage of the flaps and grafts, the penis can require torsion or curvature. Alteration of sexual function may also occur. This is less frequent with buccal mucosa grafts. It is not recommended to use buccal mucosa as a circular tube. This would lead to more failure. As the use of genital or extragenital skin mainly fail in cases of Lichen sclerosis, the use of buccal mucosa is mandatory as skin graft can become infected from the underlying disease.

20.7 Remarks

Free flap procedures in urethral reconstructive surgery are easier to perform than flap procedures. The complication rate is lower and the free graft procedures requires no extensive training in tissue transfer procedures as flaps do. If the long-term results reach our expectations, the free buccal mucosa graft will predominate over the penile flap. However, the question of when to use a free graft procedure or a more difficult flap or two-stage procedure cannot be answered definitively today. The surgeon who is involved in urethral reconstructed surgery must have all choices of surgical techniques available, adapted to the complexity, etiology, size, and location of the stricture.

References

1. Barbagli G, Palminteri E, Lazzeri M, Turini D (1999) Lichen sclerosus of the male genitalia involving anterior urethra. Lancet 354:429
2. Barbagli G, Selli C, Tosto A, Palminteri E (1996) Dorsal free graft urethroplasty. J Urol 155:123–126
3. Brakka A (1995) Hypospadia repair: the two stage alternative. Brit J Urol 76:31–41
4. Jordan GH (1987) Reconstruction of the fossa navicularis. J Urol 138:102–104
5. Jordan GH, Devine PC (1989) Surgery following the failed urethral reconstruction. In: Scott McDougal W (ed) Difficult problems in urologic surgery. Yearbook, Chicago, pp 289–309
6. Quartey JKM (1985) One-stage penile/preputial island flap urethroplasty for urethral stricture. J Urol 134:474
7. Orandi A (1972) One-stage urethroplasty: 4 years follow-up. J Urol 107:977–980
8. Schreiter F (1997) The two-stage meshgraft urethroplasty using split-thickness skin. Atlas Urol Clin N Am 5:104–108
9. Stein R, Fichtner J, Fillipas D, Hohenfellner R (1999) Harnröhrenrekonstruktion mit Mundschleimhaut. Akt Urol 30:287–294

The Use of Free Grafts for Urethroplasty

D.E. Andrich, A.R. Mundy

21.1 Introduction

Apart from isolated reports, substitution urethroplasty really began in the 1940s with Humby [1]. He used full-thickness skin grafts for urethral reconstruction, hypospadias, and urethral strictures and also described the first recorded case of buccal mucosal graft urethroplasty. After him, sporadic cases were reported in the British, European, and American literature. By the mid-1960s grafts were in regular use for urethral reconstruction for both hypospadias and strictures. The foremost proponents were Devine and Horton from Norfolk, Virginia, USA [2]. They and others continued with graft repairs into the 1970s, but by then Yaxley [3] and others began developing flap repairs. Most notable were Turner-Warwick [4] and Blandy [5] for the repair of urethral strictures in adults and Duckett [6] for the repair of hypospadias in children.

The prevailing view seemed to be that a flap was more reliable because it carried its own blood supply, although this was never proved. Quartey [7] studied the vascular basis of flap repair and through the 1980s and early 1990s flap repairs dominated genital reconstructive surgery until the Mainz group reintroduced buccal mucosal free grafts [8]. This led to a resurgence of interests in graft repairs – whatever the material used – so at the beginning of the 21st century, free grafts have regained their place in the reconstructive urologists armamentarium.

21.2 Grafts Versus Flaps

The flaps used in urethral reconstruction are random island flaps of penile or scrotal skin carried on a dartos pedicle – random, because there is no defined artery supplying them and so for the skin paddle to remain viable, an extensive dartos pedicle must be created. The disadvantage with a flap repair is that it is time-consuming (and tedious) to harvest the flap and the dissection is extensive. This produces scarring and loss of the normal contour of the penis when its dartos layer has been redeployed from part or all of its circumference.

Grafts are inherently less reliable – in theory – because they have to be revascularized. On the other hand, they are quick and relatively easier to harvest and deploy.

There are numerous short- and mid-term follow-up studies of both grafts and flaps, which essentially show about the same restricture rates [9]. In other words, there is no real difference between grafts and flaps in terms of their restricture rate and therefore unless there is a positive indication or contraindication for one or the other, the simplicity and speed by which a graft can be harvested and deployed means that this is the procedure of choice as far as we are concerned.

Positive indications in favor of a flap rather than a graft include some instances of revision surgery; any cause of local devascularization such as radiotherapy (or severe peripheral vascular disease); and local infection – all of which interfere with the ability of a graft to take.

21.3 The Principles of Grafting

Graft »take« occurs in two phases, each of which lasts about 2 days. The first phase is imbibition in which the graft is kept alive by absorbing nutrients from the plasma oozed from the surface of the graft bed. The second phase is inosculation in which the microvasculature of the graft bed links up with the microvasculature exposed on the under surface of the graft. Clearly the process leading to inosculation begins during the imbibition phase, but for the viability of the graft itself the two phases are distinct.

By the 5th day after grafting, the graft has either taken or has sloughed off. For the graft to take it must be kept in close contact with the recipient area (and not subject to either undue pressure or hematoma) and free of infection.

It is clearly an advantage if the graft has a dense plexus on its undersurface, and likewise the opposing surface of the recipient bed, to facilitate inosculation. It is an advantage if the graft is not too thick, as there is less bulk of tissue to be kept alive during the processes of imbibition and inosculation. For both these reasons, split-thickness grafts have an advantage over full-thickness grafts. A split-thickness graft is thin and depends for its take on the relatively dense intradermal plexus, which is exposed on its undersurface, whereas a full-thickness graft is substantially thicker and has to be inosculated through the subdermal plexus, which is much sparser.

On the other hand, a split-thickness graft tends to contract because of the relative absence of dermal collagen. A full-thickness graft, on the other hand, does not contract because the presence of a normal amount of dermal collagen inhibits the contraction process. Thus, if a take can be assured a full-thickness graft is much better than a split-thickness graft because it does not contract and therefore retains its natural characteristics.

The exceptions to the rule that full-thickness grafts have a rather sparse subdermal plexus are genital skin and skin from above the jaw line, including buccal mucosa. Not only do full-thickness grafts from these areas have a particularly dense subdermal plexus, but they are also thin when compared with skin from other sites. Skin from above the jaw line or from the genitalia therefore does well as a full-thickness skin graft. Few would sacrifice the skin of the face for urethral reconstruction but the skin from behind the ears (the post auricular Wolfe graft), buccal mucosa (applied as a full-thickness graft), and full-thickness grafts of penile and preputial skin are expendable within the limits of the amount usually required.

Grafts take best when they are applied as patches to place by the recipient graft bed. It is difficult to apply

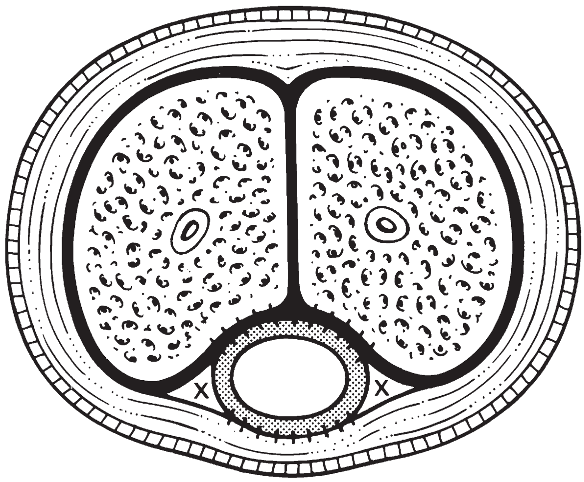


Fig. 21.1. This illustrates the problems of providing vascular support for a tubular free graft. Dorsally and ventrally (*hatched areas*) are well supported but laterally on each side (*X*) support is poor

a free graft as a tube because it is difficult to provide a supporting recipient bed equally all around the circumference of the tube and therefore ensure take (Fig. 21.1). Thus at 1–3 years of follow-up, the restricture rate of tube grafts is three times the restricture rate of patch grafts [10]. A complete circumferential reconstruction of the urethra is not commonly indicated except in the penile urethra, but when it is, it is therefore safer to apply the graft as a patch in the first instance and then to roll it into a tube as a second stage in order to achieve the lowest possible long-term restricture rate.

21.4 Summary of Principles

In short, there is no significant difference in terms of cure of the stricture between a graft repair and a flap repair but a graft repair is generally quicker and easier and so a graft is best unless there is a positive indication for a flap.

Full-thickness grafts contract less and retain their characteristics better than split-thickness grafts and so full-thickness grafts should be used whenever possible.

The best sources of material for a full-thickness graft are the postauricular skin, buccal mucosa, and penile and preputial skin.

Patch grafts do better than tube grafts and so when a circumferential reconstruction of the urethra is required, it is best to do it in two stages.

21.5 Urethroplasty Using Free Grafts

There is little or no place for substitution urethroplasty in the posterior urethra and this will not be discussed further.

21.6 Bulbar Urethroplasty

The vast majority of bulbar urethral strictures are fairly straightforward strictures in which a one-stage repair is possible. These were (and, by some surgeons, still are) commonly repaired with a preputial/penile skin flap. These days, a graft of buccal mucosa or full-thickness penile shaft skin is more commonly used. Until recently, the bulbar stricture was opened on its ventral aspect and the graft (or flap) was sewn in ventrally to close the defect. Recently, Barbagli [11] has introduced the dorsal stricturotomy and patch as the dorsal siting of the graft provides better support, with a better vascular bed and better long-term stricture-free survival as a consequence. A particular problem of a ventral patch was out-pouching of the patch because of lack of support. This in turn led to postmicturition dribbling, postcoital pooling of semen and a variety or irritative symptoms in addition. In this regard, a ventral buccal mucosal graft – being tougher than skin – gives better results than a ventral skin graft. With a dorsally placed stricturotomy and patch, there is probably no difference between the two [12].

There are still a few occasions when a two-stage bulbar urethroplasty is indicated: with grossly infected strictures; after excision of tumors; amyloid disease or vascular malformations of the urethra; or after excision of a Urolume stent, all of which will leave a defect that will need to be circumferentially reconstructed. Such reconstructions, as already argued, are best done in two stages. Here a graft can be placed between the two ends of healthy urethra with a scrotal funnel sutured to the margins of the graft and the proximal and distal urethrostomies. The graft is then rolled into a tube at a second stage.

21.7 Penile Urethroplasty

Simple strictures of the penile urethra are probably best treated by a one-stage flap procedure such as the Orandi flap [13].

Unfortunately, simple strictures of the penile urethra are not that common. Many are caused by either previous hypospadias repair or to lichen sclerosus (balanitis xerotica obliterans, BXO) which will usually require excision of the urethra [14]. In lichen sclerosus, this is almost always the case. In hypospadias retrieval surgery, it is less commonly necessary and indeed if the natural urethral plate is still present and can be preserved, then it should be preserved.

Lichen sclerosus is a disease of genital skin and therefore repairs using genital skin almost always lead to restricturing. Nongenital skin is less affected and so, for example, a postauricular Wolfe graft is much less likely to lead to restricturing but still occurs in approximately 30%–40% of cases. Buccal mucosa rarely suffers lichen sclerosus and so a buccal mucosal free graft should probably be used as the material of choice for the reconstruction of the urethra after excision for this disease.

Reconstruction of a previously failed hypospadias repair is not subject to this proviso. The only requirement is for sufficient skin for the repairs. If this can be harvested locally, all is well and good, otherwise a postauricular Wolfe graft provides the best material.

21.8 Points of Technique

Quilt the graft in position. This ensures fixation; provides drainage holes for any hematoma or seroma; and guarantees take at the site of each quilting stitch (and therefore of the whole graft).

In staged reconstructions, quilt the graft directly on to the tunic albuginea in the mid-line and 0.5 cm or so on either side. More laterally on each side, incorporate some dartos with the quilting stitch (Fig. 21.2). This will make the edges of the graft easier to mobilize at the second stage (Fig. 21.3).

At the second stage, don't over-mobilise the two edges of the graft. Aim to produce an oval urethra rather than a circular tube. This is less likely to interfere with the vascularity of the neourethral tube (Fig. 21.4).

At the second stage, close the neourethral tube with stitches through the dermis rather than the epidermis to reduce the risk of fistulation (Fig. 21.5).

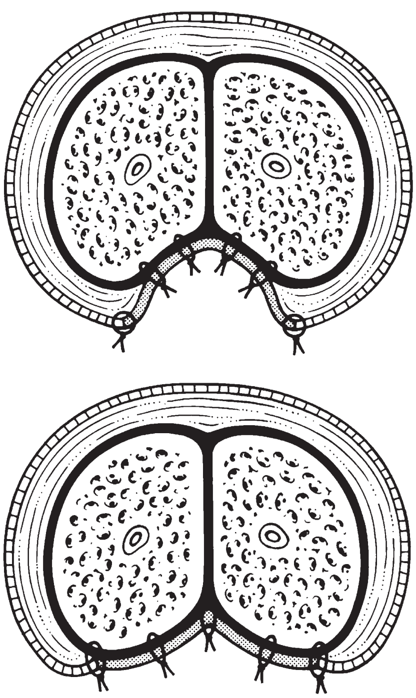


Fig. 21.2. To illustrate the incorporation of the dartos layer on the lateral aspects of the graft at the first stage of a two-stage procedure

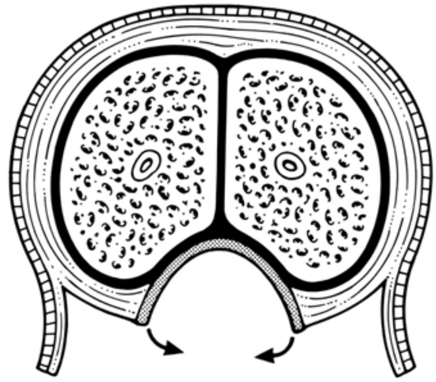


Fig. 21.3. To show how incorporating the dartos on each lateral aspect facilitates mobilization of the graft at the second stage of a two-stage procedure

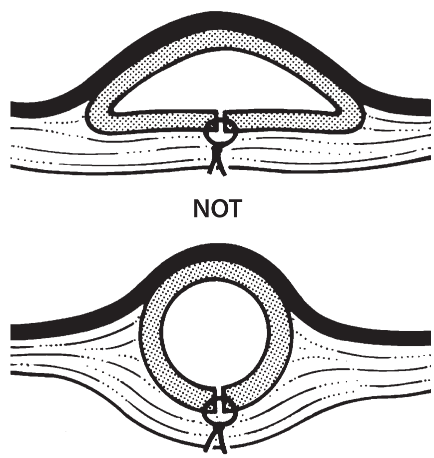


Fig. 21.4. To illustrate how closing the neourethra as an oval in the second stage of a two-stage procedure requires less mobilization and therefore less risk of ischemia

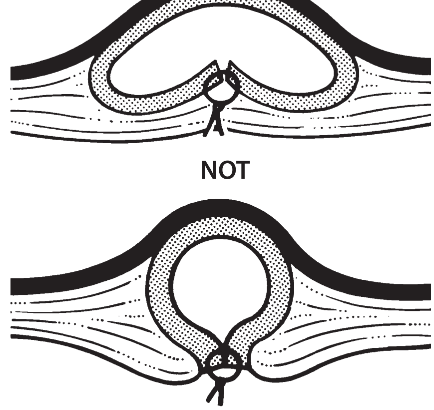


Fig. 21.5. To show how closing the dermal layer rather than the epidermal layer at the second stage of a two-stage procedure reduces the risks of postoperative fistulation

Always overclose suture lines with a layer of dartos, particularly at the corona, which is the most vulnerable area.

If a hematoma develops in the wound after the second stage, drain it. Hematomas and seromas are a common cause of fistulation because of secondary infection.

References

1. Humby G (1999) A one-stage operation for hypospadias. Br J Surg 29:84–92
2. Devine CJ, Horton CE (1961) A one-stage hypospadias repair. J Urol 85:166–172
3. Yaxley RP (1968) Another one-stage hypospadias operation. Aust N Z J Surg 38:63–65
4. Turner-Warwick RT (1960) A technique of posterior urethroplasty. J Urol 83:416–419
5. Blandy JP (1980) Urethral stricture. Postgrad Med J 56:383–418
6. Duckett JW Jr (1980) Transverse preputial island flap technique for repair of severe hypospadias. Urol Clin North Am 7:423–431
7. Quartey JKM (1985) One-stage penile/preputial island flap urethroplasty for urethral stricture. J Urol 134:474–487
8. Burger R, Muller SC, Hohenfellner R (1992) Buccal mucosal graft: a preliminary report. J Urol 147:662–664
9. Wessells H, McAninch JW (1998) Current controversies in anterior urethral stricture repair: free-graft versus pedicle skin-flap reconstruction. World J Urol 16:175–180
10. Greenwell TJ, Venn SN, Mundy AR (1998) Changing practice in anterior urethroplasty. BJU Int 83:631–635
11. Barbagli G, Selli C, di Cello V, Mottola A (1996) A one-stage dorsal free-graft urethroplasty for bulbar urethral strictures. B J Urol 78:929–932
12. Andrich DE, Mundy AR (2001) The Barbagli procedure gives the best results for patch urethroplasty of the bulbar urethra. BJU Int 88:385–389
13. Orandi A (1968) One-stage urethroplasty. B J Urol 40:77
14. Venn SN, Mundy AR (1998) Urethroplasty for balanitis xerotica obliterans. B J Urol 81:735–737

Repair of Bulbar Urethra Using the Barbagli Technique

G. Barbagli, M. Lazzeri

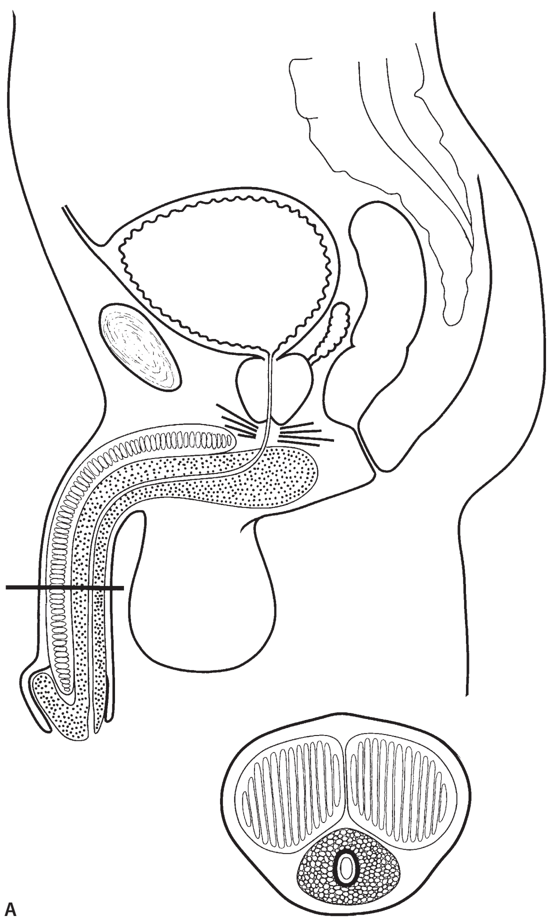
22.1 Introduction and Historical Background

