Atlas of Temporal Bone Surgery

Tuncay Ulug

Thieme

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Professor Tuncay Ulug, MD
Istanbul University
Istanbul Medical Faculty
Department of Otorhinolaryngology
Istanbul, Turkey

345 illustrations

Thieme
Stuttgart · New York

Library of Congress Cataloging-in-Publication Data is available from the publisher.

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Rüdigerstrasse 14, 70469 Stuttgart, Germany
http://www.thieme.de
Thieme New York, 333 Seventh Avenue,
New York, NY 10001, USA
http://www.thieme.com

Cover design: Thieme Publishing Group
Typesetting by Sommer Druck, Feuchtwangen, Germany
Printed in China by Leo Paper Products Ltd, Hong Kong

ISBN 978-3-13-147151-2

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“If the discoloration extends right through the bone, it must be excised and all disease must be extirpated. If there is sound bone beneath, it suffices to remove that which is diseased. It is just the same whether the skull, the breast bone or a rib be affected with caries; cauterization is useless. Excision is imperative.”

Celsus, 2000 years ago …[1]

“Trephined skull of Neolithic period that shows healed wound edges indicating recovery from an operation whose purpose, whether medical or magical, remains unknown.”[2]

[1] Ballance C. Mastoid operation: a glimpse into its history. Archives of Otolaryngology 1932;6:55–75 (With referrence to Pietzcker F. Celsus: Liber Medicinae Octavus. Caput 2. Tübingen.)

[2] Nationalmuseet, Copenhagen; Photograph by Lennart Larsen. In: Lyons A.S., Petrucelli R.J. Medicine: An Illustrated History. New York: Harry N. Abrams Inc. Publishers; 1987. Reproduced with permission.

About the Author

Professor Tuncay Ulug, MD, graduated from Istanbul Faculty of Medicine, Istanbul University, in 1987, and on completing his postgraduate training in otolaryngology at the same institution in 1991, he joined the faculty as an academician. Between 1993 and 2001, over varying periods, he attended several well-reputed clinics in otology, neurotology, skull base surgery and tumor surgery, including Zürich University, St. James's Hospital, Memorial Sloan–Kettering Cancer Center, New York University, Mount Sinai University, George Washington University—Neurosurgical Department, the Mayo Clinic, and the House Ear Institute. In this way, after having learned the modern practices assimilated over nearly 80 years in his institution, and along with the work of many experienced and skilled colleagues around the world, he was inspired mainly by the ear and skull base techniques of Ugo Fisch, the otologic and neurotologic concepts of the House school, the neurosurgical perspectives of the skull base surgeon Laligam Sekhar, and the tumor philosophy of Jatin Shah. Professor Ulug is currently a consultant at the Department of Otorhinolaryngology—Head and Neck Surgery, Istanbul Medical Faculty, Istanbul University.

Professor Ulug's clinical interests encompass the areas of otology, neurotology, skull base surgery and some fields of tumor surgery. He has delivered many scientific presentations and has contributed to many national and international scientific publications. He is a member of several societies including the Politzer Society and the European Academy of Otology/Neuro-Otology. Since 1998, as course director, he has organized the annual "International Istanbul Temporal Bone Dissection and Otology/Neurotology Courses," which attracts participants from countries from all over the world.

Professor Ulug designed the revolutionary "Ulug double-sided ear microsurgery instruments," which have been produced by Karl Storz (Tuttlingen, Germany) since 2007. He has also pioneered several surgical techniques and proposed a number of landmarks, and is currently involved in the development of new middle ear prostheses and more surgical instruments.

Preface

Otology and neurotology have become an increasingly important benchmark for modern microsurgery over the past couple of decades. The mastery of delicate techniques and execution of surgical perfection in this type of high-risk surgery can only be acquired through tremendous effort by those wishing to advance in this area. To develop the basic skills required for this surgery, temporal bone dissections, and related courses and atlases, are the main practical educational tools available.

This atlas is intentionally entitled *Temporal Bone Surgery* rather than *Temporal Bone Dissection*. This is because the procedures carried out on a cadaver bone are exactly the same as those carried out during a live operation—the only difference being the absence of blood. Furthermore, not only are the characteristics of the laboratory dissection explained in the descriptions of the techniques, but also those of live surgery.

The main principle during temporal bone dissections is to carry out as many procedures as possible on each bone. Also, during the live operation, different procedures are carried out either in sequence or simultaneously, in many instances. Therefore, this atlas illustrates more than one procedure being executed and presented in each bone and, consequently, the sequence of surgical techniques presented throughout this atlas is not based on theory, but on surgical practice.

The four principal sections of this book are: General Aspects, Surgical Techniques, Techniques and Designs Developed by the Author, and Appendix with Glossary. To gain a comprehensive understanding of the contents of this book, all sections should be read in sequence. However, before beginning to read the principal sections, the reader should first go over the list of abbreviations, so that the labeling of illustrations may be understood more easily.

The General Aspects section is important from a surgical perspective. In this section, readers will find answers to many questions relating to otologic and neurotologic practice, and tips on how to improve their surgical skills, including the precise use of the burr.

The Surgical Techniques section makes up the main and most comprehensive part of the atlas. In this section, each surgical technique is described step by step in detail using photographic illustrations, all of which have been taken by the author, showing the procedures carried out by the author. Each chapter is devoted to a particular technique and is subdivided into parts as follows: Definition, Indications, Anatomical Orientation, Surgical Steps, and Definitions and Tips; for some techniques, there is an additional part on surgical anatomy. Under the surgical steps, the concepts of the most important landmark (MIL) and the ideal instrument (II) aim to describe the most critical reference points and the surgical instruments necessary for each particular stage of procedure. Additional information required for each particular stage is presented to the reader as Definitions and Tips at the bottom of the page, precluding the need to refer to other sources.

The third section of the book includes definitions of the surgical techniques described and used by the author, and presents surgical instruments designed by the author.

The glossary in the fourth section comprises the main terminology used in otology and neurotology, in alphabetical order. In this part, the terms are described and beneficial tips are also given. In addition, each term has been classified as either an anatomical or a surgical definition. The reader should refer to the glossary as and when necessary.

From the technical publishing perspective, along with the unique way of teaching the procedures step by step, aided by illustrations and descriptions, full-page color photographs and labeled orientation photographs have been included for the first time in such a medical publication. The full-page color photographs show the details and make the book more attractive to read, and the orientation photographs enable easy and precise three-dimensional perception of each technique without creating confusion. Furthermore, the illustrations of the surgical steps are generously labeled, enabling a quick and efficient run-through of the procedures.

Finally, I would like to express my sincere gratitude to Neil Warrington and Cameron Shaw for their invaluable contributions, and to Stephan Konnry, Annie Hollins, Elisabeth Kurz, and the editorial and production staff at Thieme Publishers for their close collaboration and efficient assistance in realizing this arduous publication.

I hope that this book will provide readers with the basic, yet essential, knowledge of skills required while carrying out otologic and neurotologic procedures, both in the laboratory and in the operating room.

Professor Tuncay Ulug, MD
Istanbul, Turkey

Contents

Abbreviations

General Abbreviations

ad	Anatomical definition
sd	Surgical definition
II	Ideal instrument
MIL	Most important landmark

Anatomical and Surgical Abbreviations

A	Antrum
AB	Anterior buttress
AC	Apical turn of cochlea
AD	Aditus
AE	Arcuate eminence
AF	Annulus fibrosis
AH	Ansa hypoglossi
AHSC	Ampulla of horizontal semicircular canal
AN	Accessory nerve
APSC	Ampulla of posterior semicircular canal
ASSC	Ampulla of superior semicircular canal
AU	Auricle
BC	Basal turn of cochlea
BL	Blue line (of SSC)
C	Cochlea
CC	Common crus
CFB	Cervicofacial branch
CHSC	Crus of horizontal semicircular canal
CN	Cochlear nerve
CP	Cochleariform process
CPA	Cerebellopontine angle
CR	Crotch
CS	Cochleostomy
CSF	Cerebrospinal fluid
CT	Chorda tympani
DL	Donaldson line
DM	Digastric muscle
DR	Digastric ridge
EAC	External auditory canal
ECA	External carotid artery
ED	Endolymphatic duct
EG	External genu
EPI	Epitympanum (attic)
ES	Endolymphatic sac
ET	Eustachian tube
FA	Fossa arcuata
FB	Facial bridge
FN	Facial nerve
FP	Facial prominence
FR	Facial recess
FRI	Facial ridge
GF	Glenoid fossa
GG	Geniculate ganglion
GN	Glossopharyngeal nerve
GSPN	Greater superficial petrosal nerve
HA	Hard angle
HF	Hiatus facialis
HN	Hypoglossal nerve
HS	Henle spine
HSC	Horizontal semicircular canal
HTC	Hypotympanic cells
I	Incus
IAC	Internal auditory canal
IB	Incus body
IBR	Intact bridge
ICA	Internal carotid artery
IEAC	Isthmus of external auditory canal
IJV	Internal jugular vein
ILC	Interlabyrinthine cells
IR	Incisura Rivini
IVN	Inferior vestibular nerve
JB	Jugular bulb
KS	Koerner septum
LFN	Labyrinthine facial nerve
LP	Lenticular process
LPI	Long process of incus
M	Malleus
MAC	Macewen triangle
MC	Middle turn of cochlea
MCF	Middle cranial fossa
MEFN	Meatal facial nerve
MF	Mastoid foramen
MFN	Mastoid facial nerve
MH	Malleus head
MM	Manubrium mallei
MMA	Middle meningeal artery
MN	Mandibular nerve
MP	Meatal plane
MPP	Mucoperiosteum of promontory
MT	Mastoid tip
OA	Occipital artery
OMS	Occipitomastoid suture
OW	Oval window

P Promontory
PB Posterior buttress
PCF Posterior cranial fossa
PCS Posterior crus of stapes
PE Posterior epitympanum
PLI Posterior ligament of incus
PON Ponticulus
PP Pyramidal process
PSC Posterior semicircular canal
PSF Periosteum of stylomastoid foramen
PT Posterior tympanotomy
PTM Pterygoid muscles
PTP Pterygoid process

RFC Retrofacial cells
RLC Retrolabyrinthine cells
RW Round window

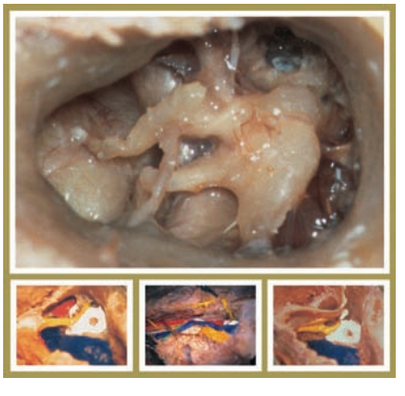
S Stapes
SA Subarcuate artery
SC Scutum
SD Stapedotomy drilling
SDA Sinodural angle
SF Stapes footplate
SH Stapes head
SLI Superior ligament of incus
SLM Superior ligament of malleus
SLR Supralabyrinthine recess
SMAS Superficial musculoaponeurotic system
SO Stapedotomy opening
SPI Short process of incus
SPM Short process of malleus
SPS Superior petrosal sinus
SS Sigmoid sinus
SSC Superior semicircular canal
SSP Superior surface of petrous bone
ST Sinus tympani
STMA Spina tympanica major
STMI Spina tympanica minor
STR Supratubal recess
SUB Subiculum
SVN Superior vestibular nerve

TA Tympanic annulus
TB Tympanic bone
TC Transverse crest
TCW Transposed canal wall
TF Temporalis fascia
TFN Tympanic facial nerve
TG Trigeminal ganglion
TL Temporal line
TLF Three-layer flap
TM Tympanic membrane
TMF Tympanomeatal flap
TMP Temporomandibular joint periosteum
TMS Tympanomastoid suture
TN Trigeminal nerve
TRA Trautmann triangle
TSM Tendon of stapedius muscle
TSS Tympanosquamous suture
TT Tegmen tympani
TTM Tensor tympani muscle
TTTM Tendon of tensor tympani muscle
TZB Temporozygomatic branch

V Vestibule
VC Vertical crest
VFT Vestibulofacial triangle
VN Vagus nerve

ZR Zygomatic root

I General Aspects



1 Introduction

Within the surgical communities, there is a misbelief that surgical techniques were established during the post-war years of the twentieth century. However, publications from the nineteenth and early twentieth centuries refer to earlier pioneering work in these techniques, and, in fact, the origin of surgical techniques can be traced back hundreds, if not thousands, of years.