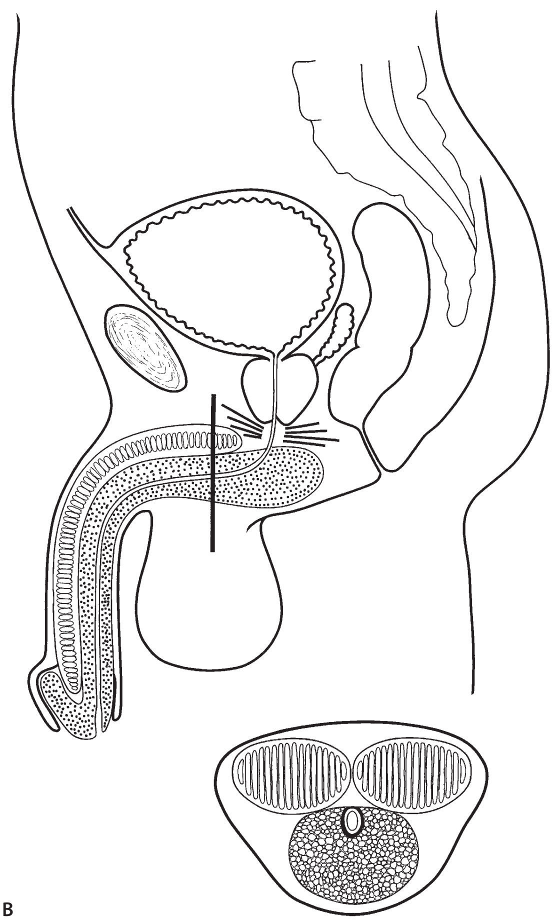
The dorsal onlay graft urethroplasty, also named Barbagli technique, builds on previous steps in the urethral surgery:

- The principles of the buried skin strip as suggested by Denis Browne [1]
- The experimental and clinical studies on urethral regeneration according to Weaver, Schulte, and Moore [2–4]
- Urethral reconstruction using a free full-thickness skin graft as popularized by Devine [5]
- The dorsal approach to urethral lumen as suggested by Monseur [6]

22.2 Anatomical Remarks

In the bulbar urethra, the relationship between the spongiosum tissue and the mucosal membrane are quite different from penile tract (◘ Fig. 22.1A): the corpus spongiosum is thick in the ventral urethral surface, and thin in the dorsal urethral surface (◘ Fig. 22.1B). Furthermore, the urethral lumen is located dorsally and not centrally (◘ Fig. 22.1B). The bulbar urethra is easily freed from the underlying corpora cavernosa (◘ Fig. 22.2D, E), and the lumen may be opened along its dorsal surface (◘ Fig. 22.2F). In patients who have undergone repeated and deep internal urethrotomies at 12 o'clock, the urethral lumen is adherent and firmly fixed to the tunica albuginea, because the longitudinal internal cut involve the urethral mucosa, spongiosum tissue, and the tunica albuginea. The healing of this kind of urethrotomy and the urinary extravasation cause a scar that joins together the urethral mucosa and the tunica albuginea. Also, in patients with an indwelling urethral stent in place, it may be difficult to approach and to free the dorsal urethral lumen. In obese patient, its may be difficult to free the urethra from the corpora cavernosa, because these patients have a deep and flat perineum. In all these patients, a ventral or lateral approach to the urethral lumen for urethroplasty could be advisable.





◘ **Fig. 22.1A, B.** Anatomy of penile (**A**) and bulbar urethra (**B**) [12, 13]

22.3 Step-by-Step Surgical Details

22.3.1 Preparation of the Bulbar Urethra

The patient is placed in simple lithotomy position, and a midline perineoscrotal incision is made overlying the stricture site (Fig. 22.2A). The bulbocavernous muscles are separated in the midline, and, in patients with proximal bulbar urethral stricture, the central tendon of perineum is dissected (Fig. 22.2B). The bulbar urethra is free from the bulbocavernous muscles for its entire length, and the muscles are fixed to a retractor using four stitches (Fig. 22.2C). The bulbar urethra is dissected from the corpora cavernosa, starting from 2 cm *distally* (not proximally) to the stricture (Fig. 22.2D). In this tract (Fig. 22.2D), it is easier to free the urethra from the corpora cavernosa, because the urethra is thinner and not involved in the disease. Using a loop, the urethra is completely mobilized from the corpora cavernosa and rotated 180 degrees (Fig. 22.2E). The stricture portion is incised dorsally, starting over the urethral catheter (Fig. 22.2E), and extending the stricturotomy for 2 cm into the healthy urethra proximal and distal to the stricture. The strictured tract is dorsally opened for all its length (Fig. 22.2F).

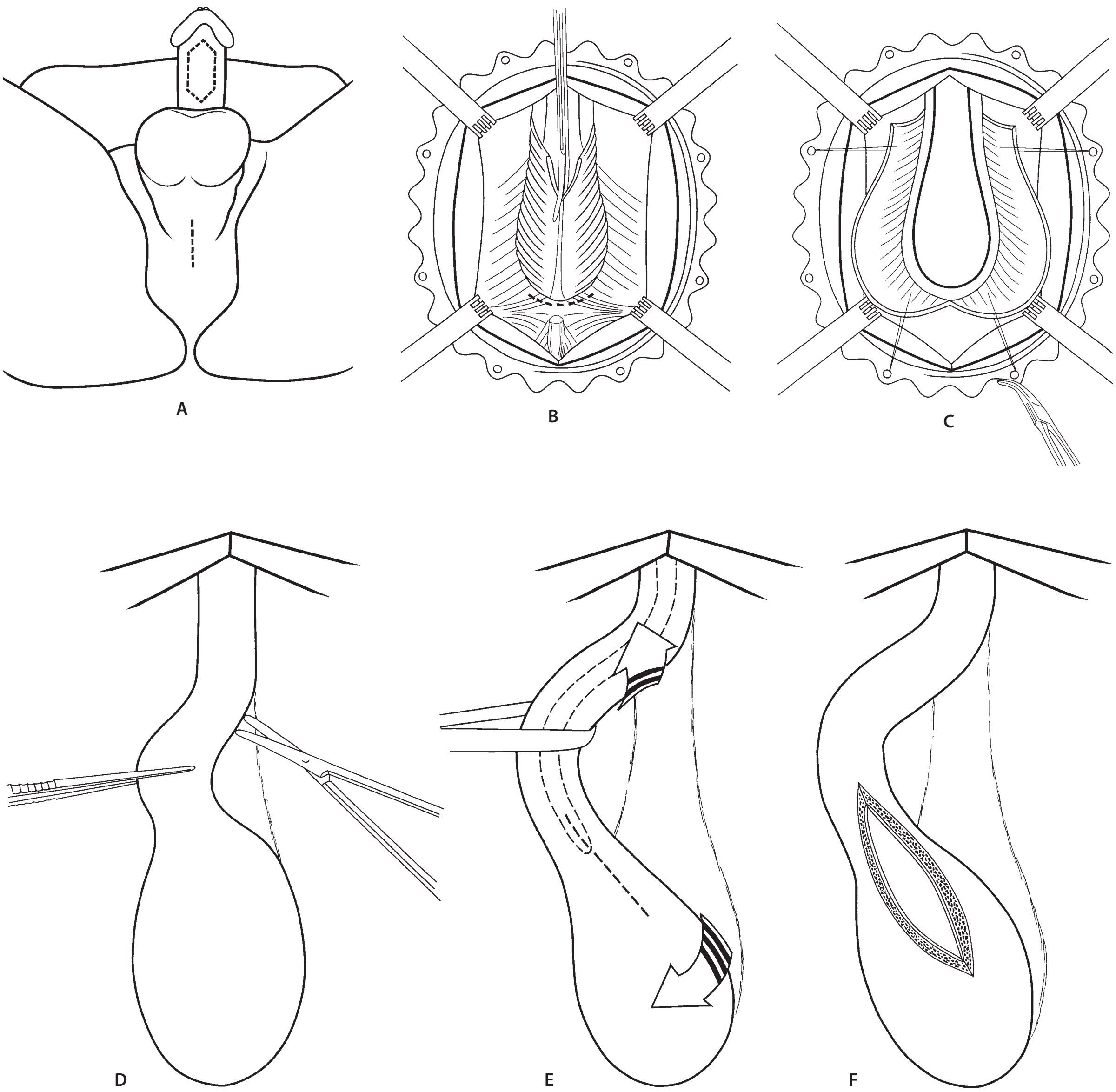


Fig. 22.2A–F. Preparation of the bulbar urethra [12, 13]

22.3.2 Preparation and Suture of the Graft (Skin or Buccal Mucosa)

In patients with stricture shorter than 4 cm, an ovoid strip of ventral penile skin is outlined for harvesting (Fig. 22.2A). In patients with stricture longer than 4 cm, a double circumferential subcoronal incision is made for harvesting a longer preputial skin strip. When local epithelial foreskin is unavailable or the patient does not agree to harvesting from the prepuce, the buccal mucosa is preferred to other various types of extragenital free grafts, because of its qualities [7]. We chose the inner check over the inner lip as a donor site, because the width of the lip limits the size of the graft [7]. Moreover, the buccal mucosa is thicker and resistant in the cheek when compared with the buccal mucosa from the lip. The buccal mucosa harvesting increases the operative time by 1 h.

Thus, a two-team approach may be used in which a perineal team exposes and calibrates the strictured tract, while another simultaneously harvests the graft from the mouth. This procedure also increases the sterilization of the surgical act. The reduced operative time has remarkable advantages and may prevent troublesome complications from prolonged lithotomy position [7].

The fenestrated ovoid preputial free skin or buccal mucosa graft is spread-fixed and quilted to the overlying tunica albuginea of the corporal bodies (Fig. 22.3A).

The right mucosal margin of the opened urethra is sutured to the right side of the patch graft, spreading open the strictured tract to the new roof, which is the flat,

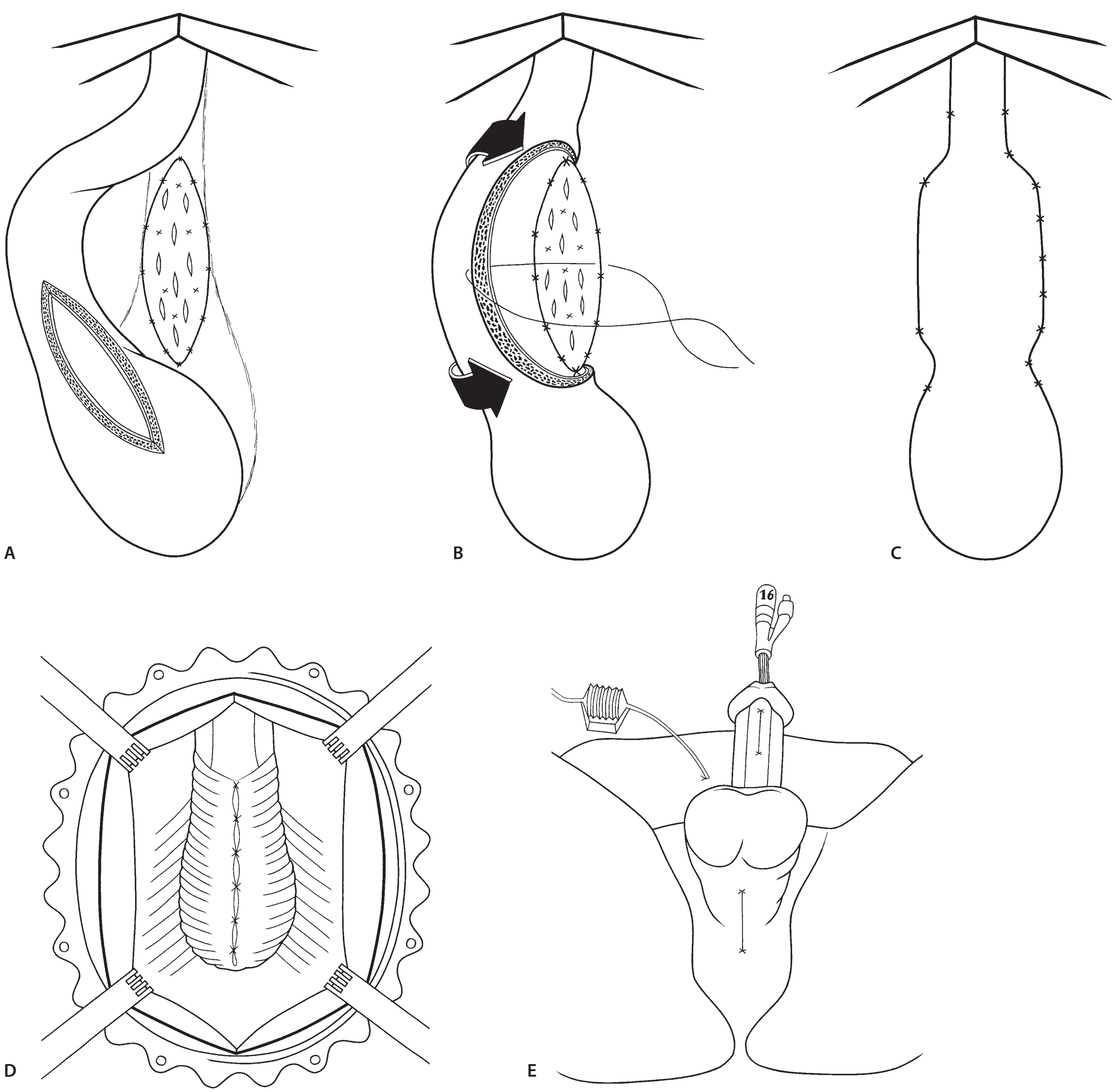
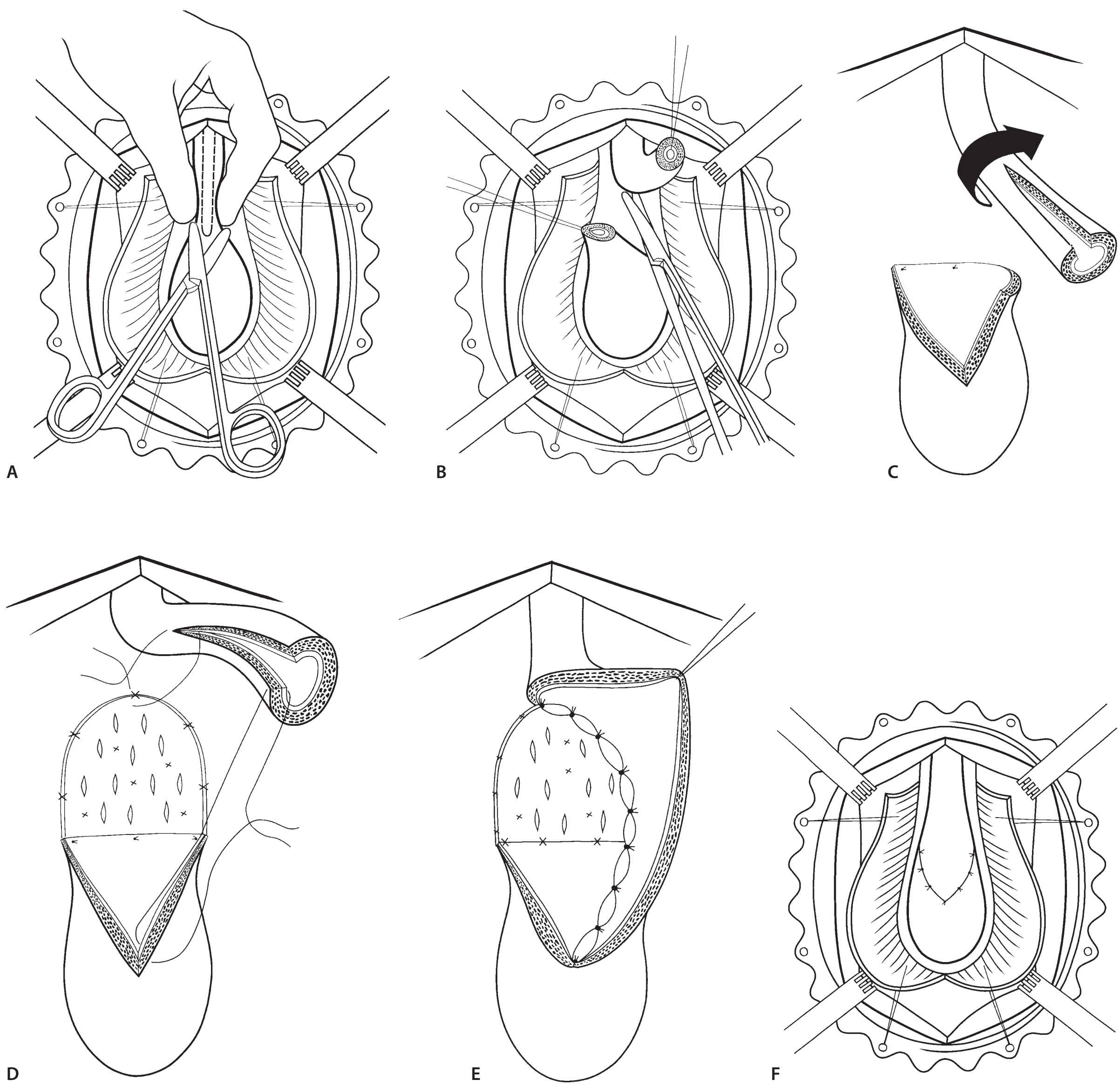


Fig. 22.3A–E. Dorsal onlay urethroplasty using skin or buccal mucosa graft: standard technique [12, 13]

fixed graft (◘ Fig. 22.3B). The urethra is rotated back to its original position (◘ Fig. 22.3B). The left urethral margin is sutured to the left side of the patch graft and corporal bodies, and the grafted area is entirely covered by the urethral plate (◘ Fig. 22.3C). The bulbocavernous muscles are approximated over the grafted area (◘ Fig. 22.3D). A small suction drain is placed in the region of the repair, and an indwelling 16-Fr silicone Foley catheter is left in place (◘ Fig. 22.3E). The suprapubic cystostomy is unnecessary.

In patients with stricture who require a complete removal of the strictured tract, the urethra is completely transected below the tip of the urethral catheter (◘ Fig. 22.4A). The urethral scar or disease is removed, and the distal and proximal urethral edges are mobilized from the underlying corpora cavernosa, using a gentle traction on the stitch fixed to the spongiosum tissue (◘ Fig. 22.4B). The proximal mucosal edge is spatulated and spread over the corpora cavernosa, and the mobilized distal urethra is widely opened along its dorsal surface (◘ Fig. 22.4C). The free skin or buccal mucosa graft is spread-fixed and quilted to the underlying corpora, and its lower margin is sutured to the proximal mucosal edge of the urethra (◘ Fig. 22.4D). The left mucosal margin of the opened distal urethra is sutured to the left side of the graft (◘ Fig. 22.4E). The urethra is rotated back over the grafted area and sutured to proximal mucosal edge and to the right corpora cavernosa (◘ Fig. 22.4F). The bulbocavernous muscles are sutured over the bulbar urethra, and the perineal closure is made as previously described.



◘ **Fig. 22.4A–F.** Augmented roof strip anastomotic urethroplasty [12, 13]

22.3.3 Preparation and Suture of the Flap

In patients with stricture that has recurred after urethroplasty, or with serious ischemic urethral disease or damage, it may be useful to use the pedicled flap so as to improve the graft take and neovascularization. A midline perineal incision is made and a longitudinal ventral penile skin island is outlined in the penile shaft (Fig. 22.5A). The bulbar urethra is circumferentially mobilized from the corpora cavernosa and rotated to 180 degrees (Fig. 22.5B). The longitudinal penile skin island is carried on the ventral dartos fascial pedicle (Fig. 22.5B) [8]. The fascial pedicle is extensively dissected and mobilized to allow the transposition of the skin island into the perineum, using a finger-made tunnel (Fig. 22.5B, *arrow*). The bulbar urethra is opened along its dorsal surface; the skin island is sutured to the corpora cavernosa, without transecting the urethra (Fig. 22.5C) or transecting completely the urethra (Fig. 22.5D). The urethra is rotated back over the island flap (Fig. 22.5E), and the grafted area is covered with the healthy urethra (Fig. 22.5F).

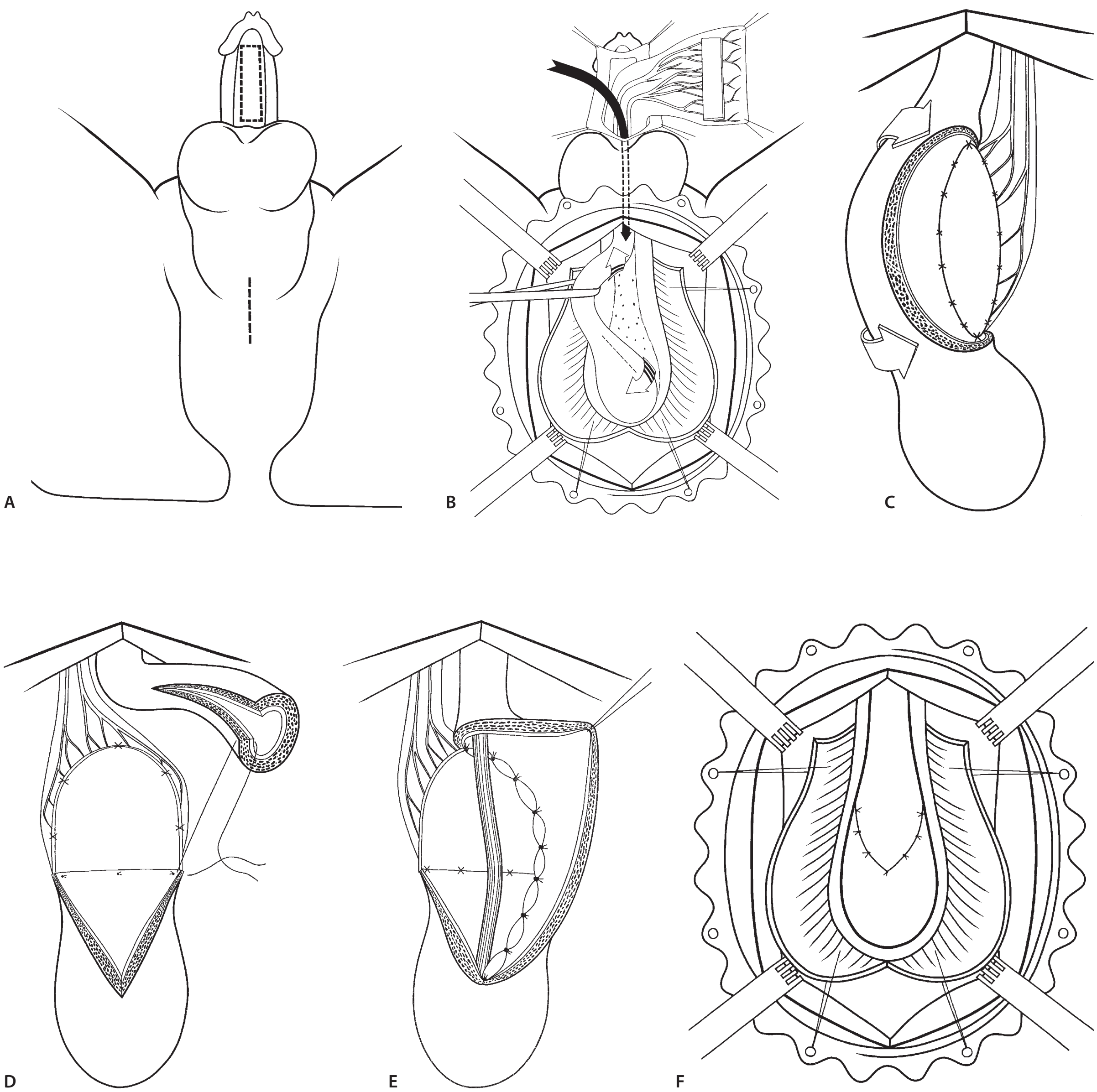


Fig. 22.5A–F. Dorsal onlay urethroplasty using a ventral penile fascial flap with longitudinal skin island

22.3.4 Postoperative Course

The day after surgery, the drain is removed, and the patient is discharged from the hospital. Three weeks after surgery, the bladder is filled with contrast medium, the Foley catheter is removed, and a voiding cystourethrography is obtained. Uroflowmetry and urine culture are repeated every 4 months throughout year 1 and yearly thereafter. Radiological studies are repeated when uroflowmetry was less than 14 ml/s. Clinical outcome was considered a failure any time postoperative instrumentation was needed, including dilatation [7].

22.3.5 Intraoperative, Perioperative, and Postoperative Complications

In patients who have undergone repeated internal urethrotomies, it may be difficult or impossible separate the urethra from the corpora cavernosa, and the tunica albuginea may be opened or injured. In this case, it is important to realize that there is damage on the corpora cavernosa and the opening must be immediately repaired. If it is difficult to free the urethra from the corpora, one can make a lateral or ventral opening into the urethral lumen. In this case, it could be better to use buccal mucosa as graft and not preputial skin.

In patients who have undergone an augmentation urethroplasty for stricture longer than 6 cm, during the first radiological investigation, the presence of a urethral fistula or an extravasation of the contrast medium can be observed. In this case, leave in place a 14-Fr Foley silicone catheter, and perform a new radiological study 2 weeks later.

22.4 Long-Term Results and Attrition Rate of the Barbagli Procedures

In 1998, we reported the outcomes of dorsal onlay graft urethroplasty using penile skin or buccal mucosa in 37 bulbourethral strictures, with a mean follow-up of 21.5 months, 34 (92%) were classified as successes, and three (8%) as failures [7].

Recently, with a mean follow-up extended from 21.5 to 43 months, the success rate of dorsal onlay procedures in 40 patients decreased from 92% to 85% [9]. In this series of patients, we did not include patients who underwent dorsal onlay urethroplasty using a pedicled flap or buccal mucosa graft [9]. In fact, the pedicled flap urethroplasty was used in only five patients, and in patients who underwent a buccal mucosa graft repair the short follow-up is not available for evaluation over time.

In 1999, other authors reported good outcomes (97%) in 28 patients who underwent a dorsal onlay graft urethroplasty using preputial skin or buccal mucosa, with a mean follow-up of 19 months [10].

In 2000, other authors reported a favorable results (93%) in 29 patients, for a median follow-up of 28 months, using an augmented roof strip anastomotic urethroplasty [11].

22.5 Conclusions

The Barbagli technique urethroplasties are safe and versatile procedures, which may be combined with various substitute materials such as preputial or extragenital skin, a buccal mucosa graft, or a pedicled flap. Other substitute materials will be possible in the future.

The long-term outcomes of a wide series of patients, reported by different institutions, showed a final success rate from 85% to 97% [7, 9–11].

For substitute materials (buccal mucosa versus preputial or penile skin), a long-term follow-up is mandatory to establish whether buccal mucosa is superior to foreskin as urethral substitution. We currently use both according to patient preference, status of the genital tissues, or stricture characteristics.

References

1. Browne D (1949) An operation for hypospadias. Proc Roy Soc Med 42:466–468
2. Weaver RG, Schulte JW (1962) Experimental and clinical studies in urethral regeneration. Sur Gynec Obst 115:729–736
3. Weaver RG, Schulte JW (1965) Clinical aspects of urethral regeneration. J Urol 93:247–254
4. Moore CA (1963) One-stage repair of stricture of the bulbous urethra. J Urol 90:203–207
5. Devine PC, Wendelken JR, Devine CJ (1979) Free full thickness skin graft urethroplasty. J Urol 121:282–285
6. Monseur J (1980) L'élargissement de l'urètre au moyen du plan sous-urétral. Journal d'Urologie 6:439–442
7. Barbagli G, Palminteri E, Rizzo M (1998) Dorsal onlay graft urethroplasty using penile skin or buccal mucosa in adult bulbo-urethral strictures. J Urol 160:1307–1309
8. Jordan GH (1998) Anterior urethral reconstruction: concepts and concerns. Contemp Urol 10:80–96
9. Barbagli G, Palminteri E, Lazzeri M (2001) Long-term outcomes of urethroplasty in patients after failed urethrotomy versus primary repair. J Urol 165:1918–1919
10. Iselin C, Webster GD (1999) Dorsal onlay graft urethroplasty for repair of bulbar urethral strictures. J Urol 161:815–818
11. Guaralnick ML, Webster GD (2000) The augmented anastomotic urethroplasty: indications and outcomes in 29 patients. J Urol 163:73
12. Barbagli G, Palminteri E, Lazzeri M (2002) Dorsal onlay techniques for urethroplasty. Urol Clin North Am 29:389–395
13. Barbagli G, Palminteri E, Lazzeri M, Bracka A (2003) Penile and bulbar urethroplasty using dorsal onlay techniques. Atlas of the Urologic Clinics of North America 11:29–41

Indications and Limitations of Buccal Mucosa Reconstructive Urethral Surgery in Hypospadias Repair

M. Fisch

23.1 Introduction

The first case report on the use of buccal mucosa for urethroplasty dates back to 1894 [1]. In 1941, Humby reported another case [2]. Almost 50years later, Bürger [3] published a series of tubularized free grafts in an animal model that he transferred to patients with hypospadias/epispadias. Reports on a free transfer of buccal mucosa and bladder mucosa in combination [4] as well as the use for repair of a urethral stricture correction in children followed [5]. Thereafter, the number of publications increased. The main indication for the implementation of buccal mucosa was urethral reconstruction in complex cases such as severe hypospadias cases [6–9] or bladder exstrophy/epispadias [8, 9]. The buccal mucosa was not only used as a tube, but also as an onlay technique [8, 9]. In 1996, the indication was extended to repair of urethral strictures in adults [10, 11] with excellent results.

Compared to skin, buccal mucosa has certain advantages. The thick epithelial layer makes the tissue easy to handle, the thin lamina propria allows blood vessels to grow rapidly [8, 9]. This is one of the reasons why a buccal mucosa graft is so easily taken. There is a high similarity between buccal mucosa and urothelium in immunohistochemistry, with a similar expression of cytokeratin and immunoglobulin A [12], the latter being responsible for a good bacterial defense. There are fewer signs of inflammation and scars after contact with urine when compared to skin [13].

23.2 Incidence and Etiology of Hypospadias

Hypospadias is a congenital anomaly with incomplete development of the urethra and the corpus spongiosum. Depending on the position of the meatus, hypospadias is classified as anterior or distal (glandular, coronal, subcoronal), middle (penile) and posterior or proximal (penile, penoscrotal, scrotal, and perineal) [14]. Roughly 65%–70% of hypospadias are anterior. The severeness of the disease is not only caused by the position of the meatus, but also by the defect of the corpus spongiosum and the degree of penile shaft curvature. Approximately 0.3%–0.7% of males are born with hypospadias [15, 16]. Increased incidences were reported in Sweden during the 1960s and in Norway, Denmark, England, and Hungary during the 1970s. In the United States, increasing incidences from the 1970s to the 1990s were published [17].

Multiple factors are involved in the etiology. Defects of the testosterone biosynthesis, type 2 mutations of the 5-alpha-reductase, and mutations of the androgen receptor are identified hormonal causes [18]. In addition, environmental factors play a role. A family disposition is described: fathers of children with hypospadias have a 7% incidence and male siblings a 14% incidence [19].

23.3 Indications and Operative Technique for Hypospadias Repair

There are cosmetic and functional indications for hypospadias repair. In distal hypospadias and a wide meatus without penile curvature, repair is done for only cosmetic reasons. As there are no functional deficits [20], informed consent of the parents is of importance. Some authors even prefer a minimally invasive procedure (meatotomy/circumcision, meatoplasty) rather then complete reconstruction [20, 21].

Functional indications for operative repair are meatal stenosis, penile curvature, and proximal hypospadias. Surgical repair encompasses penile straightening and urethral reconstruction. Whether the meatus should always be positioned at the tip of the glans is a matter of discussion [20, 21].

More then 300 different operative techniques have been described for hypospadias surgery, indicating that none is perfect. For correction of distal hypospadias the MAGPI [22] and the Mathieu technique (Flip-Flap-Verfahren) [23] were most commonly used in the past. Today, the technique described by Snoodgrass [24] with incision of the dorsal plate and subsequent tubularization is the most popular approach.

For repair of middle hypospadias, a pedicled foreskin flap is used as an onlay in most cases [25]. The flap can be dissected out of the inner or outer foreskin or even the penile shaft. The buccal mucosa free graft represents an alternative to this procedures. As in almost all cases where the urethral plate can be preserved, buccal mucosa can be used in the onlay technique. Currently, the indication for the Snodgrass technique is extended to middle and even proximal hypospadias; however, long-term results of larger series are still lacking.

Proximal hypospadias is often associated with penile curvature so that in the majority of cases straightening of the penis in combination with urethroplasty becomes necessary. For urethral reconstruction, one-stage and two-stage procedures, tubes and onlay techniques, flaps and grafts are used. Onlay techniques seem to have a lower complication rate than tubes [26, 27]; however, they encompass a two-stage approach when the urethral plate has to be sacrificed. There is agreement on some principles: hair-bearing skin should be avoided, the urethral plate should be preserved whenever possible, and bladder mucosa should no longer be used because of high complication rates and the invasiveness of the procedure. Although single-stage reconstruction with buccal mucosa tubes are described [28, 29], I personally prefer the onlay technique because of the lower complication rate. When the urethral groove can be preserved, buccal mucosa urethral reconstruction is performed as a single procedure. When the urethral plate has to be sacrificed, I chose a two-stage procedure.

Severe hypospadias is a widely accepted indication for the use of buccal mucosa either two- or onestaged, as there often is not enough penile skin left for reconstruction. In these cases, the two- or three-stage mesh graft technique is the only alternative [30].

23.4 Preoperative, Intraoperative, and Postoperative Management

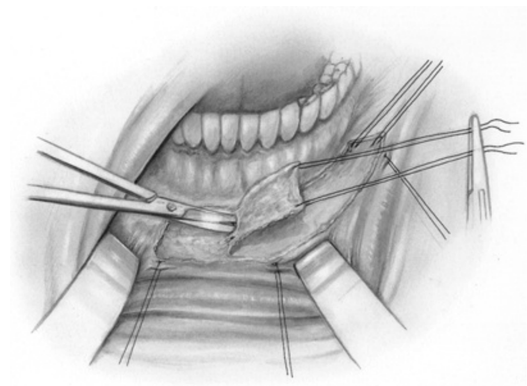
As the ideal age for reconstruction, some surgeons consider the time between the 6th and the 18th month of life [31], whereas others delay surgery until the age of 3 years. Local application of testosterone or 5a-dihydrotestosterone over a period of 4–6 weeks stimulates enlargement of the penis [32] and optimizes blood supply. During surgery, the use of magnifying glasses with a magnification of 1.5 to 2.5 as well as fine suture material (6-0 and 7-0) are standard. Monofile sutures are superior [33]. Caudal anesthesia is able to reduce the intraoperatively administered dose of analgetics as well as postoperative pain. The use of tourniquets should be avoided or used with care. Bipolar electrodes for coagulation prevent tissue necrosis.

Different methods have been used for postoperative urinary diversion: dripping stents [25], catheters, or urethral stents with cystostomy. Most surgeons use some kind of compressive dressing. However, whether there is an influence of the urine drainage as well as the dressing on the postoperative outcome is not clear [34].

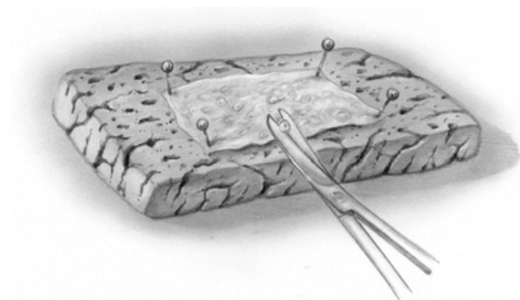
23.5 Buccal Mucosa Urethroplasty

23.5.1 Harvesting the Graft

The buccal mucosa flap can be harvested from the inner cheek and/or from the lower/upper lip. When the inner cheek is considered, the duct of the parotis gland opposite the second upper molar tooth should be respected. When the lip is chosen, stay sutures should mark the transition line of the outer lip to the inner mucosa so as not to harvest the graft on the visible outer surface. The length and width of the graft is marked with a pen and four stay sutures are placed in each corner (▫ Fig. 23.1). Submucous injection of local anesthetics with 1:100,000 adrenaline facilitates harvesting the graft and reduces postoperative bleeding and pain. The graft should be dissected as superficial as possible in order to avoid scars and dyspareunia. After removing the graft, bleeding blood vessels are coagulated (bipolar). The defect in the area of the inner cheek can be closed by a interrupted sutures (vicryle rapid 2-0), whereas the defect at the lips has to remain unsutured to avoid poor cosmetic results. The defect is covered with a moistened compress. Wounds usually heal very quickly. The buccal mucosa graft is thinned on a cork plate (▫ Fig. 23.2).



▫ **Fig. 23.1.** Harvesting of buccal mucosa graft: stay sutures mark transition line of the outer lip red to the inner mucosa; length and width of the graft is marked by 4 stay sutures placed in each corner (from Hohenfellner, Ausgewählte urologische OP-Techniken, 5.53, Abb. 5, Thieme, 1997)



▫ **Fig. 23.2.** Thinning of the mucosa graft (from Hohenfellner, Ausgewählte urologische OP-Techniken, 5.53, Abb. 6, Thieme, 1997)

23.5.2 One-Stage Hypospadias Repair with Buccal Mucosa

After artificial erection to reveal the degree of curvature, the skin is incised along the urethral plate with circumcision of the hypospadiac meatus. The dorsal incision goes along the sulcus coronarius. The whole penile shaft skin is stripped down together with the Scarpa fascia. Then the artificial erection is repeated. If a chordee is present, chordectomy is performed. A congenital curvature of the penis is corrected using the modified Nesbit technique [35] (▫ Fig. 23.3).