As with other areas of medicine, the second half of the twentieth century witnessed a major revolution in surgery. However, this revolution did not arise from nothing; this period was actually an era of refinement of existing knowledge and practice. There was an increase in the level of care for human health in general, a development of pharmaceutical treatments including antibiotics, an advance in the safety and use of anesthesia, an improvement in the design of surgical instruments and related technology, increased growth in the awareness of the necessity for documentation, and an increase in the sharing of medical knowledge as a result of advances in communication. In combination, these developments enabled review, revision, and modification of surgical techniques, resulting in a higher percentage of surgical success.

The distinctions made above, I believe, are extremely important. There has always been some form of surgery in existence; therefore, surgeons today cannot fulfill their responsibilities by practicing at an average level. The modern age demands a far greater level of surgical expertise. Besides, one must not forget that the twenty-first century may bring with it even more surprising advances. It may be that this century will witness robotled surgery, or even competition between genetic engineering and surgical practices. With the future possibilities in twenty-first century surgery, as with challenging achievements of the past, it is essential that we keep in mind the importance of contemporary "good" surgical practices, in other words "good surgery."

For the execution of "good surgery," first the "correct procedure" must be identified. Second, a "good surgical technique" must be adopted, and third a "short operating time" should be achieved. This sequence is very important. Simply carrying out a procedure in a "short time" leads to a vicious cycle of poor surgical practices. In fact, through the combination of "correct procedure" and "good technique," the ability to carry out a procedure in a "short time" is eventually achieved.

In the context of otology and neurotology, the concept of "good surgery" is based on the following components:

- precise knowledge of surgical anatomy
- precise knowledge of surgical theory
- precise control of microscopes, drills, and microsurgery instruments

By doing temporal bone dissections, attending courses, and reading atlases on temporal bone dissection, a surgeon can learn all these three components simultaneously; which would eventually result in being able to define the "correct procedure," to have a "good surgical technique," and to perform it in a "short time." This training cannot be substituted by any other training method in ear and skull base surgery.

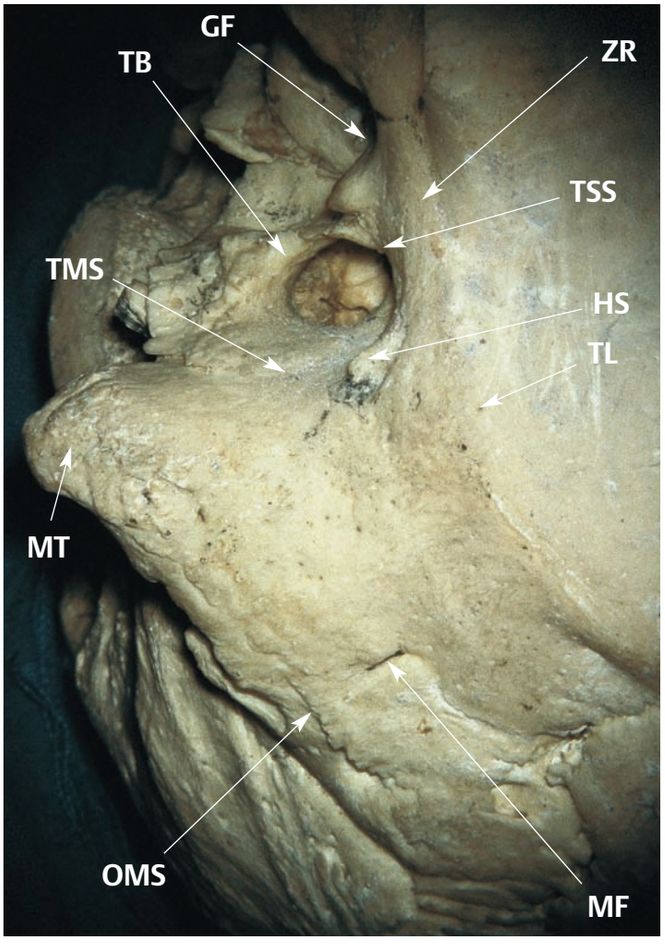
2 Surgical Anatomy

Temporal bone surgery demands advanced knowledge of surgical anatomy, and in this regard it is incomparable with any other form of surgery. Forming a two-dimensional mental picture is insufficient for this surgery; a three-dimensional, animated perception of the anatomical structures is required.

This chapter does not address the surgical anatomy of the temporal bone in detail, as the chapters on surgical techniques include a comprehensive discussion of this subject. For ease of instruction and uniform presentation, all the procedures depicted in this book have been carried out on the left temporal bone. However, the reader must also have a clear understanding of the right side, and should try to develop the ability to visualize a particular surgical site on either temporal bone, clearly and precisely.

To allow uniform presentation of the procedures, and to avoid confusion, Latin-derived terminology has been used wherever possible for orientation:

- superior (cranial): anatomical “upper”
- inferior (caudal): anatomical “lower”
- anterior (ventral): anatomical “front”
- posterior (dorsal): anatomical “rear”
- lateral (superficial): anatomical “exterior”
- medial (deep): anatomical “interior”



The superficial anatomy of the temporal bone in the surgical position (left).
GF: Glenoid fossa
HS: Henle spine
MF: Mastoid foramen
MT: Mastoid tip
OMS: Occipitomastoid suture
TB: Tympanic bone
TL: Temporal line
TMS: Tympanomastoid suture
TSS: Tympanosquamous suture
ZR: Zygomatic root

3 Surgical Theory

In temporal bone surgery, knowledge of the theory underpinning the surgical practices is very important, again incomparable to any other form of surgery. There are several reasons for this:

- Many vital structures are located in a relatively small area.
- The area to be operated on is concealed deep within.
- The surgery involved is bone surgery, which implies that the surgeon may suddenly encounter a vital structure.
- Diseases of this region are mainly benign, so protection of the critical structures is paramount.

A surgeon wishing to work in this hazardous area should keep his or her knowledge up to date by reading the most recent publications providing detailed information on temporal bone procedures, and watching or assisting experienced surgeons during such operations, as well as carrying out temporal bone dissections. Acquiring adequate knowledge of surgical theory requires all these forms of instruction.

The surgical techniques chapters also include the underlying surgical theory. For more detailed information, the reader should refer to the books listed in the “Suggested Reading” section.

4 Instrumentation and Usage

Microscope

The microscope and drill have played a major role in refining otologic and neurotologic techniques. In temporal bone surgery, good control of the microscope is very important.

High-technology surgical microscope.

As expected, use of a high-technology microscope improves the surgeon's view, which further enhances the surgical result. However, in many instances, the available microscope is not used to its full advantage. The following points should be kept in mind while using a microscope:

- Do not hesitate to use the microscope; the microscope will enhance the success of the surgery.
- Learn about the microscope's settings and practice maneuvering capabilities before using it for an operation.
- Use a higher magnification level when you are uncomfortable with your view of the surgical site.
- Adjust the microscope light so that it is high enough to see well, yet low enough to avoid reflective glare.
- Take care that the surgical microscope cover does not obstruct the path of the light, thus reducing the illumination at the surgical site.
- Enlarge the surgical field if required, which not only increases the working space, but also the illumination of the surgical site.

The Drill and Microsurgery Instruments

The general surgical procedure carried out by all surgeons, including the otorhinolaryngologist, is soft tissue surgery. However, the main procedure carried out on the temporal bone is delicate bone surgery, which is the privilege of the otorhinolaryngologist. The burr is the "scalpel" of temporal bone surgery, and special training is required to gain the ability to use it accurately. Novice use of this dangerous instrument can easily result in serious complications.

In addition, after the fundamental principles of microscopic ear surgery were introduced by Wullstein and Zöllner in the 1950s, a variety of microsurgery instruments were developed for middle ear and related surgery by pioneers during the second half of the twentieth century. Today, the main features of middle ear instruments are similar and they are all equally efficient. However, the quest for easier to use and more convenient instruments continues. The surgeon should improve his or her skills to use microsurgery instruments effectively. See also page 185.

Key Points in Burr Usage

A drill system should be provided; a good system will have the following three main features:
- high-speed revolution (>40 000 rpm)
- ability to adjust revolution speed
- ability to select clockwise and counterclockwise rotation

An irrigation system should be provided, both for the laboratory and the operating room. One of the main mistakes while drilling is not using continuous irrigation. This results in the following problems:
- The flutes of the burr may get clogged with bone dust.
- The bone and other tissues may be damaged by heat (osteitis, paralysis).
- The view may be worsened by accumulated bone dust.

All these problems contribute to an increased risk of complications. For example, facial paralysis may occur as a result of direct damage to the nerve because of reduced vision, or simply as a result of overheating of the bone adjacent to the nerve.

Although several types of burr are available on the market, there are two main types:
- the cutting burr
- the diamond burr

The cutting burr has the following advantages over the diamond burr:
- It allows quick drilling.
- It prevents the area from becoming clogged with bone dust; especially under continuous irrigation and suction, the view of the operative site always remains clear.

The cutting burr is preferable for use in the cortical bone, and away from critical structures in other parts of bone. Every surgeon should be aware of their personal limits, and when they should change to using a diamond burr.

The diamond burr has the following advantages over the cutting burr:
- The risk of encountering critical structures unexpectedly is reduced because of the burr's slower rate of extirpation.
- The risk of damage to critical structures, when it comes into contact with them, is reduced because it is blunter than the cutting burr.
- It prevents damaging soft tissues such as the tympanomeatal flap, because these tissues do not easily get entangled in it.