If the urethral plate after this procedure is soft and without tension, a single-stage urethral reconstruction can be performed; if not a two-stage procedure should be chosen. The dissected and thinned graft is anastomosed to the urethral plate by a running suture (monocryle 6-0) with the mucosal layer on the inner site (▫ Fig. 23.4). Glanduloplasty is performed by anastomosis of the glandular skin with the neourethra. To avoid meatal stenosis, the glandular wings should not completely be closed in front of the neourethra; thus the meatus comes to a glanular position but not at the tip of the glans (▫ Fig. 23.5). Covering the urethral reconstruction with well-vascularized subcutane-

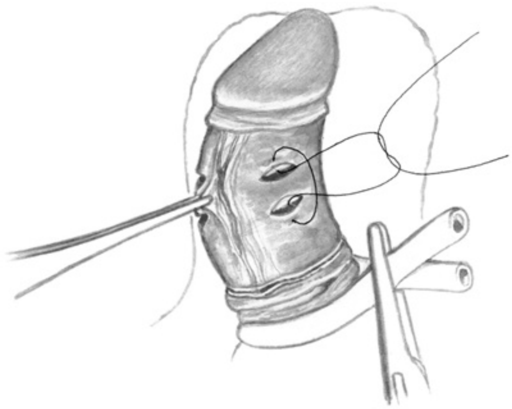


Fig. 23.3. Modified Nesbit-technique: parallel incision and inverted sutures (from Hohenfellner, Ausgewählte urologische OP-Techniken, 5.55, Abb. 13, Thieme, 1997)

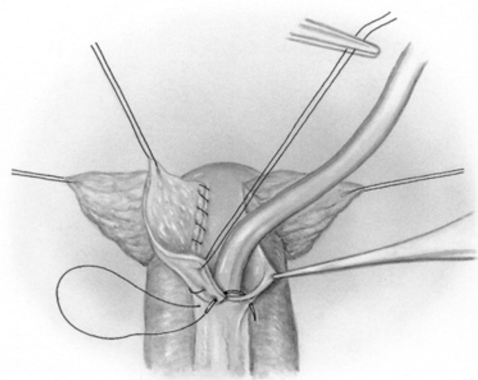


Fig. 23.4. Anastomosis of the buccal mucosa graft to the urethral plate by a running suture, mucosal layer on the inner site (from Hohenfellner, Ausgewählte urologische OP-Techniken, 5.56, Abb. 15, Thieme, 1997)

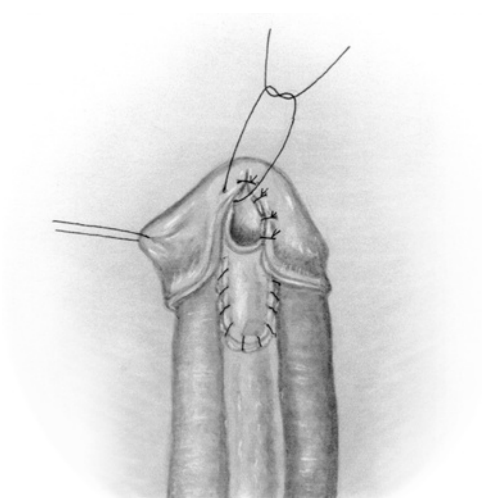


Fig. 23.5. Granduloplasty by anastomosis of the grandular skin with the neourethra; the glandular wings are not completely closed in front of the neourethra, thus the meatus comes to a glanular position but not at the tip of the glans (from Hohenfellner, Ausgewählte urologische OP-Techniken, 5.56, Abb. 16, Thieme, 1997)

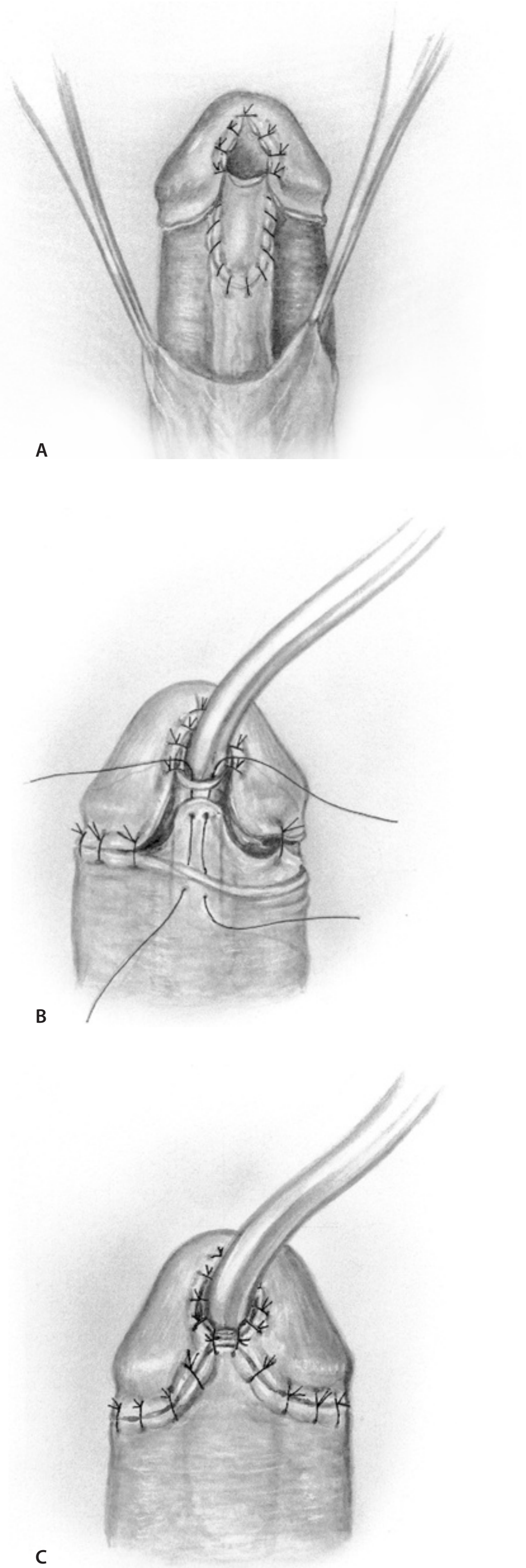


Fig. 23.6A–C. Covering of the free graft with subcutaneous tissue (**A**) and skin with reconstruction of a frenulum (**B**) (from Hohenfellner, Ausgewählte urologische OP-Techniken, 5.56, Abb. 17 and 18, Thieme, 1997)

ous tissue is of utmost importance for the outcome. The dorsal foreskin is carefully resected and the penile shaft covered with the remaining skin (Fig. 23.6A–C). A 10-Fr Websinger catheter serves as a urethral drain; a cystostomy is inserted for urinary diversion.

23.5.3 Two-Stage Hypospadias Repair

After correction of the curvature, the urethral plate is cut and the neomeatus fixed tension-free to the corporal bodies. The dorsal foreskin is incised at the 12 o'clock position and the thus resulting Byars flaps are used to cover the ventral penile shaft with skin. Urethral reconstruction is performed 9–12 months after the first intervention. A skin plate is marked at the ventral aspect and the skin incised (Fig. 23.7). The further reconstruction is in analogy to the one-stage procedure.

23.5.4 Severe Hypospadias Cases

Several unsuccessful hypospadias repairs may result in severe hypospadias with residual curvature or torsion of the corporal bodies, extensive scar tissue, and poor-quality skin left for reconstruction. Reconstructive surgery is demanding and extensive experience of the surgeon mandatory. The intraoperative approach depends on the individual situation. When using buccal mucosa as onlay, coverage of the free graft may be difficult. If there is not enough subcutaneous tissue available a pedicled flap of such tissue can be dissected out of the scrotum, rotated, and used for coverage. Or, the reconstruction can be buried into the scrotum according to the technique described by Cecil [36]. Alternatively, buccal mucosa can be used as a dorsal inlay. The second stage is performed at earliest 3 months later, when the healing is completed.

23.6 Results of Hypospadias Repair

The results of primary repair with a free graft of buccal mucosa are comparable to those obtained by other techniques such as the pedicled onlay flaps. In my own experience, the complication rate of buccal mucosa for primary repair using the onlay technique was 20% (*n*=65). With pedicled skin flaps, complication rates of 6% [37] to 33% [26] have been described. Major series report 16%–22% [27, 38, 39]. In general, onlay techniques seem to be favorable compared to tubes [26, 27]. When using a pedicled skin flap as a tube in a one-stage procedure, complications will occur in 25%–47% of patients [40, 41]. Excellent short-term results have been reported for the Snodgrass technique in distal hypospadias; however, extending the indication to proximal hypospadias led to an increase in complication rates to 17.5% [42] up to 27% [43]. Long-term results of the procedure are still lacking. Excellent results of the buccal mucosa urethroplasty have been described in severe cases of hypospadias, with a complication rate of only 16%–36% [44–47] and in my personal experience 30.3% (*n*=38).

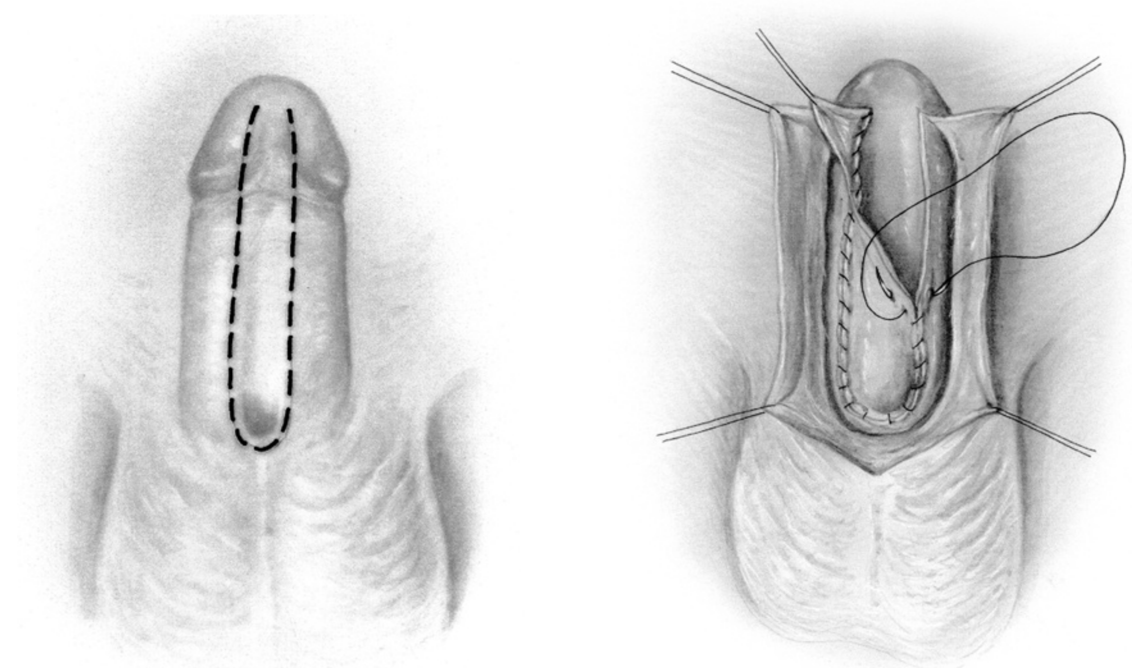


Fig. 23.7. Two-staged reconstruction: Incision along the urethral plate and anastomosis of the buccal mucosa in onlay-technique (from Hohenfellner, Ausgewählte urologische OP-Techniken, 5.57, Abb. 19 and 21, Thieme, 1997)

References

1. Sapiejko (de Kiew) (1894) Traitement des défectuosités de l'urètre par la transplantation de la muqueuse. Ann.des mal.desorg.gén-urin. 394
2. Humby GA (1941) One-stage operation for hypospadias. Br J Surg 29:84-
3. Bürger RA, Müller SC, el-Damanhoury H, Tschakaloff A, Riedmiller H, Hohenfellner R (1992) The buccal mucosal graft for urethral reconstruction: a preliminary report. J Urol 147:662–664
4. Dessanti A, Rigamonti W, Merulla V, Falchetti D, Caccia G, et al (1992) Autologous buccal mucosa graft for hypospadias repair: an initial report. J Urol 147:1081–1083
5. Monfort G, Di-Benetto V, Meyrat B (1993) Urethral stenosis in children: treatment using urethroplasty with vesical or oral mucosal graft. Ann Urol Paris 27:237–242
6. Brock JWI (1994) Autologous buccal mucosal graft for urethral reconstruction. Urology 44:753–755
7. Gonzalvez-Pinera J, Perez-Martinez A, Anjudarairo M, Marcomacian A, Aparicio-Lopez J (1994) Injerto libre de mucosa bucal para el tratamiento de hipospadias complejos. Cir Pediatr 7:48
8. Duckett JW, Coplen D, Ewalt D, Baskin LS (1995) Buccal mucosal urethral replacement [see comments]. J Urol 153:1660–1663
9. Baskin LS, Duckett JW (1995) Buccal mucosa grafts in hypospadias surgery. Br J Urol 76:23–30
10. Wessells H, McAninch JW (1996) Use of free grafts in urethral stricture reconstruction. J Urol 155:1912–1915
11. Lopez JA, Valle J, Timon A, Blasco B, Ambroj C, Murillo C, Valdivia JG (1996) Use of autologous buccal mucosal graft for urethral surgery in males. Eur Urol 29:227–230
12. Fichtner J, Macedo A, Voges GE, Fisch M, Filipas D, Hohenfellner R (1996) Buccal mucosa only for open urethral strictures repair – clinic and histology. J Urol 155:522
13. Filipas D, Fisch M, Fichtner J, Fitzpatrick J, Berg K, Störkel S, Hohenfellner R, Thüroff JW (1999) The histology and immunohistochemistry of free buccal mucosa and full-skin grafts after exposure to urine. BJU Int 84:108–111
14. Barcat J (1973) Current concepts of treatment. Horton, CE (ed) Plastic and reconstructive surgery of the genital area. 249–263
15. Duckett JW, Snyder HM (1992) Meatal advancement and glanuloplasty hypospadias repair after 1000 cases: avoidance of meatal stenosis and regression. J Urol 147:665–669
16. Gallentine ML, Morey AF, Thompson IM Jr (2001) Hypospadias: a contemporary epidemiologic assessment. Urology 57:788–790
17. Toppari J, Kaleva M, Virtanen HE(2001) Trends in the incidence of cryptorchidism and hypospadias, and methodological limitations of registry-based data. Hum Reprod Update 7:282–286
18. Silver RI (2000) What is the etiology of hypospadias? a review of recent research Del Med J 72:343–347
19. Bauer SB, Retik AB, Colodny AH (1981) Genetic aspects of hypospadias. Urol Clin North Am 8:559–564
20. Fichtner J, Filipas D, Voges G, Mottrie A, Hohenfellner R (1995) Analysis of meatal location in 500 adults: wide variation questions need for meatal advancement in all anterior hypospadias in children. J Urol 154:834–834
21. Mor Y, Ramon J, Jonas P (2000) Is only meatoplasty a legitimate solution for extreme distal hypospadias? Br J Urol 85:501–503
22. Duckett JW (1981) MAGPI (meatoplasty and glanduloplasty): a procedure for subcoronal hypospadias. Urol Clin North Am 8:513–519
23. Elder JS, Duckett JW, Snyder HM (1987) Onlay island flap in the repair of mid and distal penile hypospadias without chordee. J Urol 138:376–379
24. Snodgrass W (1994) Tubularized, incised plate urethroplasty for distal hypospadias. J Urol 151:464–465
25. Duckett JW (1992) Hypospadias. In: Walsh PC, Retik AB, Stamey TA, Vaughan ED (eds.) Campbell's Urology, 6th edn. Saunders, Philadelphia, pp 1893–1919
26. Demirbilek S, Kanmaz T, Aydin G, Yucesan S (2001) Outcomes of one-stage techniques for proximal hypospadias repair. Urology 58:267–270
27. Ghali AM, el-Malik EM, al-Malki T, Ibrahim AH (1999) One-stage hypospadias repair. Experience with 544 cases. Eur Urol 36:436–442
28. Ahmed S, Gough DC (1997) Buccal mucosal graft for secondary hypospadias repair and urethral replacement. Br J Urol 80:328–330
29. Piro C, de Diego M, Martin JA, Isnar R, Gosalbez R, Biox-Ochoa J (1998) Autologous buccal mucosal graft for urethral reconstruction. Cir Pediatr 11:71–72
30. Noll F, Schreiter F (1990) Meshgraft urethroplasty using split-thickness skin graft. Urol Int 45:44–49
31. Schultz JR, Klykylo WM, Wachsmann J (1983) Timing of elective hypospadias repair in children. Pediatrics 71:342–351
32. Bartsch G, Schweikert O, Glatzl J (1986) Sexuelle Differenzierungsstörungen. In: Hohenfellner R, Thüroff JW. Kinderurologie inKlinik und Praxis. 459–
33. Siiteri PK, Wilson JD (1974) Testosterone formation and metabolism during male sexual differentiation in the human embryo. J clin Endocrinol 38:113–125
34. Grobbelaar AO, Laing JH, Harrison DH, Sanders R (1996) Hypospadias repair: the influence of postoperative care and a patient factor on surgical morbidity. Ann Plast Surg 37:612–617
35. Nesbit RM (1965) Congenital curvature of the phallus: report of three cases with description of corrective operation. J Urol 93:230–232
36. Cecil AB (1952) Modern treatment of hypospadias. J Urol 67:1006-
37. Gearhart JP, Borland RN (1992) Onlay island flap urethroplasty: variation on a theme. J Urol 148:1507–1509
38. Castanon M, Munoz E, Carrasco R, Rodo J, Morales L (2000) Treatment of proximal hypospadias with a tubularized island flap urethroplasty and the onlay technique: a comparative study. J Pediatr Surg 35:1453–1455
39. Mollard P, Castagnola C (1994) Hypospadias: the release of chordee without dividing the urethral plate and onlay island flap (92 cases). J Urol 152:1238–1240
40. Sauvage P, Rougeron G, Bientz J, Cuvelier G (1987) Use of the pedicled transverse preputial flap in the surgery of hypospadias. Apropos of 100 cases. Chir Pediatr 28:220–223
41. Chuang JH, Shieh CS (1995) Two-layer versus one-layer closure in transverse island flap repair of posterior hypospadias. J Pediatr Surg. 30:739–742
42. Chen SC, Yang SS, Hsieh CH, Chen YT (2000) Tubularized incised plate urethroplasty for proximal hypospadias. BJU Int 86:1050–1053
43. Guralnick ML, al-Shammari A, Williot PE, Leonard MP (2000) Outcome of hypospadias repair using the tubularized, incised plate urethroplasty. Can J Urol 7:986–991
44. Castanon M, Grande C, Munoz ME, Garcia A, Morales L (1999) Treatment of severe scrotal hypospadias with onlay-type urethroplasty using mouth mucosa Cir Pediatr 12:90–93
45. Riccabona M (1999) Reconstruction or substitution of the pediatric urethra with buccal mucosa: indications, technical aspects, and results. Tech Urol 5:133–138
46. Kröpfl D, Tucak A, Prlic D, Verweyen A (1998) Using buccal mucosa for urethral reconstruction in primary and re-operative surgery. Eur Urol 34:216–220
47. Marte A, Cotrufo AM, Del Monaco C, Di Iorio G, De Pasquale M (2000) Mouth mucosa free-flap grafts in repeat operations of hypospadias. Minerva Pediatr 52:713–717

Indications and Limits for the Use of Buccal Mucosa for Urethral Reconstruction

D. Kröpfl, A. Verweyen

24.1 Introduction

The question arising in all situations where the urethra has to be substituted with other tissue because of a congenital or acquired defect is which characteristic this tissue must have and should the tissue be used as a free graft or as a pedicled flap (island flap) [16, 18].

The construction of the neourethra as a closed tube is today regarded as obsolete, regardless of which material is used to reconstruct the urethra [8, 13, 14]. In a one-stage repair, the urethra substitute should be used as an onlay patch . If the urethral plate is not present or unusable, it is constructed in a first-stage operation and the urethra then reconstructed in a second-stage operation [1, 5]. The results of urethral reconstruction with free grafts or pedicled flaps from hairless genital skin or buccal mucosa show similar success rates in large series [18]. The question is whether not only the personal preference of the surgeon but also objective factors influence the selection of the tissue or the surgical method. Objective factors that play a role in the selection of the urethra substitute are the cause of the urethral stricture or urethral disease, the anatomic position and length of the stricture, possibly an infection in the operation area, and the availability of hairless genital skin or buccal mucosa [8, 16, 18]. The same considerations would also apply if bladder mucosa was included in the choice of graft material.

Buccal mucosa was used for urethral reconstruction as early as 1941 and has found a broad use since the publication by Bürger and El Kasabi at the beginning of the 1990s [4, 6, 9]. The use of buccal mucosa for hypospadias repair was quickly followed by its use for substitution urethroplasty for urethral strictures [8, 12, 15). The euphoria generated by the excellent early results continues today because buccal mucosa is apparently also equal, if not superior, to other tissue substitutes in the long-term course [1, 2, 11]. It is currently considered to be the preferred method for the reconstruction of the urethra diseased by balanitis xerotica obliterans (BXO) and by many authors for the reconstruction of bulbar urethral strictures not suitable for an end-to-end anastomosis [1, 2, 5, 8].

Buccal mucosa has several significant advantages over the foreskin or penis shaft skin. Even after the removal of the subcutaneous tissue, the harvested graft is relatively thick, mechanically stiff and elastic, and therefore, surgically speaking, easy to handle. Buccal mucosa also has a lamina propria that is very thin but very rich in blood vessels. This allows a rapid capillary ingrowth from the recipient site and thus a good take of the graft [3]. Buccal mucosa is said to have an infection defense layer, which is distinguished by a high concentration of IgA antibodies, as a result of evolution-related qualities [3, 7]. Besides these microscopic differences, buccal mucosa was created by nature for the normal functioning in a moist environment – this may explain the currently observed good long-term results and the low reconstruction failure rate [1, 11].

24.2 Indications for the Use of Buccal Mucosa for Urethral Reconstruction

1. Urethral reconstruction for balanitis xerotica obliterans
2. Reconstruction of distal penile strictures with involvement of the fossa navicularis
3. So-called panurethral strictures
4. For bulbar urethral strictures not suitable for an end-to-end anastomosis
5. Middle and proximal hypospadias
6. Redoing hypospadia surgery requiring a urethral reconstruction.

Hypospadias treatment is not covered in the following text. The reconstruction in cases of penile urethral strictures with a missing or unusable urethral plate is not significantly different from that in hypospadias patients with similar problems.

24.3 Preoperative Preparation

The patients should preferably have no instrumental urethral intervention for the 3 months before the surgery in order to allow a correct estimation of the length of the urethral defect and to avoid having to operate in an inflamed or infected area. If miction is not possible, a suprapubic catheter should be applied first in order to avoid surgery delay. A microscopic and microbiological examination is done 1 week before the operation and the patient receives antibiotic treatment according to the examination results. In the case of long urethral defects and patients with a bulbar urethral stricture, the bowel is operatively prepared so that the patient does not have a bowel movement until a few days after the operation – this makes the necessary bed rest much easier for the patient. The shaving of the genitals occurs shortly before surgery in order to prevent an infection and also gives the surgeon the opportunity to identify the boundaries of the hairless skin.

24.4 Operative Technique

The length and width of the buccal mucosa graft to be harvested is determined first, independent of the location of the urethral stricture. The graft is then harvested, preferably from one or both inner cheeks. If necessary, the graft harvesting is extended into the upper and lower lip area. Depending on the size and age of the patient, this makes it possible to harvest grafts of up 20 cm long and 1 cm wide. A nasal intubation is normally not necessary but helpful when buccal mucosa grafts have to be harvested from both sides of the mouth. After a retractor has been placed in the mouth, the opening of Stensen's duct is identified and, if necessary, the exact position of the duct is indicated with a fine probe and marked with methylene blue. The size of the desired graft is also marked with a pen. The boundary between the submucosa and the subjacent buccinator muscle is easily presented with submucosal injection of a few milliliters of normal saline and 0.5 Xylocaine + 1: 200,000 diluted epinephrine. The graft is then incised and lifted with the stay sutures positioned at the corners. Injury to the buccinator muscle or its neurovascular supply must be avoided during the dissection. After graft harvesting, the donor site margins are raised and the donor site is closed with nonabsorbable interrupted sutures (polytetrafluoroethylene). The donor site is closed with absorbable suture material in some centers [6]. If a large quantity of graft material has to be harvested, great care must be taken at the corner of the mouth because a scarring caused by harvesting here can result in a change in facial expression. Great care must also be taken during the closing of the donor site in the lower lip area because the prolabium can otherwise turn inwards. Hemostasis is obtained with bipolar electrocautery and the oral cavity is filled with sponges at the end of the graft harvesting in order to prevent a flow of blood into the trachea or esophagus.

The graft is then thinned very carefully and remains of subcutaneous fatty tissue or muscle fibers are carefully removed. The author's experience is that the best method for this is to stretch the graft over the left index finger because this facilitates a very quick and effective graft thinning. The graft is then kept in a gentamycin solution until use.

In the case of patients with balanitis xerotica obliterans or patients with a missing urethral plate, the buccal mucosa graft is positioned with its rough side facing on the prepared bed in order to form the urethral plate. A precondition for the successful use of such a method is an adequate blood supply to the graft bed and a level bed, allowing good contact with the graft. The graft is also perforated in multiple places with a no. 11 scalpel in order to prevent hematoma formation under the graft or liquid pooling. In patients who have had multiple hypospadia surgeries, the subcutaneous tissue in the defect area is poorly vascularized or is hardly present so that the pedicled fascia dartos flap from the scrotal area or the more distant penis shaft skin area must first be repaired and positioned on the corpora cavernosa in order to facilitate a good take of the graft. If this is not done, the free buccal mucosa graft will either not take or react due to fibrosis. At all places where the rough surface of the graft does not have contact with the surrounding tissue, a more or less distinct necrosis will occur because of the lacking blood supply, which can lead to an infection and possibly the loss of the graft [10]. When positioning the sutures, it is imperative that the onlay patch has an edge-to-edge contact with the urethral plate or the surrounding skin. The author always uses only interrupted sutures because, in his opinion, this can prevent the postoperative erection problems and improves the take of the graft in the lateral areas.

The surgery area is rinsed with a gentamycin solution during the entire surgery – this prevents the graft from drying out and makes the suturing easier because the hemostasis is then less frequent. After completion of the urethral reconstruction with an onlay patch, care must be taken to properly cover the neourethra in the entire area with well-vascularized subcutaneous tissue before the skin closing. If this is not available, it is necessary to construct a fascia dartos flap from the scrotal area or further distant penis shaft skin for the covering of the skin defect.

Special care should be taken in the area of the sulcus coronarius, where the author generally tries to displace the subcutaneous tissue or the fascia dartos flap caudally in the area of the glans wing and suture it there. The author prefers polyglactin 910-suture material, which he uses in the sizes 6-0, 7-0, or 8-0 depending on the age of the patient. A penetration of the buccal mucosa epithelium by the sutures is avoided as far as possible. The skin is closed with 6-0 or 5-0 polyglactin 910-interrupted sutures.

24.5 Dressing Technique

It is important that the dressing ensures that the reconstructed urethral plate or neourethra has a good contact with the covering tissue. In the case of a urethral plate reconstruction, an ointment gauze cut to the same size as the urethral plate is first laid on the neourethra. Povidon-Iod ointment is applied to this before being covered by a second layer of sterile, balled compresses. A gauze compress adapted to the area to be covered is then positioned on top as a third layer and sutured to the surrounding skin with interrupted polypropylene sutures. The penis is then laid onto the abdominal wall and brought into an adequate position with abdominal pads and plaster. If only a urethral plate is reconstructed, urinary drainage is effected exclusively transurethrally with a silicone catheter. This is removed 5 days later after the first dressing change. In children with hypospadias, urinary drainage is effected exclusively transurethrally with feeding tubes of suitable size (approximately 2 Fr less than the size of the new reconstructed urethra). In adults, the urinary drainage is effected transurethrally with a silicone catheter and suprapubically with a suprapubic tube. The size of the transurethral catheter is 2 Fr less than the stent size.

The transurethral catheter is removed on the 10th day in the case of children. It is also removed on the 10th day in the case of adults, but an antegrade urethrography via suprapubic catheter is also performed at the same time. The suprapubic catheter is removed during this examination if there is an absence of extravasation or otherwise left in place for another week.

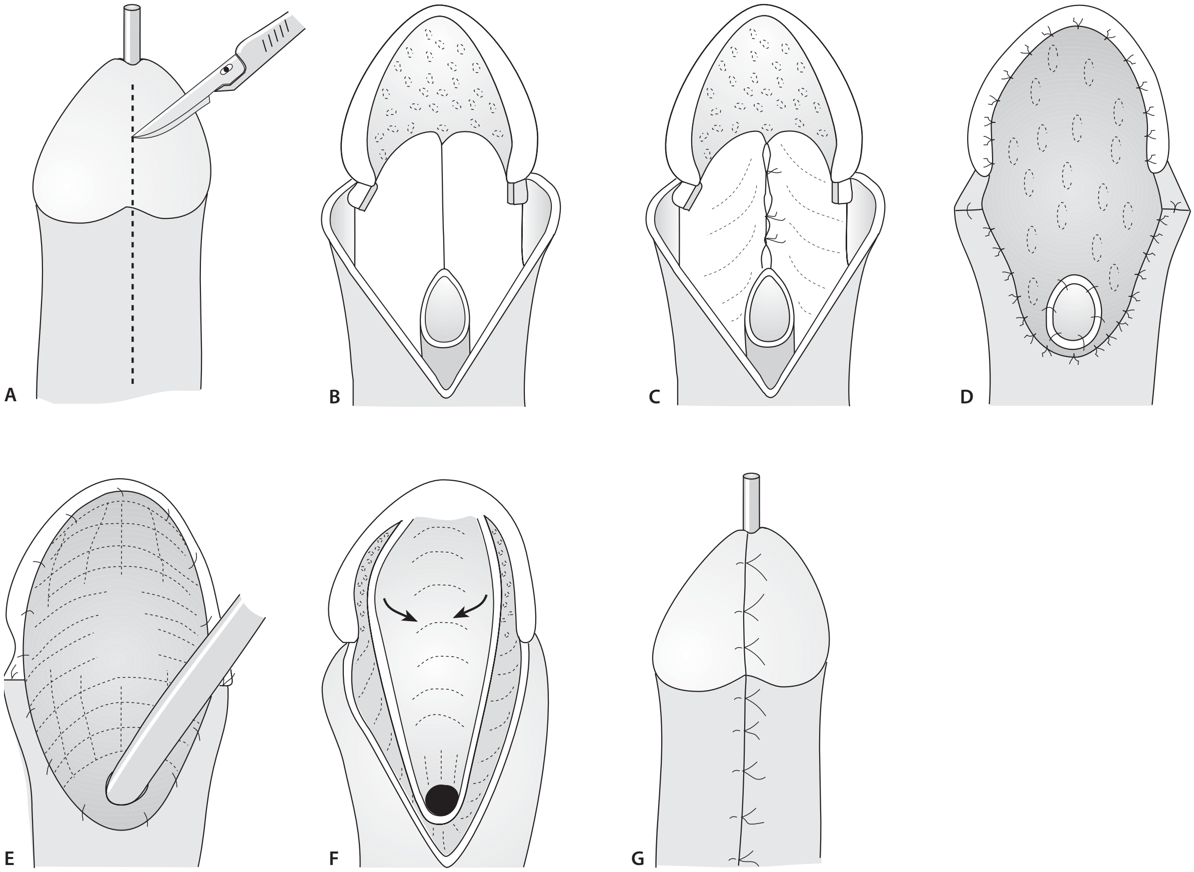


Fig. 24.1A–G. Reconstruction of the urethra in two sessions in patients with balanitis xerotica obliterans. **A** Ventral incision from the glans tip into the healthy urethra. **B** The diseased urethra part was resected. **C** Covering of the corpora cavernosa with a well-vascularized fascia dartos flap. **D** The buccal mucosa graft (with multiple perforations) was sutured into the wound area. **E** The dressing was sutured on and urinary drainage was effected with catheter. **F** The urethral plate constructed from the buccal mucosa is mobilized and closed midline. **G** Reconstruction of the urethra and the glans over a stent of suitable size

24.6 Perioperative Treatment

First- or second-generation cephalosporins are given to prevent a wound infection. For the first 4 postoperative days, strict bed rest is mandatory to facilitate the take of the graft [10]. Then the bowel movement is initiated and the dressing is changed. The patient is discharged and seen for follow-up on the 10th postoperative day.

24.6.1 Reconstruction of the Fossa Navicularis or the Distal Urethra in Patients with Balanitis Xerotica Obliterans

The penis and urethra are incised via a probe or a smaller catheter inserted into the urethra. This incision extends approx. 1–1.5 cm into the well-vascularized urethral tissue characterized by a normal color. The entire diseased tissue is resected. If the patient is not yet circumcised at this time, the skin of the inner foreskin is resected without damaging the subjacent dartos fascia. The covering of the exposed inner side of the glans wings and the corpora cavernosa is then effected with a dorsal to ventral transposed fascia dartos flap using the button-hole method. The previously perfectly tailored buccal mucosa graft is placed on the glans extended by stay sutures. This is then very carefully anastomosed with the skin of the glans or the penis shaft skin, with interrupted sutures. It is incised in its proximal part and placed around the urethra stump. The anastomosis between the urethra stump and the graft is also effected with interrupted sutures. This is then covered, as already described, with an ointment gauze with Povidon-Iod (see Fig. 24.1A–E).

The reconstruction of the urethra in the second operation, performed at least 6 months later, is shown in Fig. 24.1f. The buccal mucosa graft is mobilised and tubed on a 24/26-Fr stent with interrupted sutures. The glans is closed with sutures that grasp deep into the glans tissue and additionally with very fine skin sutures. The urinary drainage can be effected exclusively transurethrally for 7–10 days in such cases.

24.6.2 Reconstruction of Pars Pendulans Urethra Strictures Extending into the Fossa Navicularis

In contrast to the technique used for patients suffering from BXO, the urethral plate is not resected but instead exposed with a longitudinal incision via a probe or a catheter. The incision of approximately 1.5 cm extends into the healthy tissue. The bleeding in the area of the well-vascularized corpus spongiosum urethra is stopped with a 5-0 or 6-0 continuous running suture. A buccal mucosa graft suitable for the urethral defect is then harvested. This can be formed from two parts if necessary. The graft is carefully prepared and then placed over a stent suitable for the age of the patient, on the urethral plate and anastomosed to the plate with interrupted sutures, as already described. Before closing the glans wings, an attempt is made to position the subcutaneous tissue from the surrounding area or a fascia dartos flap over the neourethra. The entire neourethra is also covered with the subcutaneous tissue. The glans and the skin are closed midline with interrupted sutures (see ▫ Fig. 24.2A–E). The penis is then wrapped with a Povidon-Iod ointment gauze and circular-applied compresses. This dressing is then fixed to the surrounding skin with polypropylene sutures. A further fixing with elastic plaster then follows (▫ Fig. 24.2A). ▫ Figure 24.2E shows two ointment gauze pads, positioned parallel adjacent to the urethra, which are intended to effect a good contact of the subcutaneous tissue with the neourethra.

If the patient is not sufficiently prepared for any reason, e.g., there are signs of a urethral infection or inflammatory changes in the urethral plate area, the urethra is marsupialized in a first session and the reconstruction takes place 6 months later. Although this means that the repair is done in two stages, it offers the greatest chance of success. If the urethral plate is not adequate in shorter areas, it can be resected and then reanastomosed. In situations where the defect is too long for a reanastomosis, a part of the urethra can be formed into a tube providing the defect length is not overlong.

24.6.3 Long and Panurethral Strictures

The operative technique is in principle identical to that for strictures of the pars pendulans urethral. A one-stage reconstruction is performed if the patient has a preservable urethral plate and shows no sign of a urethral infection or inflammation in the urethral plate area. The incision runs from the meatus externus urethra to approximately 1.5 cm into the healthy bulbar urethra. The musculus bulbospongiosus is incised midline and carefully preserved. The buccal mucosa onlay patch, which can consist of several parts, is then brought into the correct position over a stent suitable for the size of the patient and anastomosed with the urethral plate with interrupted sutures. In the proximal area, the musculus bulbospongiosus, respectively the corpus spongiosum of the bulbar urethra, is closed midline over the onlay patch. The covering of the other parts of the onlay patch is effected as described in the above text (▫ Fig. 24.3A–B).

The urinary drainage in such patients is both suprapubic and transurethral, as described in the operative technique section. The dressing technique is identical to that described above. Mini-Redon drainage tubes are often positioned in the proximal part of the wound.

24.6.4 Panurethral Complete Defects of the Urethra

In these rare cases of panurethral complete defects of the urethra, the urethral plate is first constructed from buccal mucosa and then reconstructed in a second session with a midline closure or with a second onlay patch. If the patient does not have an adequate tissue situation for the positioning of a free graft, the well-vascularized tissue must first be displaced to the ventral side of the penis. This is usually effected with a fascia dartos flap. The buccal mucosa is then positioned on the prepared graft bed . If possible, the width of the harvested graft is then more than 2 cm – this allows a subsequent simple closure in the midline. It is also very important in this technique that the urethral plate is positioned on an adequate graft bed in order to avoid a fibrotic plate, which can result in a penis curvature, respectively prevent a reconstruction of the neourethra. This technique is very similar to the mesh graft technique with split skin, except that it provides the advantages of buccal mucosa [17].

24.6.5 Reconstruction of Bulbar Urethral Strictures

The author prefers the Barbagli technique with the modifications described by Pansadoro [2, 15]. The urethral stricture is first identified with the Sachse urethrotome under video guidance and incised 1.5 cm distal and proximal at 12 o'clock. The author is of the opinion that this has two advantages:

1. The normal pink-colored urethra can be easily distinguished from the grey, poorly vascularized strictured urethra under optimum viewing conditions and optical control, especially when video technology is used.
2. The incision, especially in the proximal sphincter area, occurs under optimum viewing conditions. The position of the proximal stricture end near the sphincter is repeatedly checked endoscopically during the operation if necessary (▫ Fig. 24.4A–D).