Close to the facial nerve and other vital structures, use of the diamond burr is preferred. However, it should be kept in mind that the diamond burr may also cause facial paralysis due to overheating or excessive pressure.

Other points regarding burr usage are summarized below:
- Use the largest suitable burr for the procedure. The large burr, contrary to common belief, poses a lesser danger of sudden uncontrolled penetration.
- Ensure that the cutting burr has enough flukes. If the burr has an insufficient number of flukes, the burr can skip over rather than engage the bone because of the large bite pattern.
- Never use burrs with a damaged shaft. Distorted burr shafts also result in skipping of the burr because of uncontrolled movements.
- Use the burr under continuous, copious irrigation, except in certain specific situations.
- Drill along the axes of the critical structures, which will prevent extensive damage in case of direct contact with the structure.
- Set the drill to rotate away from the critical structure that is to be protected when drilling along the axis is not possible. In case of any skipping, the burr will not catch on the critical structure and therefore do no damage.
- Drill with the side of the burr rather than the tip.This allows faster drilling because of the larger size of the flukes on the side of the burr. Furthermore, this improves vision as the view is not obscured by the burr tip.
- Train yourself to be able to see "through" the bone and to notice color and structural changes. Temporal bone surgery is based on seeing the structures through the last remaining shell of bone before actual exposure.
- Also train yourself to sense the differences in resistance encountered by the burr tip, as well as the changes in the sound of the drill while in use as the bone gets thinner or its structure changes, with the same intent.
- Use different handpiece shafts according to the procedural needs: a short shaft in the cortical bone, a long shaft in the deeper regions, and an angled shaft in the external auditory canal.

Burr Usage in Bleeding Control

The burr also has an important role in controlling bleeding through the bone. For control of bleeding through the bone, the following alternatives may be used:

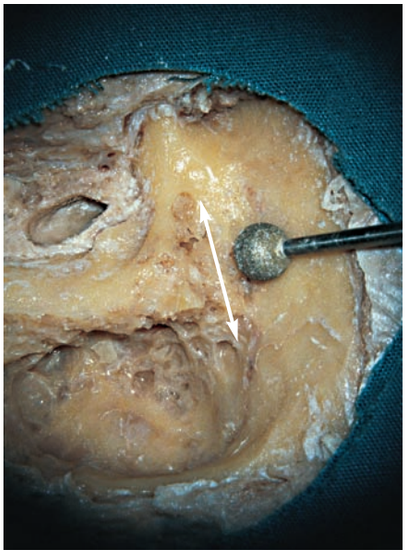
- a diamond burr
- cauterization
- bone wax
- absorbable compressed sponge (Gelfoam, Spongel, etc.)
- absorbable hemostatic products (Surgicel, etc.)

The technique of stopping oozing through the bone by the use of a drill is relatively simple; on a low-speed setting, the largest possible diamond burr should be moved along the surface of the bleeding area without irrigation.

Burr Usage around the Critical Structures

The initial drilling process for exposure of the middle cranial fossa dural plate requires the largest available cutting burr, e. g., 7 mm.
The direction of drilling is anteroposterior, i. e., parallel to the dura of the middle cranial fossa.
Copious irrigation is mandatory.

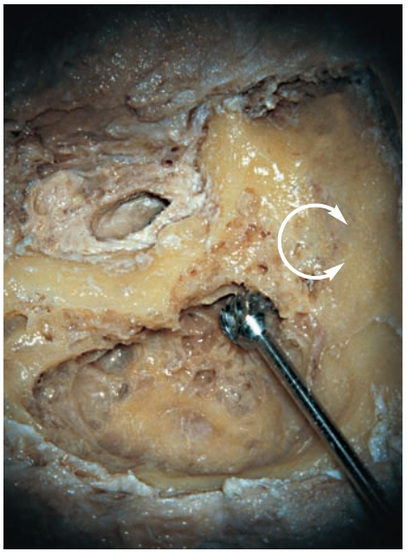
The initial drilling process for exposure of the sigmoid sinus dural plate requires the largest available cutting burr, e. g., 7 mm.
The direction of drilling is superoinferior, i. e., alongside the sigmoid sinus.
Copious irrigation is mandatory.



The subsequent delicate drilling process in the exposure of the middle cranial fossa dural plate requires the largest available diamond burr, e. g., 7 mm.
The direction of drilling is anteroposterior, i. e., parallel to the middle cranial fossa dura.
Copious irrigation is mandatory.

The subsequent delicate drilling process in the exposure of the sigmoid sinus dural plate requires the largest available diamond burr, e. g., 7 mm.
The direction of drilling is roughly superoinferior; i. e., along the sigmoid sinus.
Copious irrigation is mandatory.

The initial drilling process to locate the antrum requires the largest available cutting burr, e. g., 7 mm.
Following this, smaller different-sized cutting burrs are used.
The burr is used in a circular motion, with the direction of the shaft slightly off angle from posterosuperior to anteroinferior, parallel to the posterosuperior wall of the external auditory canal.
Copious irrigation is mandatory.



If the antrum is to be exposed directly, then a smaller cutting burr is more suitable, e. g., 5 mm.
The burr is used in a circular motion, with the direction of the shaft slightly off angle from posterosuperior to anteroinferior, parallel to the posterosuperior wall of the external auditory canal.
Copious irrigation is mandatory.

The drilling of the bone covering the incus laterally requires a small cutting burr, later substituted by a diamond one, e. g., 1–2 mm.
The burr should remain precisely in place during this stage and should not be moved at all to prevent contact with the incus.
Irrigation is used as necessary.

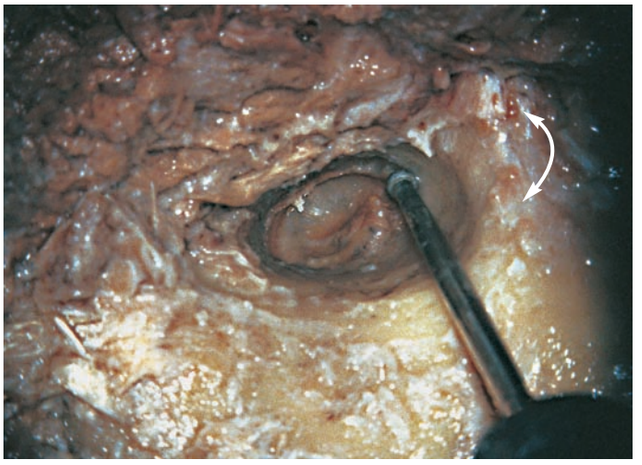
The drilling of the bone in close proximity to the mastoid segment of the facial nerve requires a medium-sized diamond burr, e. g., 3–4 mm.
The direction of drilling is superoinferior, i. e., parallel to the facial nerve.
Copious irrigation is mandatory.

Delineation of the sinodural angle initially requires a medium-sized cutting burr, later substituted by a diamond one, e. g., 3–4 mm.
The burr should be moved along the groove, from posterolateral to anteromedial.
Copious irrigation is mandatory.

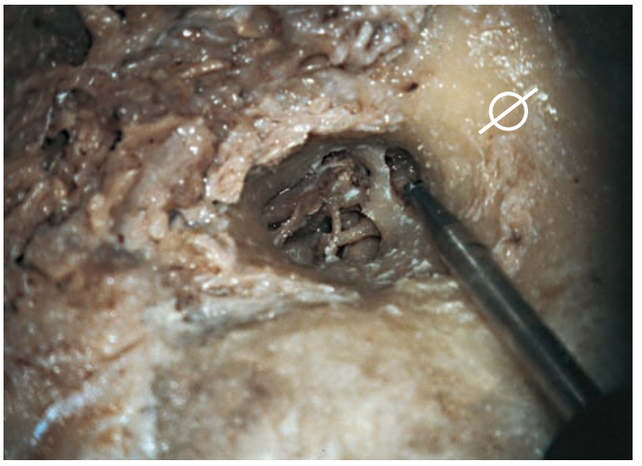
The exenteration of the interlabyrinthine, retrolabyrinthine, and retrofacial cells initially requires a small cutting burr, e. g., 2–3 mm.
The burr is moved alongside each semicircular canal and each segment of the facial nerve.
Copious irrigation is mandatory.

The subsequent drilling of the interlabyrinthine, retrolabyrinthine, and retrofacial cells requires a small diamond burr, e. g., 2–3 mm.
The burr is moved alongside each semicircular canal and each segment of the facial nerve.
Copious irrigation is mandatory.

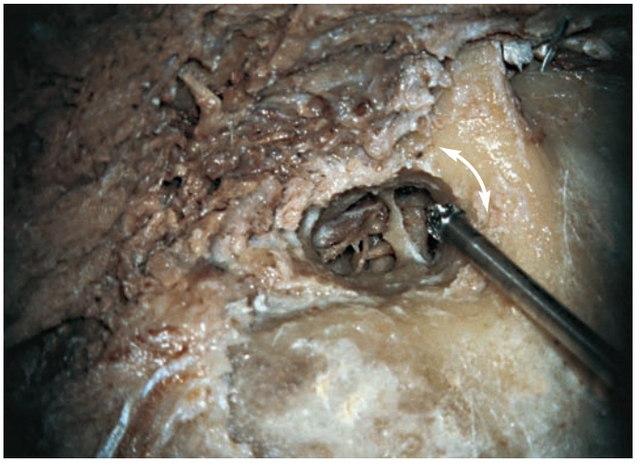
Enlargement of the lateral part of the external auditory canal requires a medium-sized cutting burr, e. g., 3–4 mm.
The burr is moved circumferentially around the walls of the canal.
Copious irrigation is mandatory.



Enlargement of the medial part of the external auditory canal requires a small diamond burr, e. g., 1–2 mm.
The burr is moved circumferentially around the walls of the canal.
Irrigation is used as necessary.



In atticotomy and its modifications, the drilling process medially requires a small cutting burr, e. g., 1–2 mm.
The burr should remain precisely in place during this stage to prevent contact with the incus and malleus.
Irrigation is used as necessary.



In atticotomy and its modifications, the drilling process laterally requires a medium-sized cutting burr, e. g., 3–4 mm.
The burr is moved in a semicircular fashion along the superior wall of the canal.
Copious irrigation is mandatory.