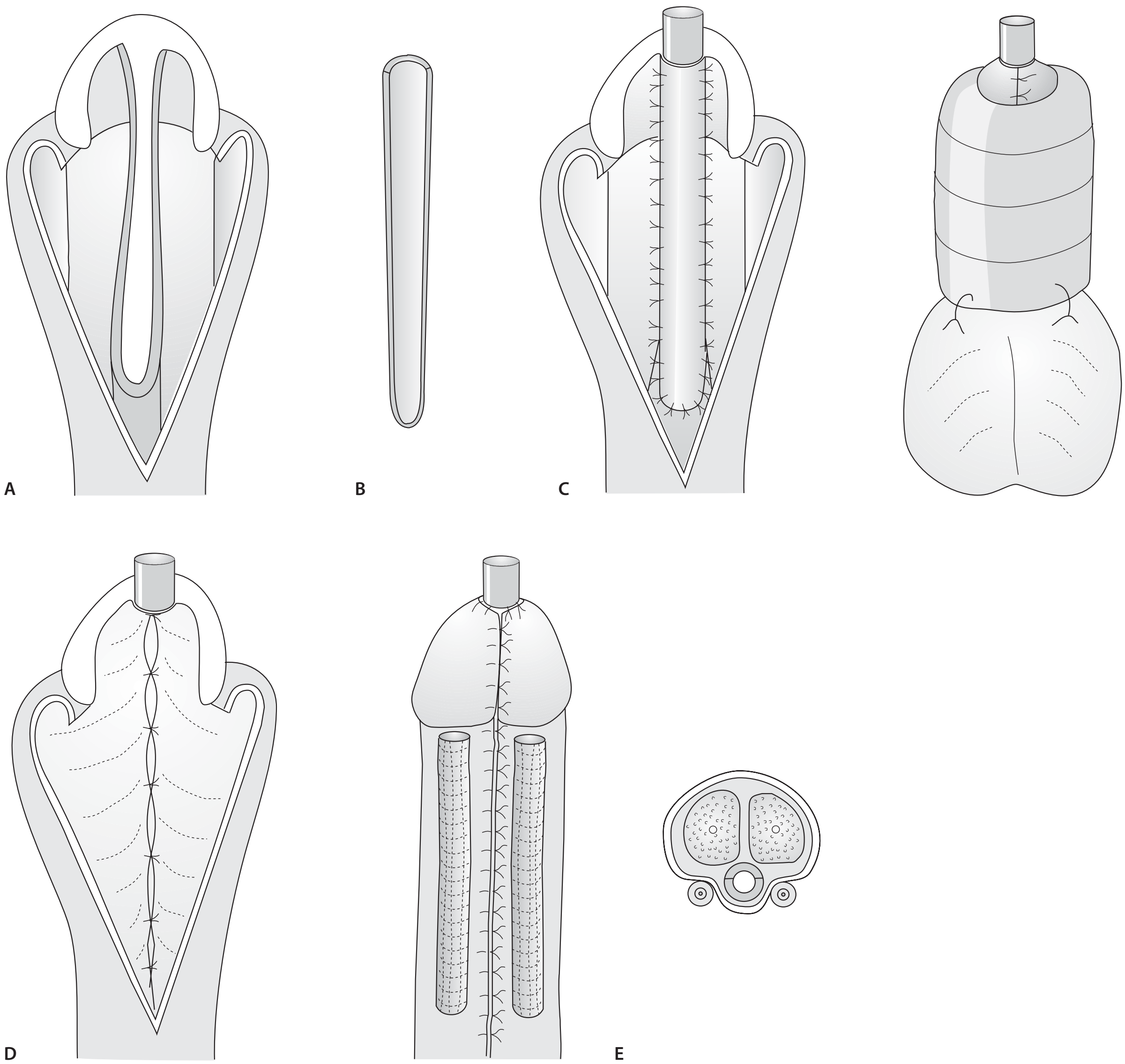
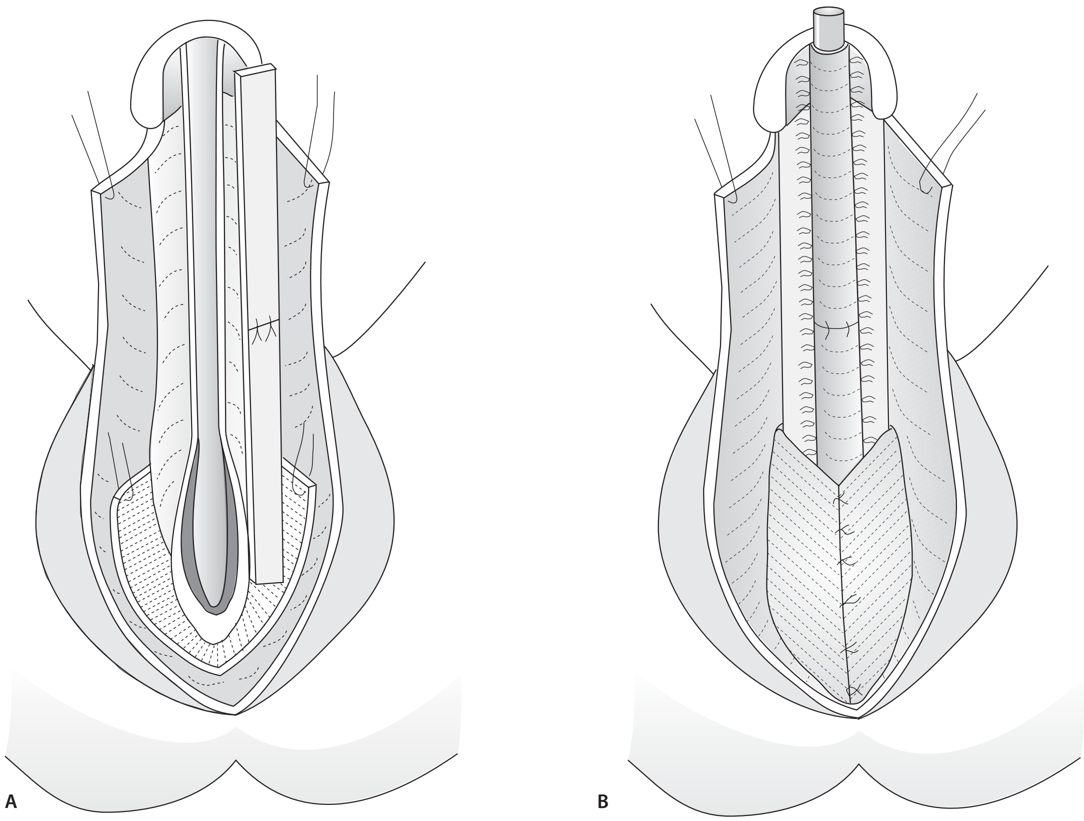


Fig. 24.2A–F. Reconstruction of the penile urethra with buccal mucosa onlay patch. **A** Ventral incision in the urethra from meatus into the healthy tissue. **B** Prepared buccal mucosa graft. **C** Placing of the buccal mucosa graft over a stent and anastomosis with the urethral plate with interrupted sutures. **D** Covering of the new reconstructed urethra with well-vascularized tissue. **E** Midline closure of the glans and the penis shaft skin. Placement of two rolled ointment gauze pads parallel to the new reconstructed urethra. Sectional view

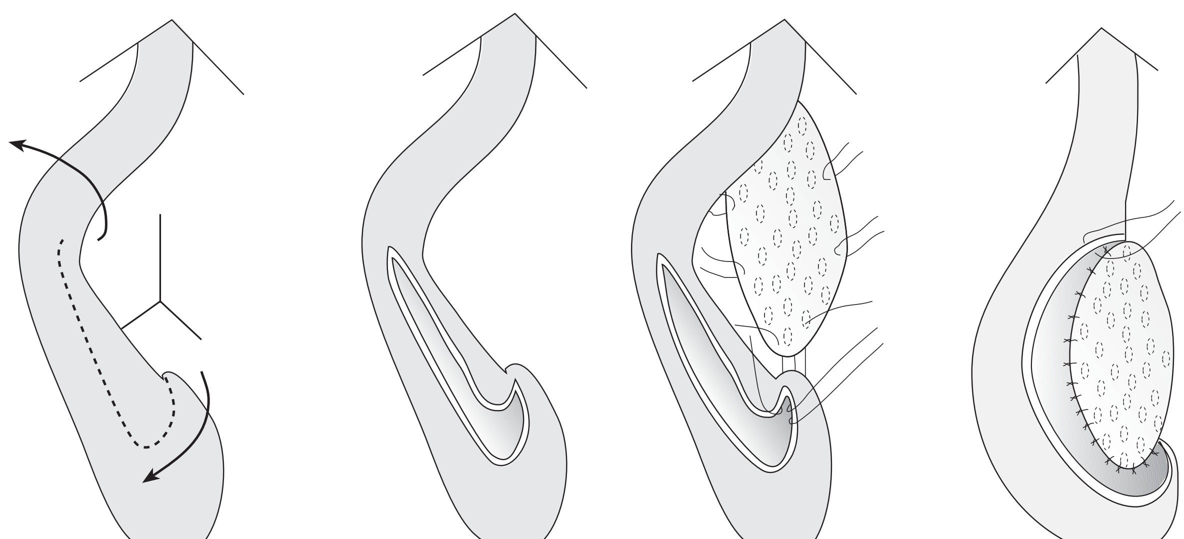
The patient is placed in a lithotomy position. The perineal incision is made midline and the presentation of the proximal urethra and the musculus bulbospongiosus is made much easier by the use of a wound holder having elastic bands reinforced with hooks. The musculus bulbospongiosus is separated midline and the bulbar urethra is mobilized. The penile urethra is then mobilized caudally into the pars pendulans urethra area. The incised urethra is identified and endoscopically examined again to confirm that the externally visible incision corresponds to the internal incision. The incision is otherwise suitably lengthened. The buccal mucosa graft, tailored to the urethral defect and perforated in multiple places with a scalpel, is then sutured to the incised urethra in the proximal area with 5-0 polyglecaprone-interrupted sutures. The sutures are first placed but not knotted until three or four sutures have been placed on each side. The buccal mucosa graft, with its rough sides facing, is then sutured to the corpora cavernosa penis. The buccal mucosa graft, thus stretched out on the rear face of the corpora cavernosa, is then affixed, first on the left side and then on the right side, with interrupted sutures. The musculus bulbospongiosus is then carefully closed midline and the wound is drained with mini-Redons and closed in layers. Urinary drainage is effected with a 16-Fr silicone catheter and additionally with a suprapubic catheter. The catheter is removed after 10 days if the radiological check shows an absence of extravasation or otherwise left in place for another week.



A

B

Fig. 24.3A, B. Reconstruction of a panurethral stricture with buccal mucosa onlay patch. **A** The urethral stricture was incised from the glans tip deep into the healthy area of the bulbar urethra. The musculus bulbospongiosus was separated in the middle and held aside with stay sutures. The two buccal mucosa grafts were anastomosed together. **B** The reconstruction of the urethra was effected with a stent of suitable size. The musculus bulbospongiosus was reanastomosed midline



A

B

C

D

Fig. 24.4A–D. Reconstruction of the bulbar urethra with buccal mucosa. **A, B** The exposed and mobilized proximal penile and bulbar urethra is rotated, so that the incised stricture is presented. **C** The buccal mucosa patch in then affixed in the proximal area of the incised stricture with interrupted sutures. The patch is then sutured to the tunica albuginea of the corpora cavernosa. **D** First the left side and then the right side of the incised urethra is sutured to the fixed buccal mucosa patch

24

24.6 Conclusions

Buccal mucosa free grafts have several advantages over the foreskin or penile shaft skin in reconstructive urethral surgery. The material is easy to harvest, relatively thick, mechanically stiff, and elastic. Its resistance to infection and the thin lamina propria improve graft take. It is resistant to skin diseases and therefore the material of choice for the treatment of patients with BXO. In circumcised patients and patients with defects of penile skin, the use of buccal mucosa makes the reconstruction of long urethral strictures possible in one session. In patients with complete loss of the urethra, two-stage procedures are preferred because the results of a patch urethroplasty are much better. The Barbagli technique of dorsal patch urethroplasty combined with visual urethrotomy has several advantages. The endoscopy incision offers optimum conditions for identification of the scared urethra and the dorsal position of incision avoids the bleeding problems associated with ventral bulbar urethral incisions. In most patients, the dorsal position of the graft avoids pouch formation with concomitant postvoid dribbling and urinary tract infections. The special characteristics of buccal mucosa give some hope that the initial satisfactory results will be unchanged in long-term follow-up.

Editorial Comment

The long-term results are now available, published by the Mainz Group in 2004 [19], entitled 'Long term outcome of ventral buccal mucosa onlay graft urethroplasty for urethral stricture repair'.

Sixty-seven patients underwent ventral buccal mucosa onlay graft surgery for urethral stricture repair. All patients had undergone prior internal urethrotomy, mean 2.9 procedures. The average length of the strictures was 4.3 cm (range, 3–17 cm). Thirty-two patients were followed longer than 5 years (mean, 6.9 years). The overall complication rate was 25% (80/32) with one fistula, one graft necrosis and four recurrent strictures on the proximal anastomosis treated successfully with internal urethrotomy. No case of periurethral diverticulum was observed radiologically or clinically. Two lower lip scars with transient impairment of lip motility were observed.

In conclusion, with all complications occurring within the first 12 months, the long-term results over a period of 10 years are promising. The ventral onlay graft has shown an outcome with success similar to the outcome of the dorsal procedure.

References

1. Andrich DE, Mundy AR (2001) Substitution urethroplasty with buccal mucosal free grafts. J Urol 165:1131–1134
2. Barbagli G, Selli C, Tosto A, Palminteri E (1996) Dorsal free graft urethroplasty. J Urol 155:123–126
3. Baskin LS, Duckett JW (1995) Buccal mucosa grafts in hypospadias surgery. Br J Urol 76:23–30
4. Bürger PA, Müller SC, El Damankoury H, Tschakaloff A, Riedmüller H, Hohenfellner R (1992) The buccal mucosa graft for urethral reconstruction: a preliminary report. J Urol 147:662–664
5. Depasquale I, Park AJ, Bracka A (2000) The treatment of balanitis xerotica obliterans. Br J Urol 86:459–465
6. El-Kasaby AW, Fath-Alla M, Noweir M, El-Halaby MR, Zakaria W, El-Beialy MH (1993) The use of buccal mucosa patch graft in the management of anterior urethral strictures. J Urol 149:276–278
7. Filipas D, Fisch M, Fichtner J, Fitzpatrick J, Berg K, Storkel S, Hohenfellner R, Thüroff JW (1999) The histology and immunohistochemistry of free buccal mucosa and full-skin grafts after exposure to urine. Br J Urol 84:108–111
8. Greenwell TJ, Venn SN, Mundy AR (1999) Changing practice in anterior urethroplasty. Br J Urol 83:631–635
9. Humby G (1941) A one-stage operation for hypospadias. Br J Surg 29:84–92
10. Jordan GH (2002) Principles of tissue transfer techniques in urethral reconstruction. Urol Clin North Am 29:267–275
11. Kane CJ, Tarman GJ, Summerton DJ, Buchmann CE, Ward JF, O'Reilly KJ, Ruiz H, Thrasher JB, Zorn B, Smith C, Morey AF (2002) Multi-institutional experience with buccal mucosa onlay urethroplasty for bulbar urethral reconstruction. J Urol 167:1314–1317
12. Kröpfl D, Tucak A, Prlic D, Verweyen A (1998) Using buccal mucosa for urethral reconstruction in primary and re-operative surgery. Eur Urol 34:216–220
13. Mundy AR (1993) Results and complications of urethroplasty and its future. Br J Urol 71:322–325
14. Mundy AR (1995) The long-term results of skin inlay urethroplasty. Br J Urol 75:59–61
15. Pansadoro V, Emiliozzi P, Gaffi M, Scarpone P (1999) Buccal mucosa urethroplasty for the treatment of bulbar urethral strictures. J Urol 161:1501–1503
16. Roehrborn CG, McConnell JD (1994) Analysis of factors contribution to success or failure of 1-stage urethroplasty for urethral stricture disease. J Urol 151:869–874
17. Schreiter F, Noll F (1987) Meshgraft urethroplasty. World J Urol 5:41–46
18. Wessells H, McAninch JW (1998) Current controversies in anterior urethral stricture repair: free-graft versus pedicled skin-flap reconstruction. World J Urol 16:175–180
19. Fichtner J, Filipas D, Fisch M, Hohenfellner R, Thüroff JW (2004) Long-term outcome of ventral buccal mucosa onlay graft urethroplasty for urethral stricture repair. Urology 64:648–650

Two-Stage Procedures

Two-Stage Mesh-graft Urethroplasty

F. Schreiter

25.1 Introduction

Most uncomplicated strictures of the anterior and posterior urethra are successfully treated with a one-stage procedure. Among these procedures are stricture resection and consecutive end-to-end anastomosis or contemporary methods of tissue transfer such as flap procedures. However, complex strictures with significant scar tissue formation of the urethra, strictures that have undergone prior repeated surgery, and urethra malformations found in severe hypospadia cases continue to present a challenge for surgery. The problems arise from a lack of the healthy elastic tissue needed to reconstruct the urethra. This applies in particular for long strictures that involve the entire length of the urethra.

The classical two-stage methods developed in the 1950s, represented here by the Bengt-Johanson procedure, were based on marsupilization of the restricted urethra, followed by a second operative stage after the first stage had healed. All these methods used scrotal or perineal skin for reconstructing the urethra. Bengt-Johanson's great achievement was the development of a reconstructive-surgery urethral treatment that is suitable for all types of strictures. However, the drawback of this method was that hair growth occurred because scrotal and perineal skin was used, which could lead to chronic urinary tract infection, abscesses, calculi, and fistulas. Scrotal skin, which is extremely elastic, often resulted in the formation of diverticula and sacculations in the neourethra.

Consequently, the author investigated the use of the mesh-graft procedure in an attempt to become independent of scrotal or perineal skin by using hairless skin, which is transplanted free in a two-stage procedure. The high contraction and stricture recurrence rate, when penile hairless skin was used in a single stage procedure, precluded us from using our technique as a single-stage procedure.

Although the two-stage mesh-graft procedure as a safe operation can be used for every type of stricture, its real advantage is apparent when used for complex strictures, especially when there is severe scar tissue formation and absence of healthy penile skin for reconstruction of the neourethra.

25.2 Basic Considerations in Complex Urethral Strictures

The surgical principle is the free transfer of full-thickness skin (inner layer of the foreskin or distal penile skin), or very thin split-skin grafts in circumcised patients. A mesh-graft dermatome is used to process the loose grafts into a mesh. This mesh-graft is transplanted to the location of the exposed and marsupialized urethra. After the complete epithelialization of the free transplanted mesh-graft, there will be an ample amount of hairless, vital, and soft tissue that can be used to reconstruct the new urethra in a second surgical stage.

To improve surgical results, three important principles should be taken into account when performing surgery on complex urethral strictures:

1. The tissue required to easily shape a new urethra that is wide enough and free from tension can be created through loose transplants of full-thickness skin (the inner layer of the foreskin has proven best for this purpose) or distal penile shaft skin, or – in most cases of long and complicated strictures – split-skin grafts.
2. This results in a neourethra that is free from hair, thereby preventing chronic infection, calculus formation, restricturing, and sacculation.
3. Free grafts should heal in an open and dry environment. This requires a two-stage surgical procedure. Therefore, for reasons of dependability and security, very complex strictures should be treated with a two-stage surgical procedure.

Two-stage mesh-graft urethroplasty meets these requirements for treating complex urethral strictures.

25.3 Pathophysiology

Extended and complex urethral strictures are either iatrogenic, the result of a traumatic insertion of endoscopic instruments (catheter, cystoscope, resectoscope) or the result of a urethritis caused by prolonged indwelling catheter use. This especially occurs with long-term indwelling catheter treatment in patients with cardiac or post-traumatic shock, through pressure necrosis and hypotension. Secretion of mucous and infection along the catheter in conjunction with pressure damage caused by the foreign body (catheter) promote the formation of periurethral infiltrates. The infection then leads to the formation of scarred bridges between opposite regions of mucous membranes, and above all to a cicatricial contraction of the corpus spongiosum urethrae (spongiofibrosis). Postoperative infections, calculus formation, and recurrence caused by repeated operations on a urethral stricture, especially when scrotal skin was used to reconstruct the urethra, results in an extended and complex stricture, often affecting the meatus of the urethra. The more pronounced the scarring, the greater the urethra's tendency to shrink and the more extensively the urethral stricture will manifest.

25.4 Preparing for Surgery

The patient's genital area is shaved, including the perineal region. The bowels are thoroughly emptied prior to surgery using laxatives.

25.4.1 Position

In frontal urethral stricture cases, patients can be positioned in a supine position. The lithotomy position is used in cases of posterior or extended strictures.

25.4.2 Instruments

Compressed air or an electrically driven split-skin dermatome for harvesting the split thickness skin graft and a mesh-graft dermatome to prepare the mesh (e.g., E. Zimmer with 1×1.5 matrix), one or two 1–1.5 ratio mesher sheets, a set of Béniqué sounds, knob sounds, bipolar pick-ups for electrocoagulation, and Metzenbaum scissors are required for surgery.