II Surgical Techniques

5 Cortical Mastoidectomy

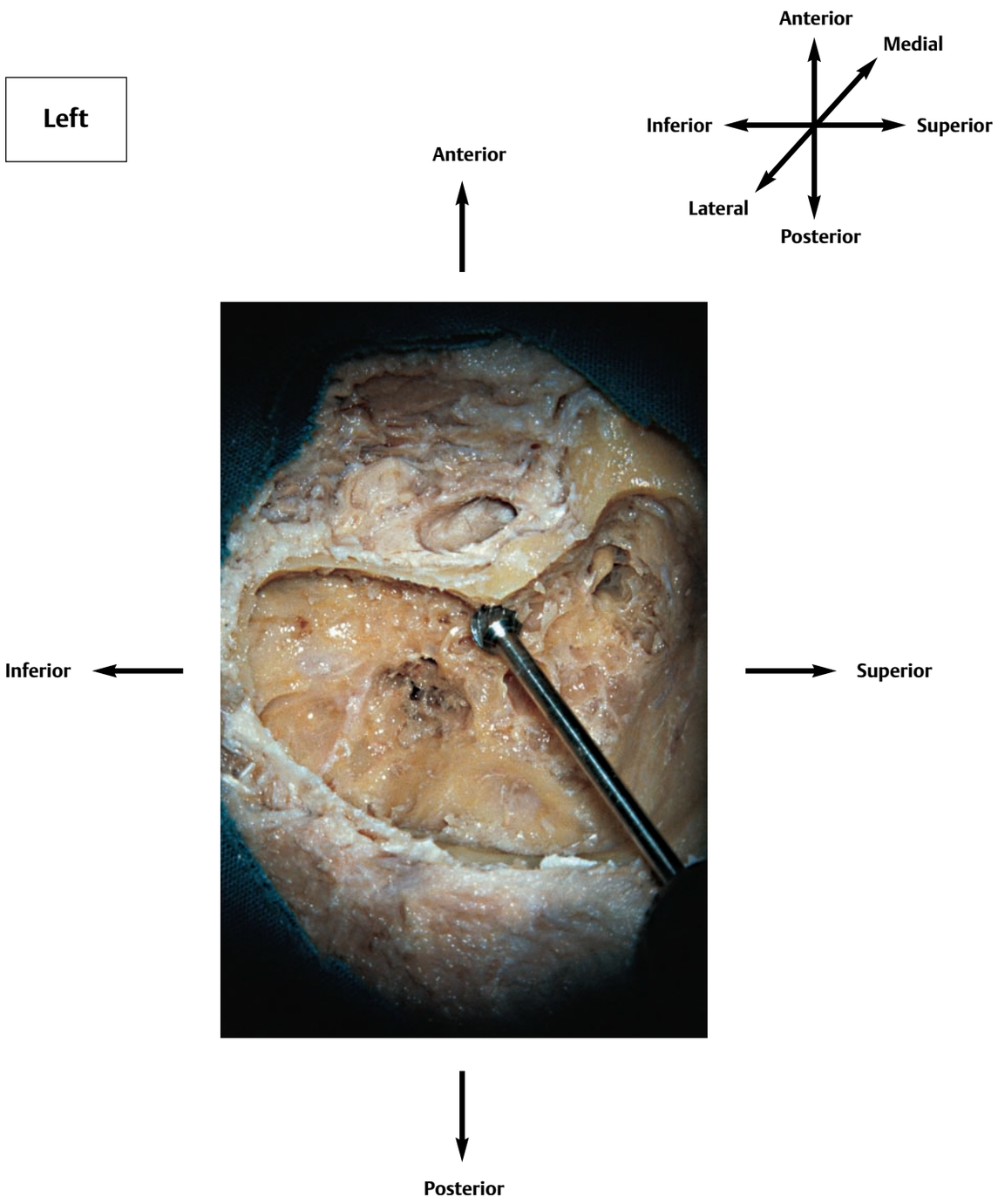
Definition

Exenteration of the mastoid portion of the temporal bone without disturbing the anatomical integrity of the external and middle ear. This is the basic operation in temporal bone surgery. It is also called “simple mastoidectomy.”

Indications

A cortical mastoidectomy is usually performed in acute mastoiditis. It is also used in many other situations as an isolated procedure, or as the first stage of more advanced procedures. Finally, it forms a part of intact canal wall surgery used in chronic otitis media.

Anatomical Orientation



Cortical mastoidectomy—an intermediate stage

Surgical Steps

The soft tissues are elevated from the lateral surface of the temporal bone with a raspatory, exposing the mastoid tip inferiorly, the temporal line superiorly, the skin of the external auditory canal anteriorly, and the mastoid emissary vein area posteriorly. It is important to expose the zygomatic root anterosuperiorly.

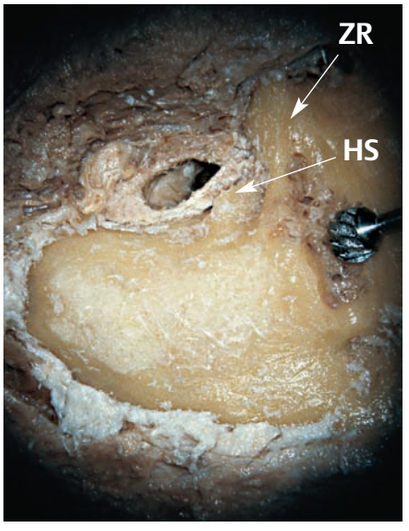
II*: Raspatory
MIL*: Henle spine

EAC: External auditory canal
MT: Mastoid tip
TL: Temporal line

The largest cutting burr and the largest suction tip, with a high rate of irrigation, should be used during the initial cortical exposure. The cortical bone is drilled along the temporal line, extending to approximately 1 cm above the temporal line. The direction of drilling should be parallel to the middle cranial fossa dura.

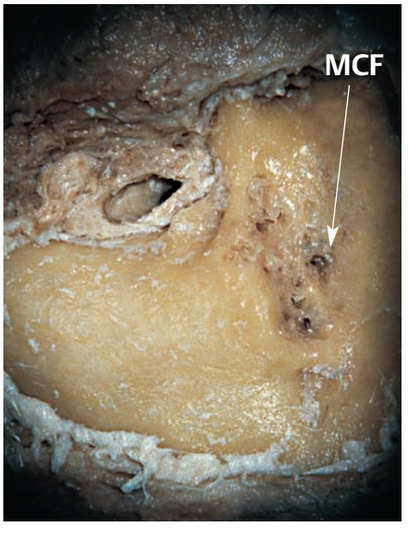
II: 7 mm cutting burr
MIL: Temporal line

HS: Henle spine
ZR: Zygomatic root



In this way the cells and the compact bone in close proximity to the temporal line are exenterated. Drilling with a cutting burr is continued until the hard bone over the middle cranial fossa dura is partially exposed.

MCF: Middle cranial fossa (dural plate)



Definitions and Tips

- **Henle spine (spine of Henle, suprameatal spine):** *Definition:* The bony spine at the posterosuperior part of the entrance to the external auditory canal. *Tips:* The spine of Henle is an important landmark for all mastoidal and transmastoidal procedures in otologic and neurotologic surgery. The Macewen triangle (suprameatal triangle) is located immediately behind the suprameatal spine.

* **II:** Ideal instrument
MIL: Most important landmark

In the next step, the bone over the sigmoid sinus is removed, working 1–2 cm posterior to the external auditory canal. The drilling is done in a superior to inferior direction, parallel to the posterior wall of the external auditory canal and approximately parallel to the sigmoid sinus. In this way, the superficial mastoid cells are exenterated.

II: 7 mm cutting burr
MIL: Posterior wall of external auditory canal

The bone close to the sigmoid sinus is not cellular, and therefore the sigmoid sinus can be identified early, provided that efforts are made to identify any area of smooth bone and any color changes. Drilling with a cutting burr is continued until the hard bone over the sigmoid sinus is partially exposed.

SS: Sigmoid sinus (dural plate)

Following on from this, the cutting burr is replaced with a diamond burr. The bone is removed until an eggshell-thin layer of compact bone remains over the sigmoid sinus. This thin bone, called the sigmoid sinus dural plate, appears as a bluish discoloration during both temporal bone dissection and in the live operation. However, during the dissection, if the sigmoid sinus walls have been previously damaged, it appears as a yellowish-white discoloration.

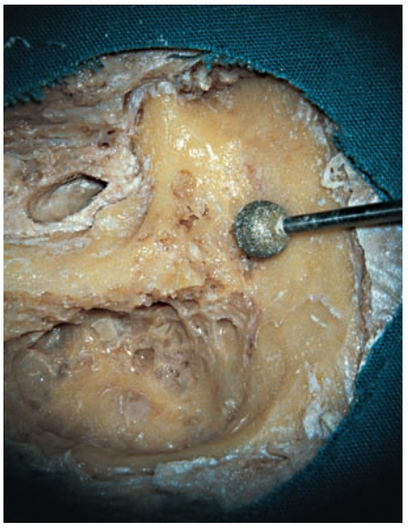
II: 7 mm diamond burr
MIL: Sigmoid sinus dural plate

Definitions and Tips

- **Landmark:** *Definition:* Reference point. *Tips:* Temporal bone surgery is based on detailed anatomical knowledge and good drilling technique. Landmarks, as a part of anatomical knowledge, have a major role in surgery. Some landmarks are important only as landmarks, i. e., they do not have any functional significance, for example the spine of Henle or the vertical crest. However, other landmarks have functional significance in addition to their utilization as reference points, such as the horizontal semicircular canal.
- **Sigmoid sinus dural plate (sinus sigmoideus dural plate):** *Definition:* The eggshell-thin bone covering the sigmoid sinus. *Tips:* The posterior surface of mastoid and petrous bone is covered with the dura of the posterior cranial fossa. The sigmoid sinus occupies only part of this dura. The fact that the sigmoid sinus is the prominent and critical structure in the posterior cranial fossa accounts for its influence on the terminology.

The same procedure is carried out superiorly. Using a large diamond burr, the middle cranial fossa dura, covered with an eggshell-thin layer of bone, is exposed. This thin bone, called the middle cranial fossa dural plate, is visualized as a pinkish discoloration during the operation, and as a whitish discoloration during temporal bone dissection.

II: 7 mm diamond burr
MIL: Middle cranial fossa dural plate



Because the critical structures have been completely skeletonized superiorly and posteriorly, the bone over the antrum can be drilled quickly with a large cutting burr and the antrum penetrated. This technique overcomes the difficulty in identifying the antrum if the Koerner septum is encountered.

II: 7 mm cutting burr
MIL: Henle spine

KS: Koerner septum

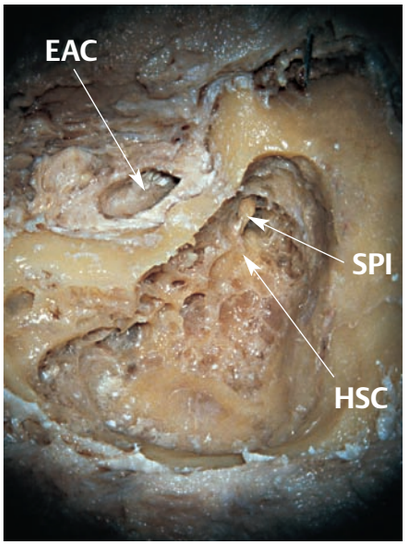
The lateral wall of the antrum is removed without letting the drill touch the bottom. If a sufficient amount of bone has been removed, the horizontal semicircular canal will be seen in the medial wall of the antrum as a smooth, hard bone. The horizontal semicircular canal is the most important landmark in all types of mastoid procedures and, after its identification, the surgeon can work safely.

II: 4–5 mm cutting burr
MIL: Horizontal semicircular canal

A: Antrum
HSC: Horizontal semicircular canal

Definitions and Tips

- **Middle cranial fossa dural plate (middle fossa dural plate):** *Definition:* The eggshell-thin bone covering the middle cranial fossa dura. *Tips:* The delineation of the dural plate of the middle cranial fossa allows for the identification of a safe landmark, maximal exposure, extirpation of any pathologic tissue if present, and the preservation of the intracranial structures.
- In a cortical mastoidectomy, the sequence of bone removal and exposure of the anatomical structures may be changed. It is possible first to locate the antrum, and then to drill from the center to the periphery. However, the identification of vital structures through the technique of skeletonization, then drilling from the periphery to the center, is faster and safer.



Following the identification of the horizontal semicircular canal, more bone is carefully removed anteriorly, with the purpose of identifying the short process of the incus. If fluid is allowed to fill the antrum, the incus can be seen before actual exposure.

II: 2–3 mm cutting burr
MIL: Short process of incus

EAC: External auditory canal
HSC: Horizontal semicircular canal
SPI: Short process of incus

Continuing to drill with a small cutting burr, the posterosuperior wall of the external auditory canal is thinned, and the incus is completely exposed. To prevent sensorineural hearing loss during the operation and damage to the posterior incudal ligament during the dissection, care should be taken not to touch the incus while the bone is being drilled.

The view of the mastoid cavity after the complete exposure of the posterior epitympanum. To exenterate the fossa arcuata accurately, i. e., the area adjacent to the superior semicircular canal, the surgeon should take a more inferior position and have a clear view from inferior to superior. The inferior part of the mastoid, including the mastoid tip, has not yet been exenterated.

FA: Fossa arcuata

Definitions and Tips

- **Fossa arcuata:** *Definition:* The fossa described by the author, which is exposed when the arcuate eminence of the petrous bone is skeletonized through the mastoid. It lies in the deep part of the dural plate of the middle cranial fossa close to the superior semicircular canal. *Tips:* This fossa is, as expected, immediately next to the superior semicircular canal. The dural plate of the middle cranial fossa is more inferiorly located laterally and more superiorly located medially because of the fossa arcuata. It is important to be aware of this when exposing the area around the superior semicircular canal.

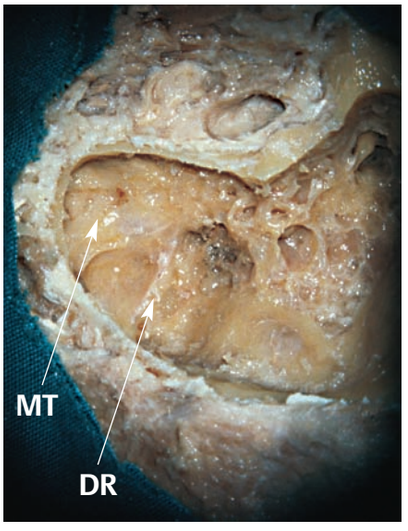
The next step is exenteration of the mastoid tip. Using a large cutting burr, the air cells in this region are removed. As with all bone procedures, copious irrigation is necessary to remove bone dust, avoid clogging of the burr, and prevent frictional burning of bone.

II: 7 mm cutting burr
MIL: Mastoid tip

The mastoid tip is skeletonized, and the medial plate of the mastoid tip is delineated. Subsequently, the digastric ridge is exposed and followed anteromedially toward the stylomastoid foramen.

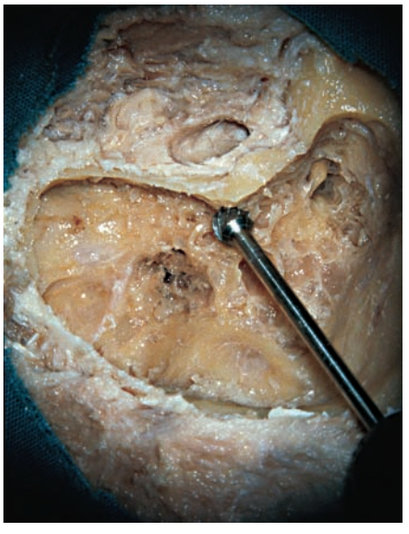
II: 4–5 mm cutting burr
MIL: Digastric ridge

DR: Digastric ridge
MT: Mastoid tip



The last stage is to thin the bone covering the posterior wall of the external auditory canal. The bone is removed step by step with a medium-sized cutting burr, taking care not to penetrate the ear canal. The bone removal is completed when the posterior wall of the ear canal is seen as a tiny bony plate.

II: 4–5 mm cutting burr
MIL: Posterior wall of external auditory canal



Definitions and Tips

- **Light-bending refraction of incus:** *Definition:* Observation of the incus in a fluid environment before its actual exposure. *Tips:* As a result of the phenomenon of light refraction in fluid, if the antrum is filled with fluid, the incus can be seen under the microscope before the actual exposure. This maneuver allows early identification of the incus and prevents damage to it.
- **Digastric ridge:** *Definition:* The ridge that is formed by the bulge created by the insertion of the digastric muscle into the mastoid tip. *Tips:* The digastric ridge is skeletonized during mastoidectomy and followed up to the stylomastoid foramen to locate the facial canal. The digastric ridge and the periosteum of the stylomastoid foramen are important landmarks for identification of the distal mastoid segment of the facial nerve.

The surgical site following completion of cortical mastoidectomy. The resulting exposure extends from the mastoid tip inferiorly to the dural plate of the middle cranial fossa superiorly, and from the posterior wall of the external auditory canal anteriorly to the dural plate of the sigmoid sinus posteriorly.

DR: Digastric ridge
EAC: External auditory canal
MCF: Middle cranial fossa (dural plate)
MT: Mastoid tip
SS: Sigmoid sinus (dural plate)
ZR: Zygomatic root

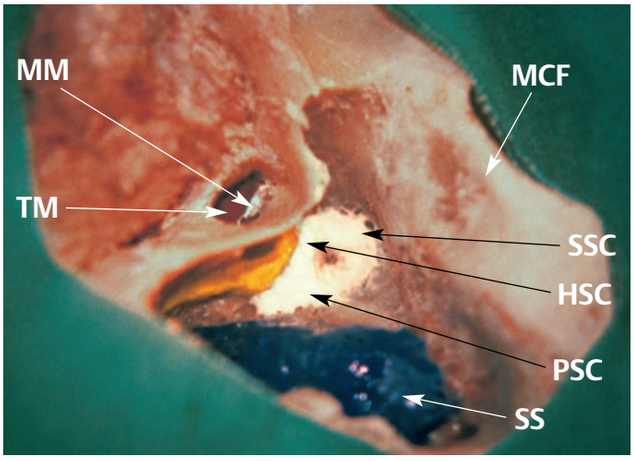
Definitions and Tips

- **Koerner septum:** *Definition:* The area of fusion between the squamous and petrous bones. It consists of nonpneumatized, solid bone that begins at the petrosquamous suture and extends across the entire mastoid cavity, at a depth of 0.5–1 cm from the mastoid cortex. *Tips:* The Koerner septum separates the superficial cells from the deeper cells and the antrum. Because of its solid nature, it can be mistaken for the labyrinth. If it becomes difficult to identify the antrum when the Koerner septum is encountered, the middle cranial fossa dura should be skeletonized and followed medially to locate the antrum and epitympanum.
- The spine of Henle is usually used as a reference point to locate the antrum. However, Ulug et al. have shown that this landmark can be used to identify various critical structures encountered in skull base surgery and, more importantly, to define the exact direction of working while carrying out procedures in this area. (Ulug T, Ozturk A, Sahinoglu K. A multipurpose landmark for skull-base surgery: Henle's spine. *J Laryngol Otol* 2005;119: 856–861.)
- It is not necessary to reach the borders of the mastoid in every case; it depends on the purpose of the approach and the lesion present. However, when cortical mastoidectomy is the initial step for a more advanced procedure, delineation of the mastoid borders, which means skeletonization of the middle cranial fossa, sigmoid sinus, and the digastric ridge, creates a wider exposure that allows the deeper structures to be accessed more safely and quickly.

Surgical Anatomy

A dissected temporal bone in a cadaver. Cortical mastoidectomy has been carried out and the important anatomical structures have been exposed and dyed for illustrative purposes.

HSC: Horizontal semicircular canal
MCF: Middle cranial fossa (dural plate)
MM: Manubrium mallei
PSC: Posterior semicircular canal
SS: Sigmoid sinus (dural plate)
SSC: Superior semicircular canal
TM: Tympanic membrane



Definitions and Tips

- The principal techniques for approaching the mastoid and middle ear with respect to access through the soft tissues are:
  – retroauricular approach (e. g., classical cortical mastoidectomy)
  – endaural approach (e. g., classical atticoantrotomy)
  However, it is possible to carry out a cortical mastoidectomy using the endaural approach, and an atticoantrotomy using the retroauricular approach. In addition to the retroauricular and endaural approaches, superior and anterior approaches have been proposed in literature, but these are not currently being used.
- The principal techniques for approaching the mastoid and middle ear with respect to access through the bone are:
  – transcortical route (e. g., classical cortical mastoidectomy)
  – transmeatal route (e. g., classical atticoantrotomy)
- The principal techniques for approaching the mastoid and middle ear with respect to the direction of access are:
  – outside-in technique (e. g., classical cortical mastoidectomy)
  – inside-out technique (e. g., classical atticoantrotomy)
- The principal techniques for approaching the mastoid and middle ear with respect to preservation of the posterior wall of the external auditory canal are:
  – canal wall up (e. g., classical cortical mastoidectomy)
  – canal wall down (e. g., extension of classical atticoantrotomy)
  In addition to these, there are modified techniques where partial or total ear canal reconstruction, or partial or total mastoid cavity obstruction are performed.