25.5 Surgical Technique

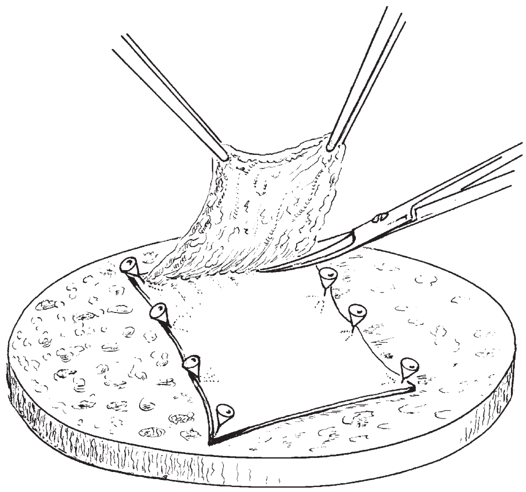
25.5.1 Posterior Urethroplasty

25.5.1.1 First Stage

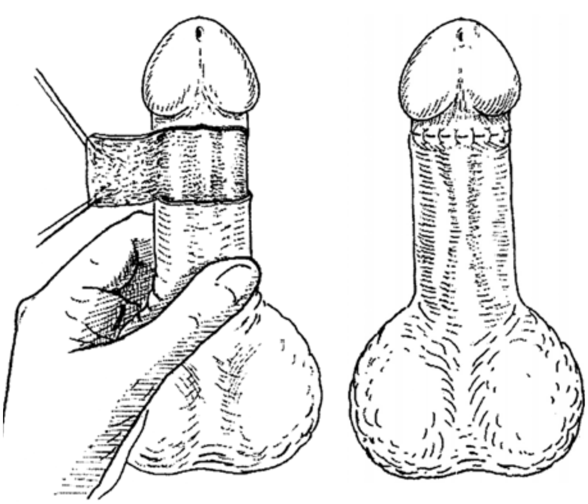
In uncircumcised patients, the foreskin is used, as this tissue is best suited for full-thickness skin grafts. First, perform an extended circumcision (◘ Fig. 25.1). Stretch the 50–60 cm^2 of foreskin obtained in this way onto the cork board, carefully and completely remove the subcutaneous tissue using the scissors. The fatty tissue has been completely removed when no larger vessels are visible on the full-thickness skin graft. This is necessary to achieve rapid revascularization of the free graft from the nutritive base (◘ Fig. 25.2).

If no foreskin is available, thin split-skin grafts may be used. Here, skin from the inside thigh, the groin above the hairline, and buttocks is an obvious choice due to the lithotomy position of the patient undergoing urethral surgery.

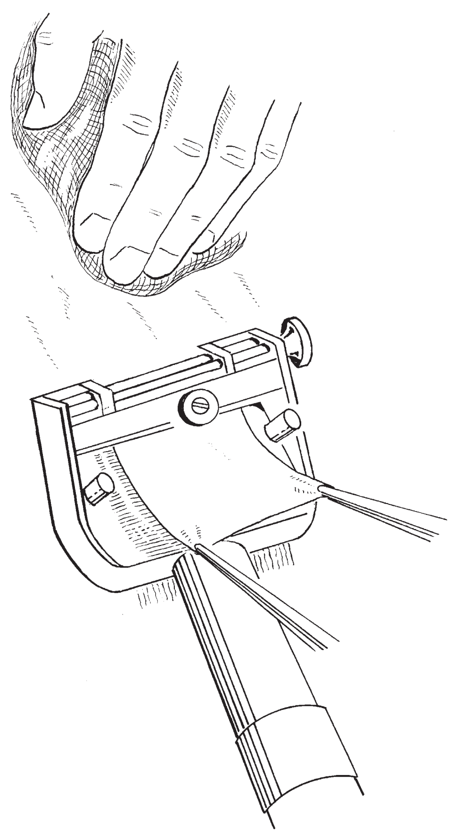
To remove the split skin, use an electric or compressed-air-driven split-skin dermatome with adjustable incision width and size (◘ Fig. 25.3A, B).



◘ **Fig. 25.2.** Defatting of the graft



◘ **Fig. 25.1.** Circumcision



◘ **Fig. 25.3.** Harvesting of the mesh-graft (split-skin dermatoma)

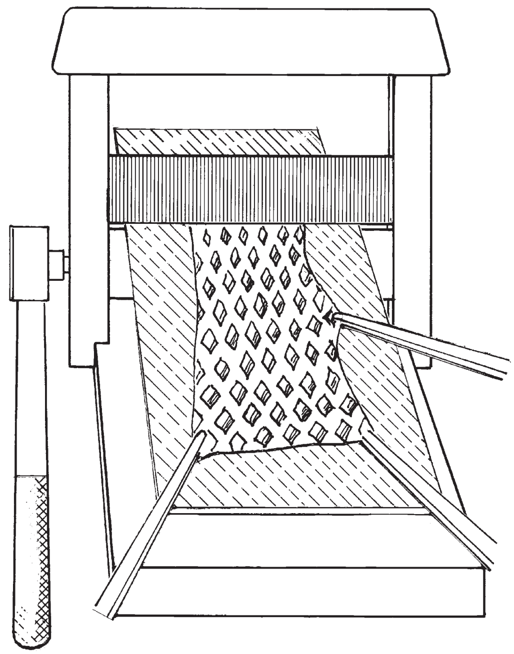
Using a mesh-graft dermatome, the foreskin or shaft skin is processed to a mesh, in a 1:1.5 ratio (◘ Fig. 25.4).

The skin on the penile shaft is incised in the raphe along the length of the stricture (◘ Fig. 25.5).

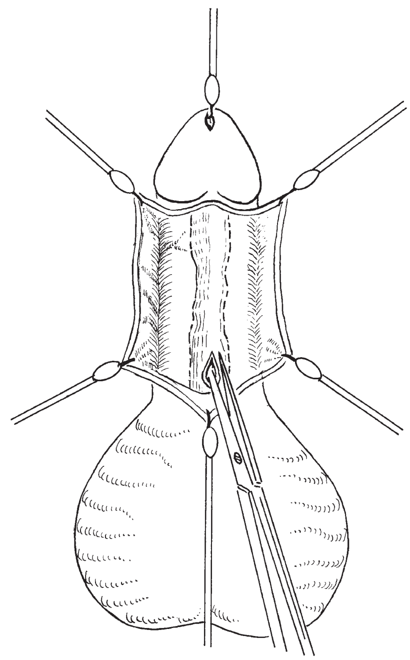
The stricture is cut open along its length with a pair of scissors (◘ Fig. 25.6).

The stricture must be laid open down to the healthy urethral tissue, where no spongiofibrosis is evident along the spongy body of the urethra (◘ Fig. 25.7).

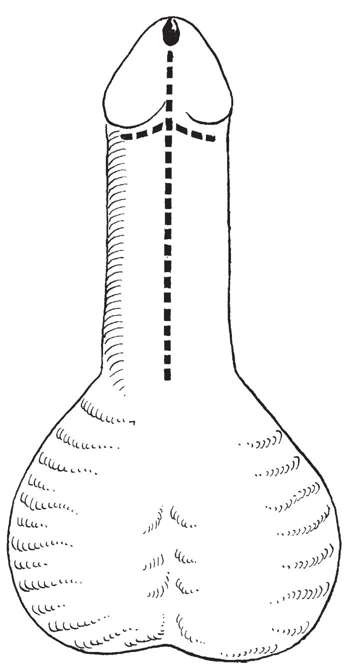
The free meshed graft is sewn into the edge of the marsupialized urethra and the edge of the penile skin. As there is a certain shrinkage tendency during the healing



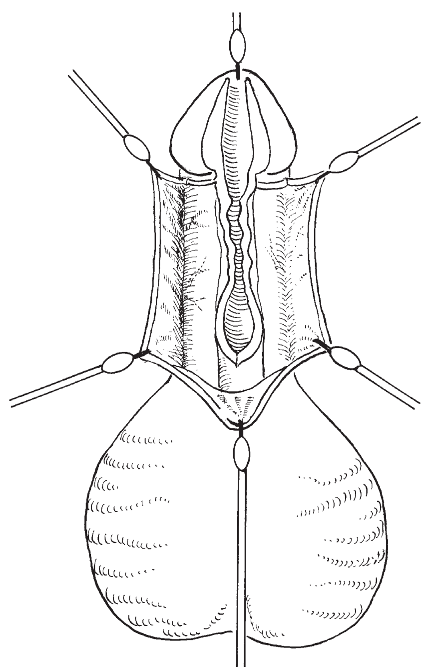
◘ **Fig. 25.4.** Meshing the graft (mesh-graft dermatoma)



◘ **Fig. 25.6.** Marsupialization of the strictured urethra



◘ **Fig. 25.5.** Skin incision in anterior strictures



◘ **Fig. 25.7.** Stricture opened

process, the sewn-in grafts should be as wide as possible. The graft is fixed in place by means of a interrupted, running, absorbable suture (Fig. 25.8).

After 1–2 weeks, the graft has healed and the epithelization is complete.

After 8–12 weeks, the graft has stabilized to such an extent that the 2nd stage of the surgery, shaping the new urethra, can be carried out

25.5.1.2 Second Stage

The second stage is performed after complete epithelialization of the graft. The reconstruction of the neourethra should be not performed before 8 weeks. The longer the time between the first and the second step of the operation, the better the quality of the tissue that is used for the reconstruction of the urethra.

A sufficiently wide circumferential incision of the graft is made (Fig. 25.9).

The mobilization of the transplanted penile skin has to be directed laterally, not mobilizing the transplant tissue, which is used for the reconstruction of the neourethra.

A 24-Fr catheter is used to close the graft, which is elastic, supple, has good circulation, and tends to roll up, with an interrupted running suture using absorbable monofilament thread. Pick a suture technique whereby an inverting, interrupted stitch occurs at the outside of the cut edge of the graft, resulting in suture without leaving epithelium insulae outside, which prevent later fistulas (Fig. 25.10).

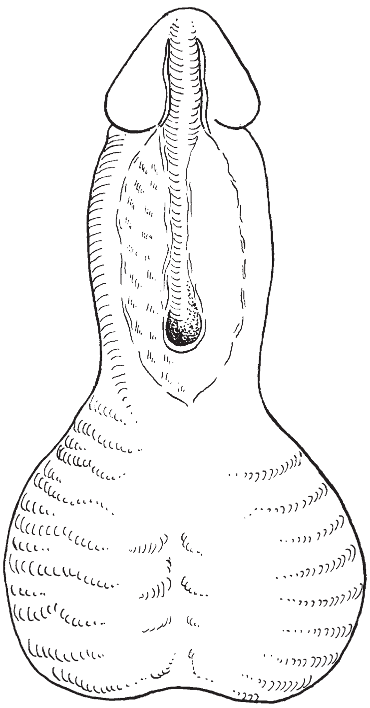


Fig. 25.9. Healed transplant

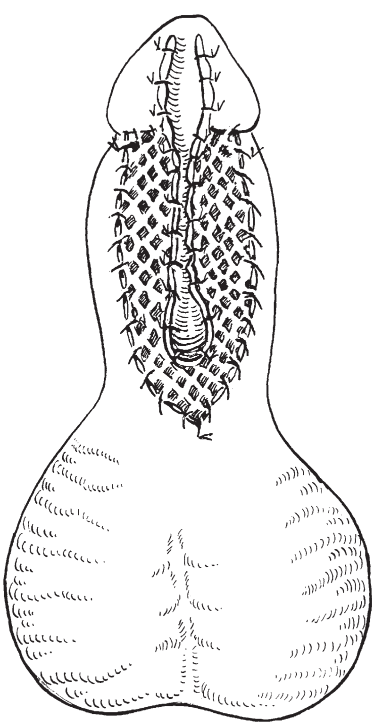


Fig. 25.8. Mesh-graft transplant, sutured

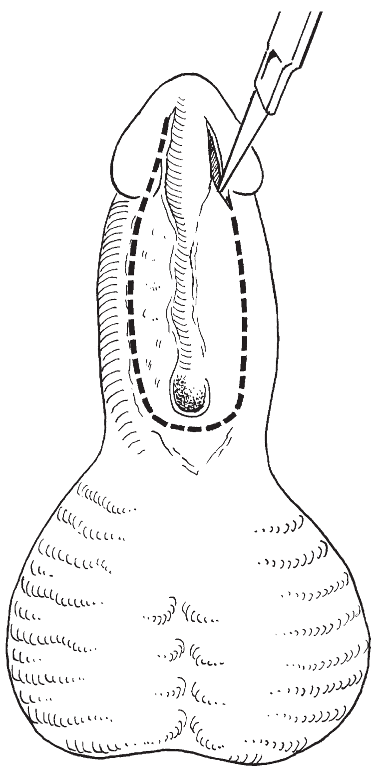


Fig. 25.10. Peritomy of the healed transplant

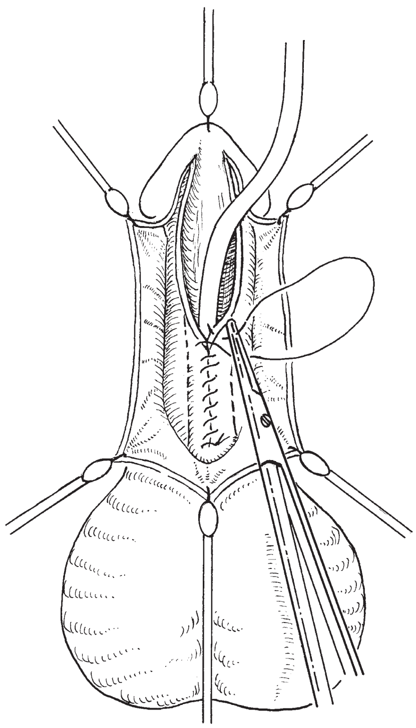
To cover the skin defect, the penile shaft skin must now be completely mobilized. Use the scissors to remove the epithelium from the edges of the glans; this will form the posterior wall of the meatus to be created (◘ Fig. 25.11).

To begin forming an asymmetrical advancement flap according to Marberger and Byars, the outer penile skin has to be incised dorsally (◘ Fig. 25.12).

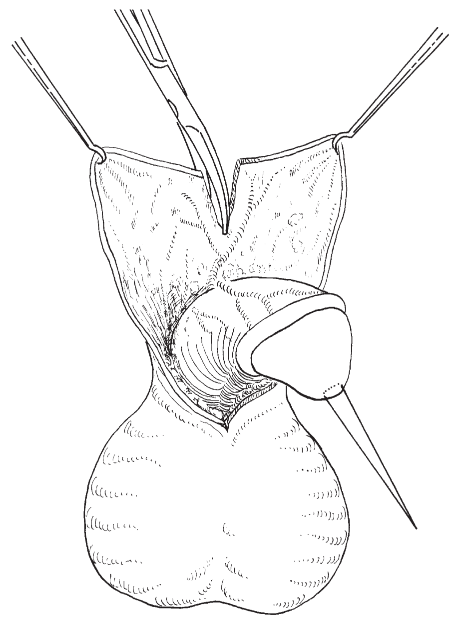
On the dorsal side of the penis, connect the skin of the penile shaft to the edge of the inner foreskin layer on the glans with single stitches (◘ Fig. 25.13).

The top of the flap of penile shaft skin, which has been rotated to the front, is sewn to the edges of the glans, from which all epithelium has been removed, to form the anterior wall of the passage to be formed. This puts the meatus nearly at the tip of the glans.

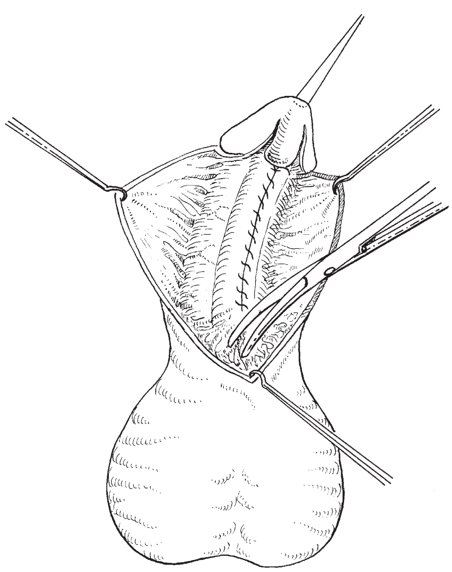
The asymmetrical rotation flap is put on the penile shaft in such a way that the suture line of the newly formed neourethra is covered (◘ Fig. 25.14).



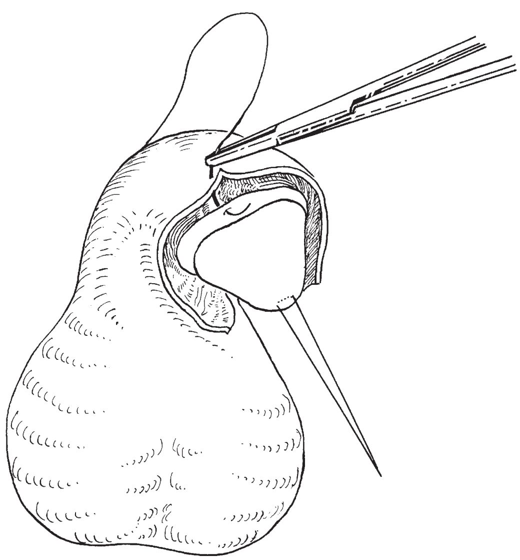
◘ **Fig. 25.11.** Reconstruction of the neourethra(see suture technique)



◘ **Fig. 25.13.** Dorsal incision and creating the Byars flap



◘ **Fig. 25.12.** Mobilizing the penile skin



◘ **Fig. 25.14.** Suture of the skin to the coronal rim

The Marberger/Byars sliding-flap technique completes the stricture repair (Fig. 25.15).

A loose circular pressure bandage ensures good hemostasis. Thin suction drainages may be used for draining.

25.5.2 Posterior Urethroplasty with Partial Replacement of the Urethra

The bulbar section of the urethra is nearly always easily accessed via a midline perineal incision. Other access paths to the rear of the urethra, involving the formation of a broad-base perineal flap, are usually unnecessary and are only required if there is extreme scarring in the perineal raphe.

The completely obliterated urethra is laid open and resected, exposing the proximal and distal healthy urethra (Fig. 25.16).

The resultant urethral defect is lined with a meshgraft and fixed at the edge of the perineal skin and at the rim of the urethral stumps with monofilament suture 5-0 (Fig. 25.17).

After healing of the transplant, the reconstruction of the urethra is made analogously to the anterior urethroplasty.

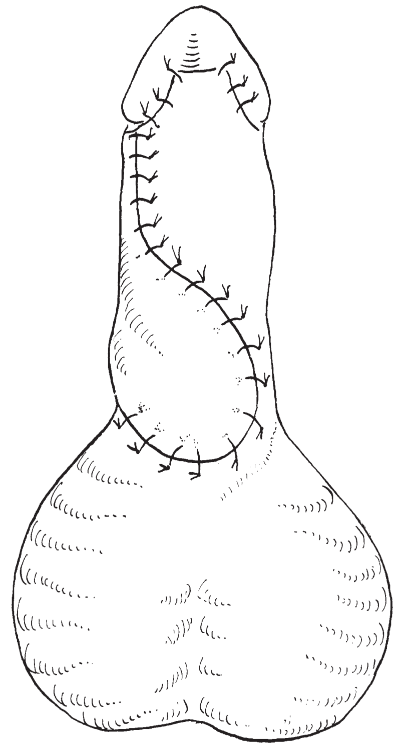


Fig. 25.16. Finishing the Byars flap.