6 Posterior Tympanotomy

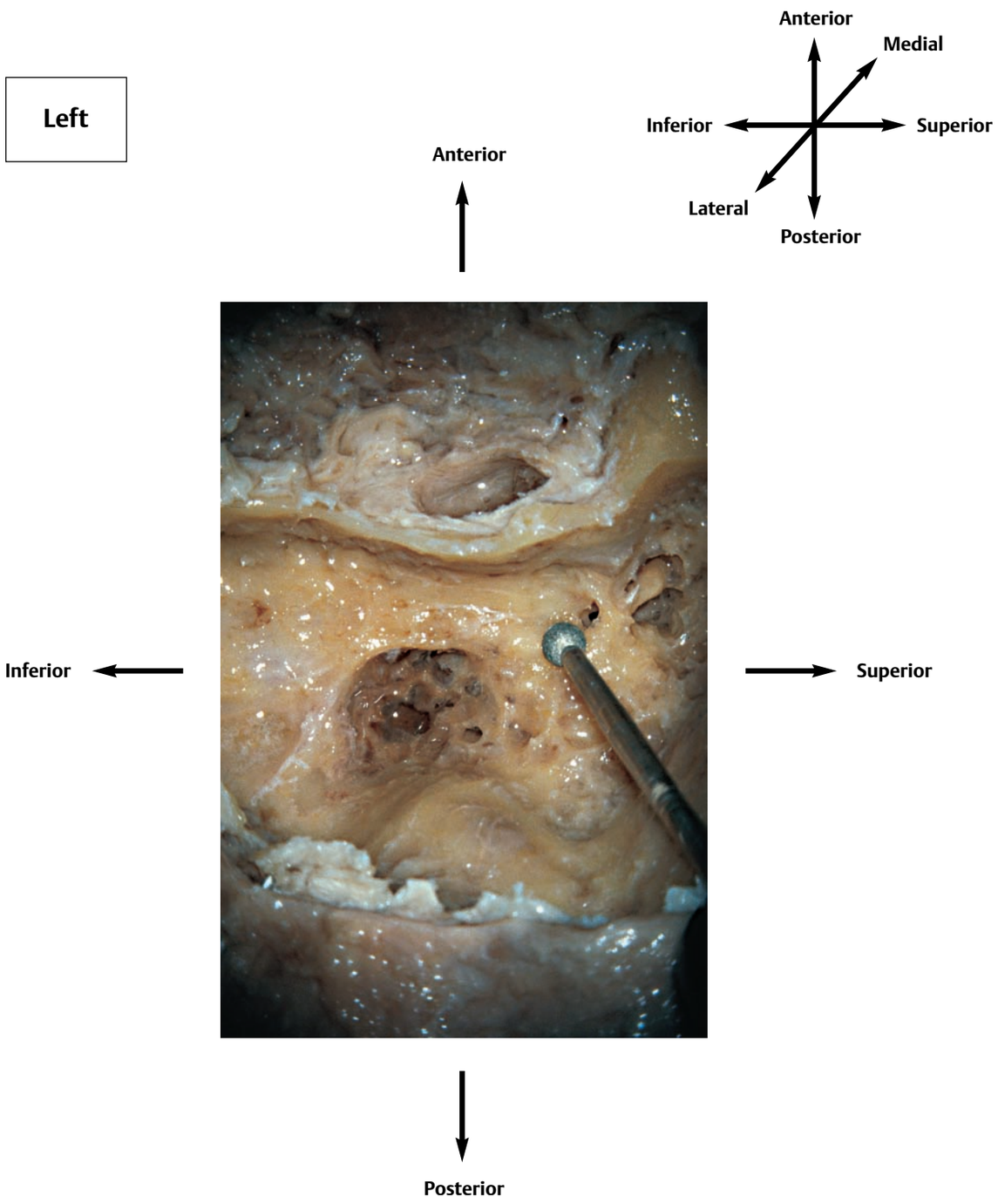
Definition

Opening a window from the mastoid to the middle ear between the facial nerve and chorda tympani, following a cortical mastoidectomy. It is also known as the "facial recess approach."

Indications

A posterior tympanotomy is mainly carried out in "intact canal wall" cholesteatoma surgery, cochlear implantation, and active middle ear device implantation.

Anatomical Orientation



Completed posterior tympanotomy

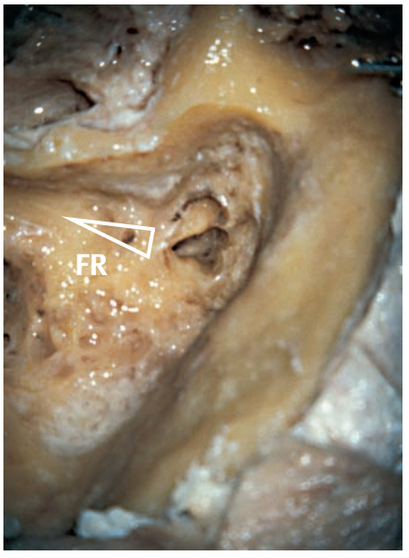
Surgical Steps

After the cortical mastoidectomy has been carried out, the bone is ready for the posterior tympanotomy. Posterior tympanotomy does not always require a mastoid cavity as large as in the classical cortical mastoidectomy. However, a classical cortical mastoidectomy cavity allows better exposure and an easier posterior tympanotomy procedure.

DR: Digastric ridge
EAC: External auditory canal
MCF: Middle cranial fossa (dural plate)
SS: Sigmoid sinus (dural plate)

A close-up view of the facial recess area where posterior tympanotomy will be carried out.
The facial recess is limited superiorly by the short process of the incus, anteriorly (anterolaterally) by the chorda tympani, and posteriorly (posteromedially) by the facial nerve. This critical triagonal area is illustrated in the figure.

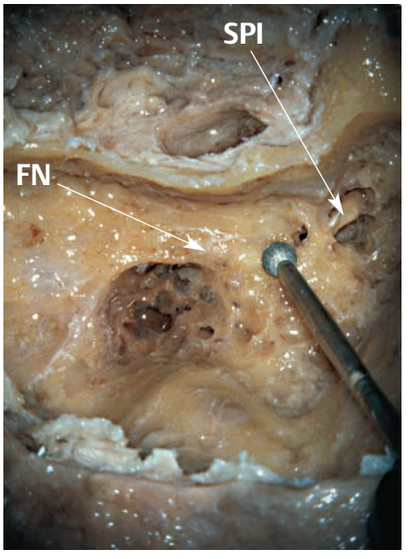
FR: Facial recess



Using a small diamond burr, drilling of the facial recess triangle is started. The burr should be moved parallel to the axis of the expected position of the facial nerve. The reflection of the facial nerve through the bone is pink in color during the live operation, but white on the cadaveric temporal bone.

II: 2–3 mm diamond burr
MIL: Short process of incus

FN: Facial nerve
SPI: Short process of incus



Definitions and Tips

- **Facial recess (posterior tympanotomy area, suprapyramidal recess):** *Definition:* The triangular area limited anteriorly (anterolaterally) by the chorda tympani, posteriorly (posteromedially) by the facial nerve, and superiorly by the fossa incudis (or posterior buttress). *Tips:* Drilling of this area, i. e., carrying out a posterior tympanotomy procedure, enables the connection of the mastoid cavity with the meso- and hypotympanic parts of the tympanic cavity via a tunnel, in operations such as intact canal wall tympanomastoidectomy or cochlear implantation. In addition, this is one of the areas where cholesteatoma may be concealed.

Once the reflection of the facial nerve is visible, the facial recess area can be exenterated rapidly using a cutting burr. A diamond burr may be used in place of a cutting burr if the surgeon wants to work more carefully.

II: 2–3 mm cutting and diamond burrs
MIL: Facial nerve

In this way, the cells of the facial recess are exposed gradually. The facial recess may contain air cells or it may consist of only compact bone. The bony bridge between this area and the short process of the incus is the posterior buttress.

SPI: Short process of incus

Continuing exenteration of the facial recess enlarges the posterior tympanotomy. The microsurgical instrument in the figure is pointing to the external genu, i. e., the pyramidal segment of the facial nerve.

PB: Posterior buttress

Definitions and Tips

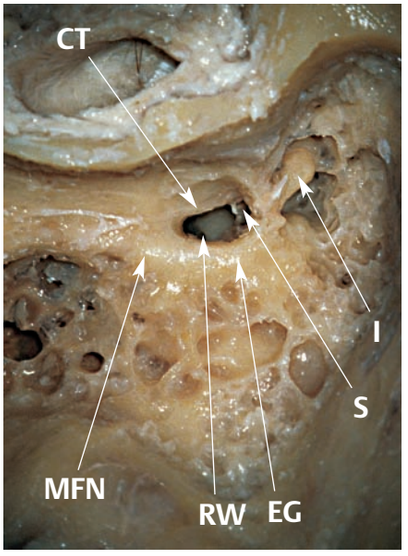
- **Posterior buttress (incus buttress):** *Definition:* The bony bridge surgically created between the facial recess and the fossa incudis, which extends from the posterior wall of the external auditory canal to the horizontal semicircular canal. *Tips:* Preservation of the posterior buttress during posterior tympanotomy prevents contact of the drill with the posterior ligament of the incus and consequent sensorineural hearing loss.

In the next step, the posterior tympanotomy is extended anteriorly. The chorda tympani must be preserved carefully during this stage. Note that the facial canal has a more posterior location, in comparison with the posterior edge of the short process of incus.

FR: Facial recess

The completed posterior tympanotomy. The triangular area limited anteriorly by the chorda tympani, posteriorly by the facial nerve, and superiorly by the posterior buttress has been completely exenterated. Through the opening that has been created, the middle ear structures, i. e., the round window and stapes, can be seen.

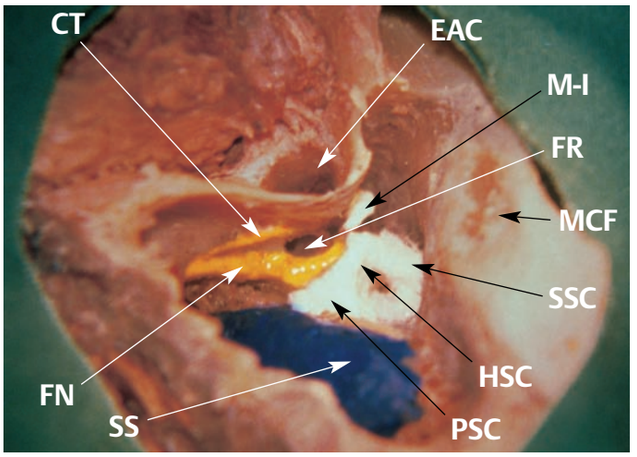
CT: Chorda tympani
EG: External genu
I: Incus
MFN: Mastoid facial nerve
RW: Round window
S: Stapes



Definitions and Tips

- Two different surgical techniques can be used when carrying out a posterior tympanotomy. The first technique involves taking the posterior edge of the short process of the incus as a reference and working anterior to the imaginary vertical line drawn from this point in an inferior direction. Then a small opening is made into the tympanic cavity and enlarged step by step. Although this is a relatively simple technique, there is a higher risk of damage to the facial nerve. The second technique involves first skeletonizing the facial nerve by leaving an eggshell-thin bone covering it. This is followed by a quick posterior tympanotomy procedure, keeping the reflection of the nerve under constant observation. The execution of this technique requires greater technical expertise; however, the risk of damage to the facial nerve is lower.
- Preservation of the posterior buttress should not be considered absolutely necessary; it can be extirpated if required. In addition, the long process of the incus is often damaged by erosion in cholesteatoma cases, where removal of the posterior buttress is required. This erosion lowers the risk of sensorineural hearing loss during removal of the buttress.

Surgical Anatomy



A dissected temporal bone in a cadaver. A posterior tympanotomy has been carried out, and the important anatomical structures have been exposed and dyed for illustrative purposes.

CT: Chorda tympani
EAC: External auditory canal
FN: Facial nerve
FR: Facial recess
HSC: Horizontal semicircular canal
M-I: Malleus and incus
MCF: Middle cranial fossa (dural plate)
PSC: Posterior semicircular canal
SS: Sigmoid sinus (dural plate)
SSC: Superior semicircular canal

Definitions and Tips

- The canal through which the facial nerve runs is called the facial canal; it is also called the fallopian canal. Some of the anatomical terms used in otology are derived from the pioneers who first described them, i. e. eponyms, which are as follows:
  - Canal of Fallopius (fallopian canal, facial canal, canalis facialis)—first defined by Gabriele Fallopio, an Italian anatomist, in the sixteenth century.
  - Tube of Eustachius (eustachian tube, auditory tube, tuba auditiva)—first defined by Bartholomaei Eustachii, an Italian anatomist, in the sixteenth century.
  - Membrane of Shrapnell (Shrapnell membrane, pars flaccida)—first defined by Henry Jones Shrapnell, a British surgeon, in the nineteenth century.
  - Spine of Henle (Henle spine, suprameatal spine)—first defined by Friedrich Gustav Jacob Henle, a German anatomist and pathologist, in the nineteenth century.

7 Cochlear Implantation

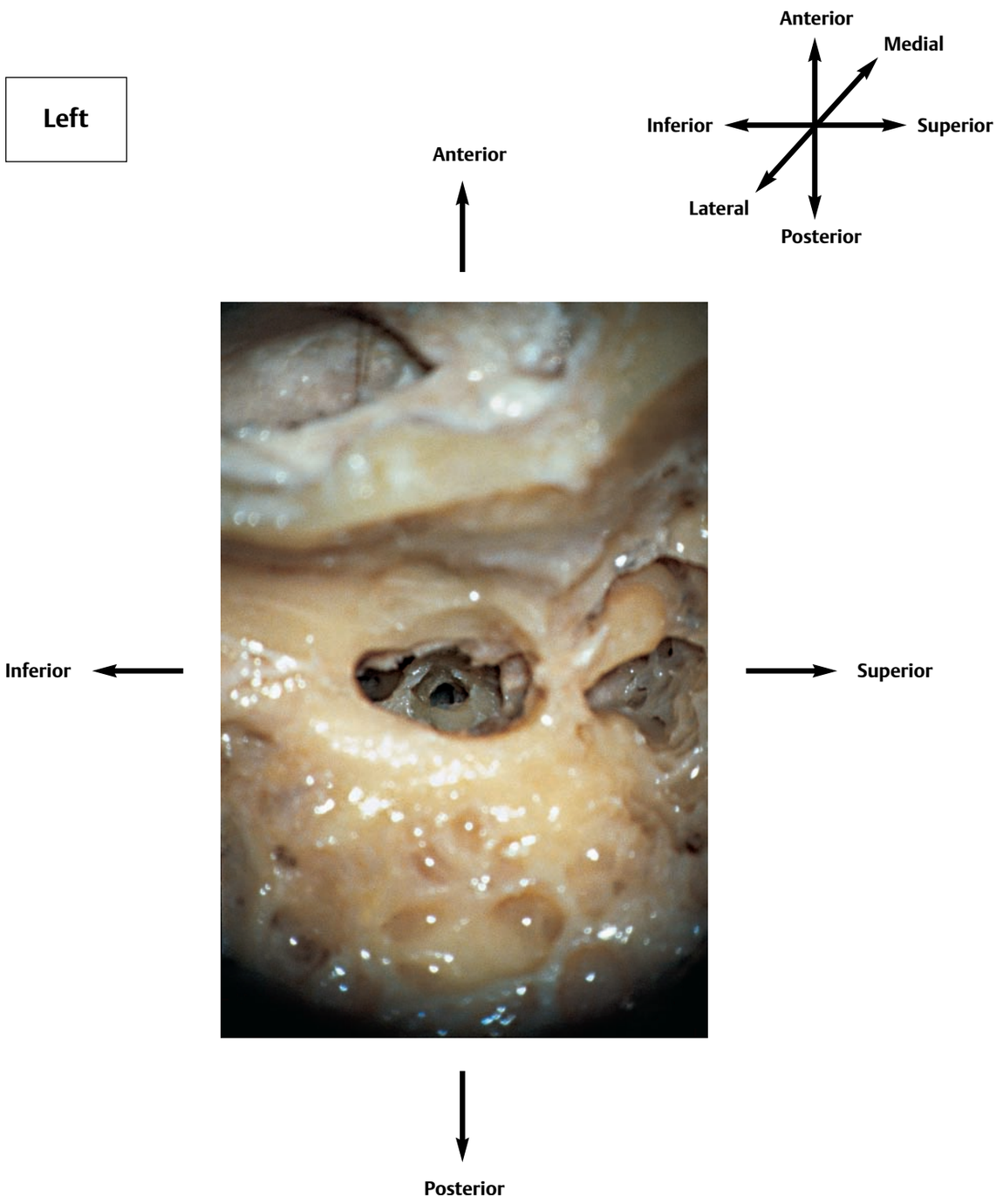
Definition

Following cortical mastoidectomy and posterior tympanotomy, carrying out a cochleostomy or preparing the round window, and inserting the electrode array of the cochlear implant. The receiver-stimulator package is placed into the well created in the cortex of the temporal bone.

Indications

Cochlear implantation surgery.

Anatomical Orientation

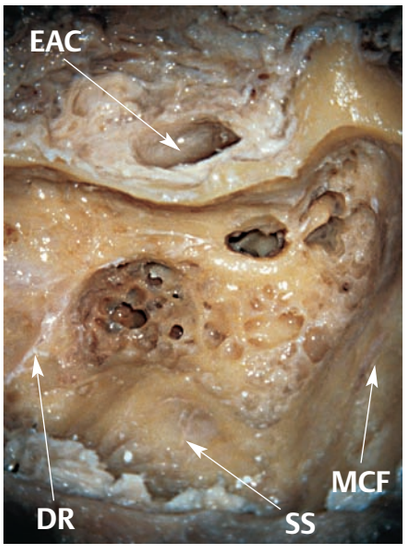


Completed cochlear implantation

Surgical Steps

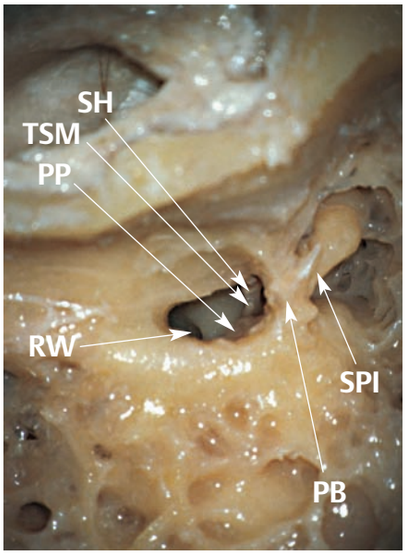
The cortical mastoidectomy has been completed, and the posterior tympanotomy carried out. During the operation, exenteration of the mastoid cavity is restricted to a smaller size as a smaller cavity enables better electrode array fixation.

DR: Digastric ridge
EAC: External auditory canal
MCF: Middle cranial fossa (dural plate)
SS: Sigmoid sinus (dural plate)

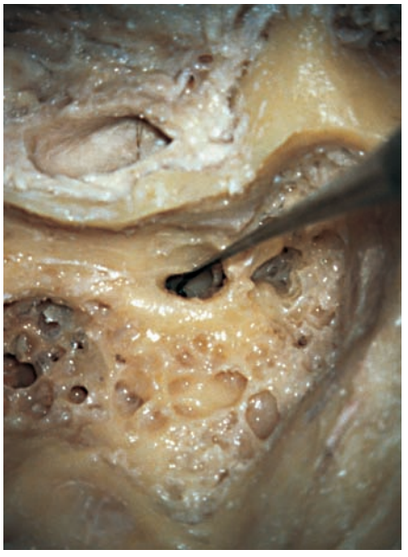


The view of the middle ear through the posterior tympanotomy opening. The critical structures of the tympanic cavity, i. e., the stapes, pyramidal process, and round window, can be seen.

PB: Posterior buttress
PP: Pyramidal process
RW: Round window
SH: Stapes head
SPI: Short process of incus
TSM: Tendon of stapedius muscle



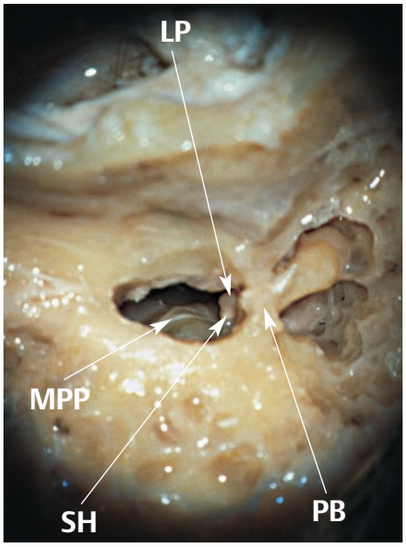
The microsurgical instrument, which has been inserted through the posterior tympanotomy opening, is pointing to the round window. The round window is the site of insertion for the electrode array in the "round window technique" and the main landmark for the drilling site in the "cochleostomy technique."



Definitions and Tips

- The main surgical steps during a classical cochlear implantation procedure are:
  - limited cortical mastoidectomy
  - posterior tympanotomy
  - cochleostomy or round window preparation
  - drilling a well for the receiver-stimulator package
  - placing the receiver-stimulator package and inserting the electrode array

A curved micro dissector points to the location where the cochleostomy should be carried out. This is 1–2 mm anteroinferior to the round window. The posterior tympanotomy is enlarged depending on the needs of the case. If the view is restricted, the chorda tympani may be removed and an "extended posterior tympanotomy" carried out.



In this temporal bone, there is no need to extend the posterior tympanotomy; the exposure of the promontory is enough to perform a safe cochleostomy. At this stage, the mucoperiosteum of the promontory is elevated anteriorly. The incudostapedial joint and the stapes head can be seen directly medially to the posterior buttress.

LP: Lenticular process
MPP: Mucoperiosteum of promontory
PB: Posterior buttress
SH: Stapes head

The next stage is the cochleostomy. The tip of the same microsurgical instrument again points to the location of the area of the cochleostomy, which is 1–2 mm anteroinferior to the round window.