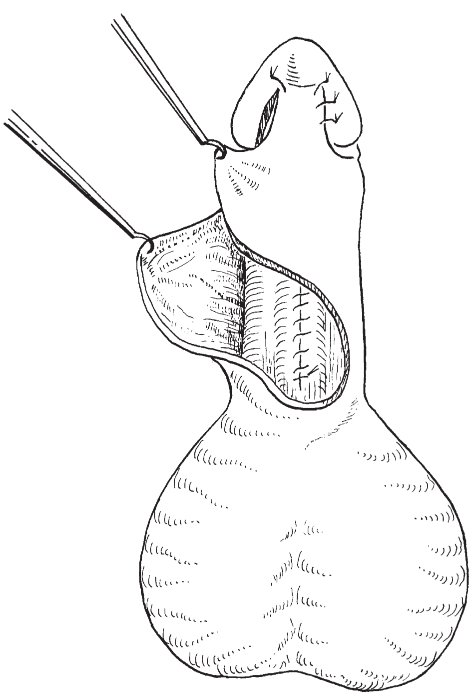


Fig. 25.15. Creating the meatus by asymmetric flap (Byars)

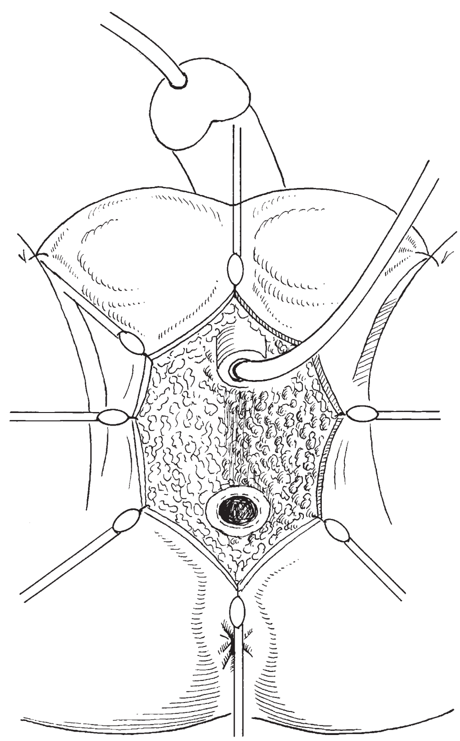


Fig. 25.17. Total resection of a posterior complete stricture.

25.5.3 Complex Strictures Along the Entire Length of the Urethra

In complex strictures that run the length of the urethra, the stricture is best opened by dividing the scrotum. Therefore, the skin incision runs through the raphe of penis, scrotum, and peritoneum (Fig. 25.18).

After splitting of the M. bulbocavernosus, the urethral stricture is cut open lengthwise with the scissors up to the healthy urethral tissue (Fig. 25.19).

To reduce the resultant graft surface, the side of the scrotum is stitched up above the testicles (Fig. 25.20).

To arrive at a sufficient amount of transplantable tissue, it is necessary to resort to a split-skin graft at this point. If foreskin is available, it is best used for the penile part of the urethra (Fig. 25.21).

After the healing of the graft, it is peritomized, as in the treatment of frontal strictures, the lateral scrotum sutures are opened in order to restore the anatomy of the scrotum after the urethra has been reconstructed. When

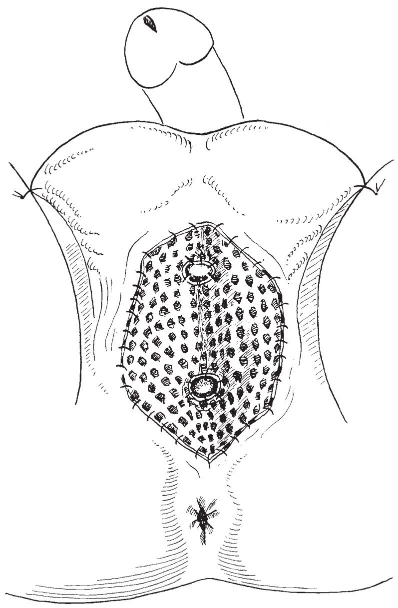


Fig. 25.18. Covering the wound with mesh-graft

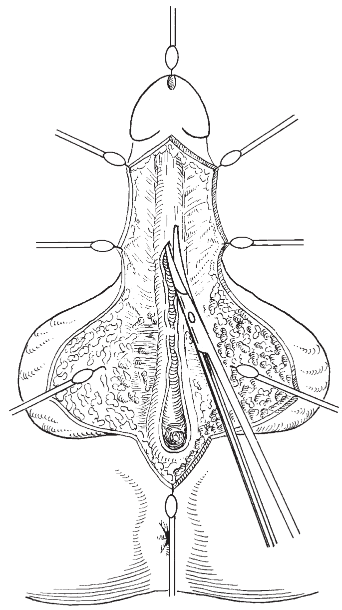


Fig. 25.20. Division of the scrotum and marsupialization of the urethra

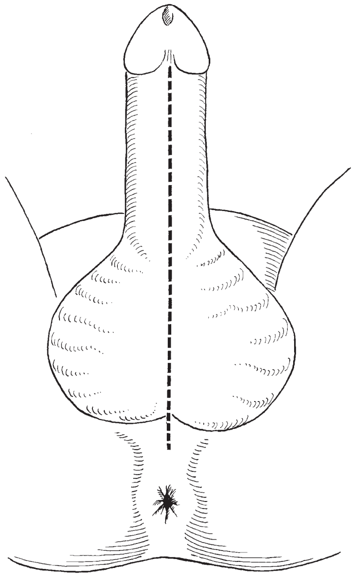


Fig. 25.19. Incision of a total stricture of the urethra

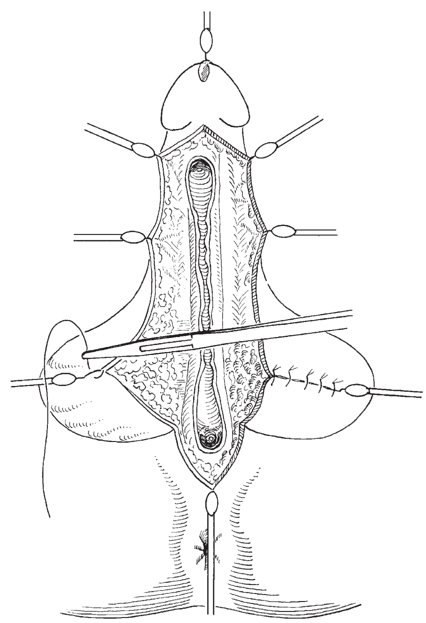


Fig. 25.21. Narrowing of the transplant surface

circumcising the graft, special attention should be paid to ensure that the graft is well separated in the bulbous part and is not cut too widely, in order to prevent pouch-like diverticulation at this location (Fig. 25.22).

The neourethra is closed analogously to the method shown for the frontal stricture, using inverting running stitches, as an interrupted, running suture using 4-0 monofilament absorbable material (Fig. 25.23).

After the reconstruction of the neourethra, the penile shaft skin is once again sewn across the neourethra's suture row as an asymmetrical sliding flap (Figs. 25.24, 25.25).

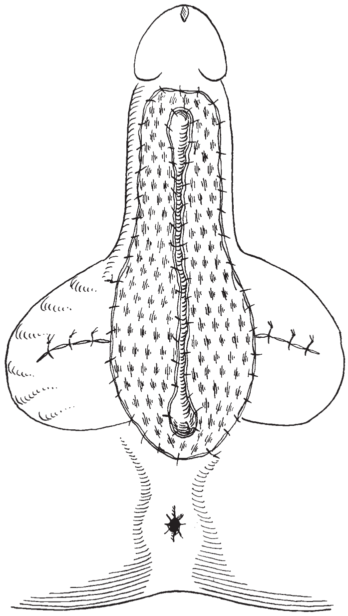


Fig. 25.22. Meshing the defect

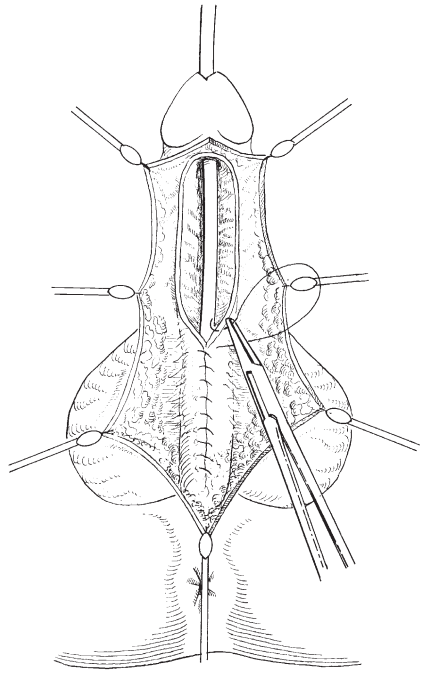


Fig. 25.24. Creation of the neourethra

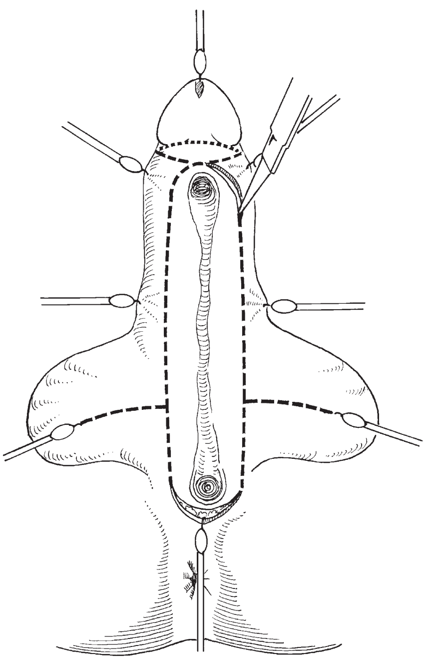


Fig. 25.23. Peritomy of the healed transplant and cutting lines to reconstruct the scrotum

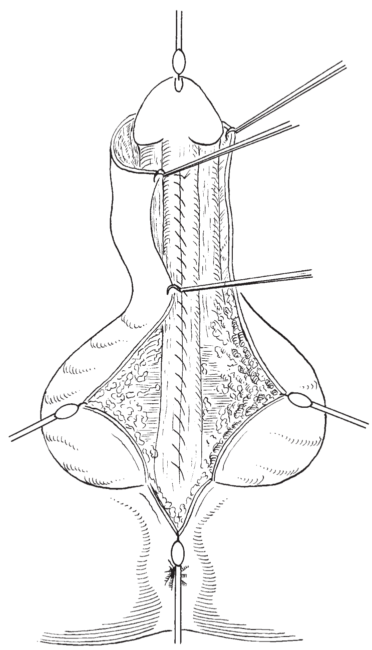


Fig. 25.25. Covering the skin defect (asymmetric flap) and reconstruction of the scrotum

25.6 Tricks and Pitfalls in Mesh-Graft Urethroplasty

Mesh-graft urethroplasty is not suited for primary hypospadia repair. The mesh-graft should not be placed directly on the spongy body of the penis' »naked« tunica albuginea once the chorda has been removed. There would be interaction between the mesh-graft and the tunica albuginea, causing the graft to scar, resulting in another cordlike scar and a bent penis.

However, two-stage mesh-graft urethroplasty is a good choice for reconstructing the urethra in severe hypospadia cases. Once the scar tissue has been removed, these patients, who have typically undergone several prior operations, usually have enough soft subcutaneous tissue that can serve as a nutritive base for the mesh-graft transplant, like the tunica dartos of the scrotum. To have a nutritive tissue sheet between the tunica albuginea of the penis and the transplant is of extreme importance for the soft and scar-free healing of the transplanted graft.

Because split-skin grafts tend to shrink and form scars, it is important to ensure that the grafts are not cut too thick when taking a split-skin graft. The grafts should be so thin that they are translucent and that writing on the base underneath the transplant remains legible through it.

When using foreskin as a full-thickness skin graft, extreme care must be taken to completely remove the layer of fat from the underside of the graft, to allow for rapid immigration of capillary blood vessels into the graft. In full-thickness skin grafts, revascularization always takes a bit longer than in split thickness skin grafts, and the danger of transplant rejection is greater in full-thickness skin grafts. Any remaining subcutaneous fat prevents the rapid revascularization of the full-thickness skin grafts.

25.6.1 Dressing Technique

The technique used to dress the area is of extreme importance. This is particularly true for dressing after the first stage. Movements between the mesh-graft and the underlying surface as well as contact with the opposite mesh-graft planes must be avoided under all circumstances.

To achieve this, fatty gauze is used to cover the entire wound area. Additionally, an edge of a strip of the fatty gauze is inserted into the proximal and distal ends of the urethra, because here the contact of the opposite mesh-graft planes is likely (Fig. 25.26).

Absorbant gauze soaks up the wound secretions, whose production is increased during the first postoperative days. The gauze keeps the wound bed dry and supports healing (Fig. 25.27).

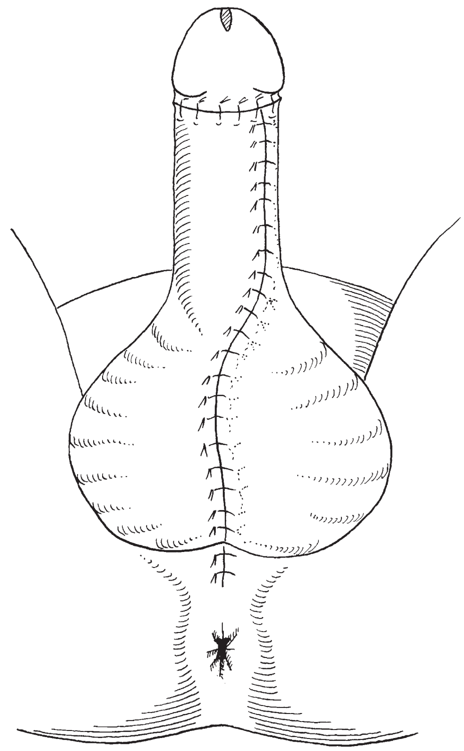


Fig. 25.26. The completed reconstruction

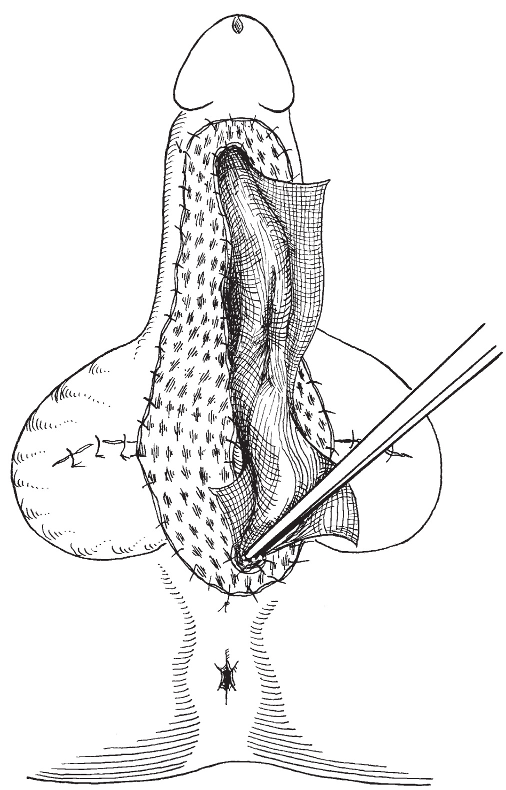


Fig. 25.27. Dressing. Fatty gauze is inserted into the proximal and distal urethra to prevent stenosis

To apply gentle pressure to the mesh-graft and to enhance contact to the underlying surface, an elastic bandage fixes the previously mentioned layers of dressing (Fig. 25.28).

The first change of the dressing should not be done until a period of 5–7 days has elapsed. In this period, the revascularization of the graft takes place, and this phase of revascularization should not be interrupted by an early change of the dressing (Fig. 25.29).

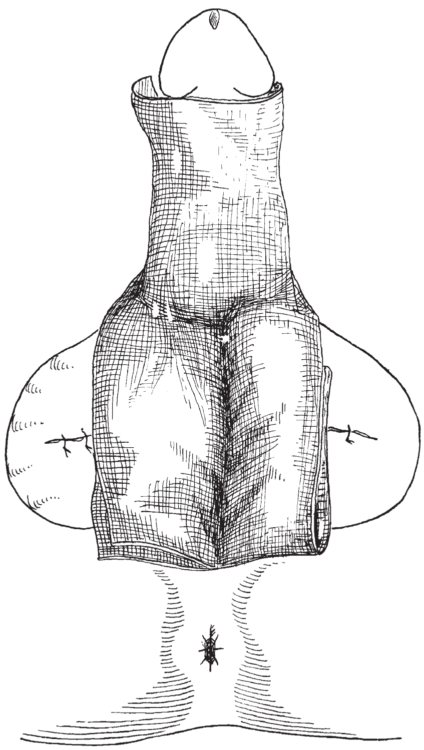


Fig. 25.28. Dressing. Fatty gauze between the two transplanted surfaces to prevent bridging and adhesion.

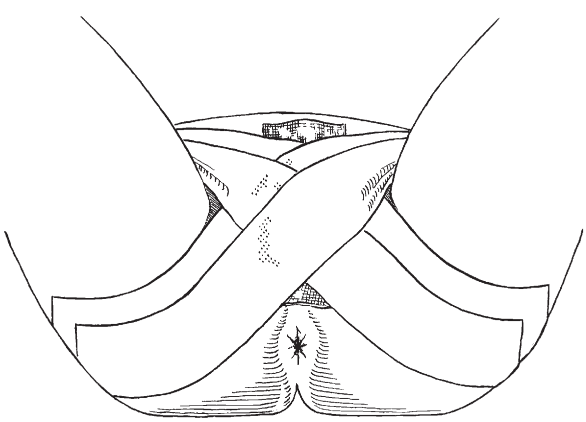


Fig. 25.29. Dressing. An elastic bandage fixes the dressing over the graft

25.6.2 Postoperative Care

Postoperatively, bowel movement should be avoided for at least 5–7 days. This can be managed by the use of tinctura opii or other bowel movement-stopping drugs. This stopping of bowel movement is especially important in long or posterior strictures, because fecal contamination is likely due to the extent of the incision. These patients are kept on bed rest for 7 days and are not allowed to walk for another week.

References

1. Blandy JP, Singh M, Tresidder GC (1968) Urethroplasty by scrotal flap for long urethral strictures. Brit J Urol 40:261–267
2. Byars LT (1995) A technique for consistently satisfactory repair of hypospadias. Surg Gynecol Obstet 100:184–190
3. Devine PC, Horton CE, Devine CJ Sr, Devine CJ Jr, Crawfort HH, Adamson JE (1963) Use of full thickness skin grafts in repair of urethral strictures. J Urol 90:67–71
4. Johanson B (1953) Reconstruction of the male urethra in strictures. Application of the buried intact epithelium tube. Acta Chir Scand. [Suppl] 167:1
5. Marberger H, Bandtlow KH (1976) Ergebnisse der Harnröhrenplastik nach Johanson. Urologe A 15:269–272
6. Schreiter F, Koncz PM (1983) Traitement des sténoses urétrales compliquées par suture urétrale bout-à-bout et urétrplastie par greffe libre de prépuce. In Cuckier J (ed) Les implants cutanés dans la réparation des sténoses urétrales. Necker Masson, Paris, pp 34–41
7. Schreiter F, Noll F (1987) Meshgraft urethroplasty. World J Urol 5:41
8. Schreiter F, Noll F (1989) Mesh-Graft urethroplasty using split-thickness skin graft or foreskin. J Urol 142:1223–1226

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