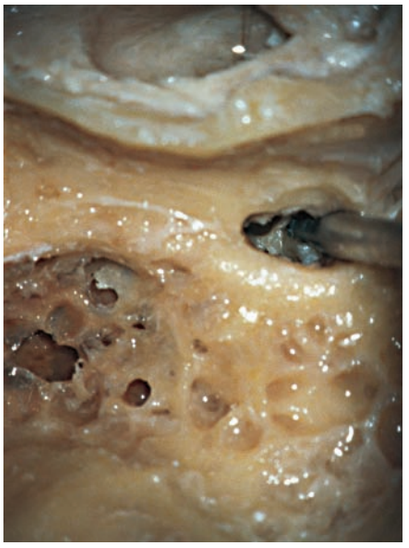
RW: Round window

Definitions and Tips

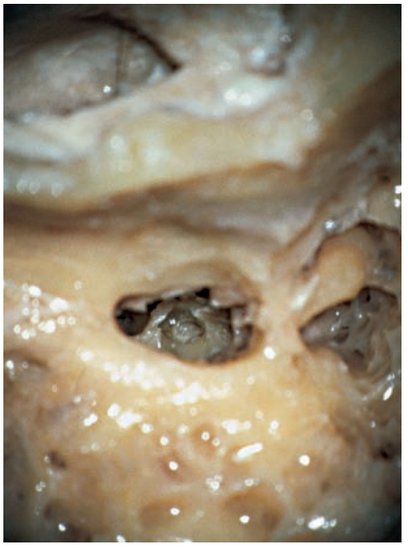
- **Cochleostomy:** *Definition:* Drilling a window through the promontory into the scala tympani of the basal turn of the cochlea, 1–2 mm anteroinferior to the round window. *Tips:* Using a cochleostomy for electrode array insertion simplifies the surgical technique, requiring a smaller posterior tympanotomy. However, the round window insertion technique, while requiring a larger posterior tympanotomy that extends adjacent to the facial nerve, presents the advantage of less trauma to the inner ear structures.

Cochleostomy is carried out by first using a small cutting burr and then a small diamond burr. During the live operation, while carrying out this procedure, it is important to use burrs with thin shafts to improve vision.

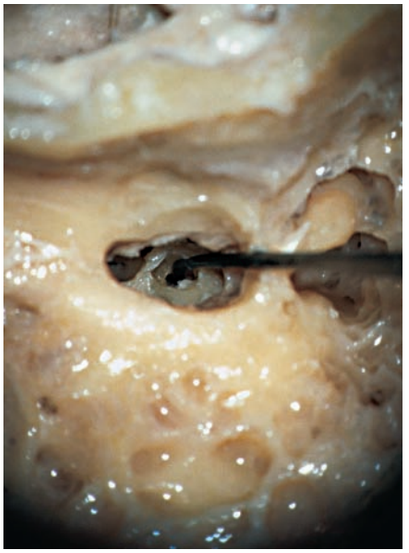
II: 1 mm or smaller cutting and diamond burrs
MIL: Round window



The cochleostomy has been completed, taking care not to damage the endosteum of the cochlea. This close-up view shows the cochleostomy with the intact endosteum. In addition, the lenticular process of incus and the stapes head can be seen superiorly, which are landmarks of secondary importance after the round window for a cochleostomy.



Once the intact endosteum is identified, it is punctured with a sharp microsurgical instrument to reach the scala tympani of the basal turn of the cochlea. During the operation, care should be taken to finish all the drilling work and stop all oozing of blood before puncturing the endosteum.



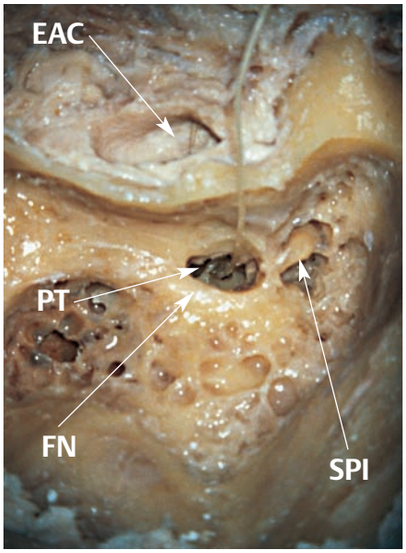
Definitions and Tips

- There are three sets of techniques for cochlear implantation: classical implantation techniques, minimally invasive implantation techniques, and alternative implantation techniques.
- Minimally invasive techniques differ from the classical techniques only with regard to soft tissue handling. Alternative techniques differ from the classical techniques as they bypass the posterior tympanotomy step, using different routes.

The cochleostomy has been carried out, and the final preparation for electrode array insertion has to be done. During the operation, a well for the receiver-stimulator package should have been drilled into the temporal bone cortex, posterosuperior to the created mastoid cavity, and the package should have been secured before the insertion of the electrode array.

CS: Cochleostomy

Close-up surgical view of the cochleostomy and the basal turn of the cochlea through the posterior tympanotomy opening. The next and final step of the procedure will be the delicate grasping and insertion of the electrode array under the magnified view of the microscope.



Simulated insertion of the electrode array. A catgut suture has been inserted through the mastoid cavity, the posterior tympanotomy, and the cochleostomy into the basal turn of the cochlea. In this way the most delicate part of the cochlear implantation procedure has been completed.

EAC: External auditory canal
FN: Facial nerve
PT: Posterior tympanotomy
SPI: Short process of incus

Definitions and Tips

- There are different types of minimally invasive techniques in cochlear implantation. The three-layer flap cochlear implantation technique, which was described, and is used routinely, by the author, reduces operation time, enables complete coverage and safe fixation of the receiver-stimulator, and prevents flap breakdown and implant extrusion or migration. See page 182.

8 Transcortical Exposure of the Epitympanum

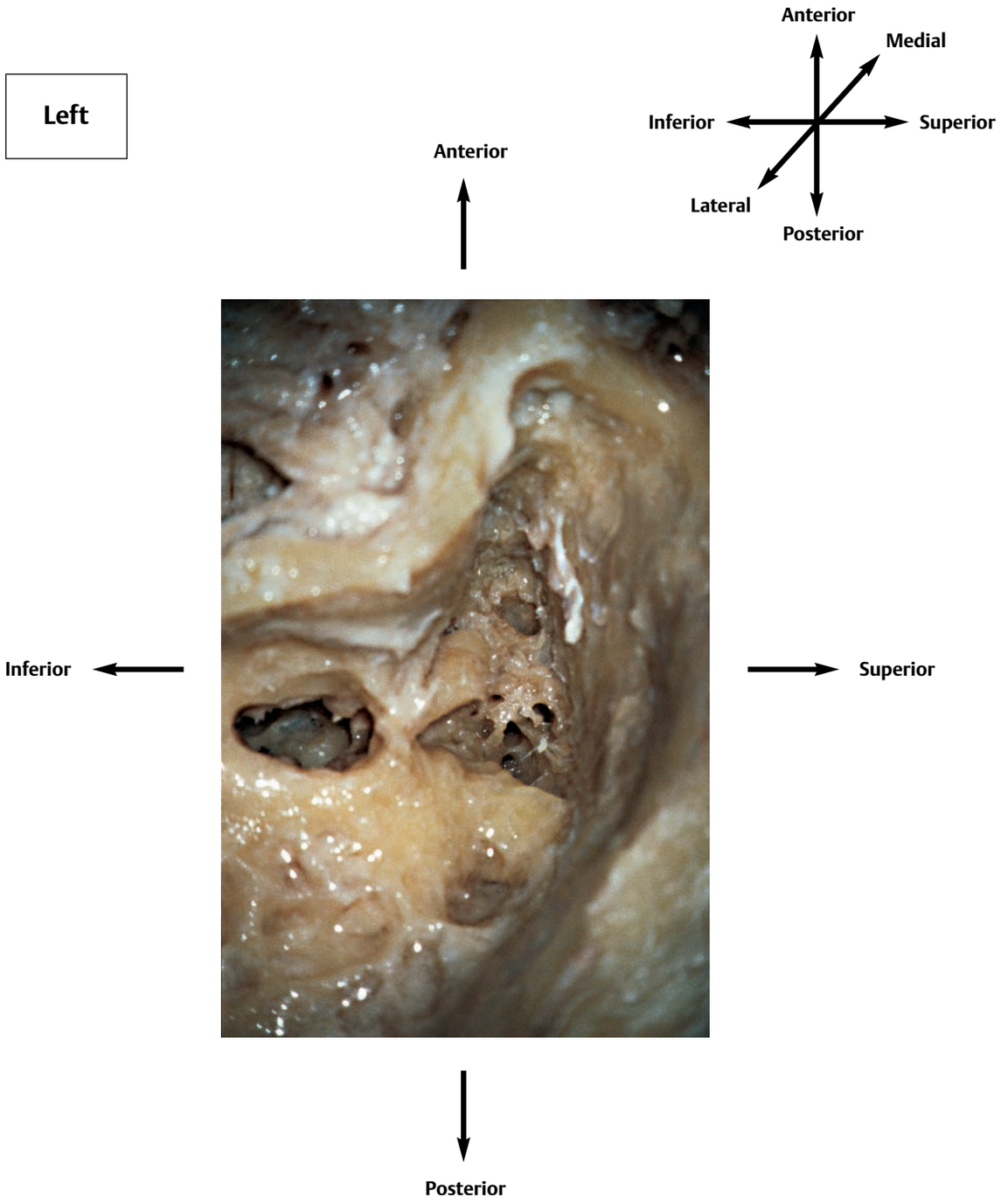
Definition

The transcortical, full exposure of the epitympanum, generally carried out after a cortical mastoidectomy. Alternatively, it may be called epitympanotomy.

Indications

The main indication is in the surgery for chronic otitis media with cholesteatoma.

Anatomical Orientation



Epitympanotomy—an intermediate stage

Surgical Steps

The cortical mastoidectomy and posterior tympanotomy have been completed. The temporal bone is ready for epitympanotomy. In chronic otitis media surgery, an epitympanotomy or epitympanectomy is carried out with or without a posterior tympanotomy, depending on the needs of the case.

DR: Digastric ridge
EAC: External auditory canal
MCF: Middle cranial fossa (dural plate)
SS: Sigmoid sinus (dural plate)

The zygomatic root is identified and using a medium-sized cutting burr, the bone in this area is removed. Care should be taken not to damage the dura of the middle cranial fossa superiorly and the superior wall of the external auditory canal inferiorly.

II: 3–4 mm cutting burr
MIL: Zygomatic root

ZR: Zygomatic root

Following extirpation of the lateral bone at the zygomatic root, the exposure is widened. The medial bone, which is close to the incus and malleus, is left untouched until the final stage of the procedure.

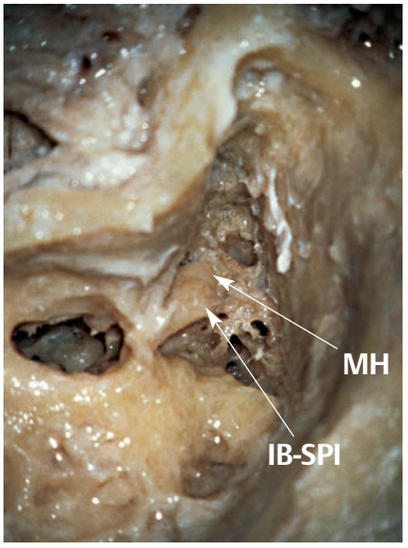
Definitions and Tips

- **Epitympanum (attic):** *Definition:* The superior part of the tympanic cavity. *Tips:* The epitympanum comprises the area medial to the pars flaccida and scutum, and includes the head of malleus, the body of incus, and the surrounding structures. It is divided into two parts by the cog—the anterior epitympanum (supratubal recess) and the posterior epitympanum.

The layer of bone in the immediate vicinity of the incus and malleus is carefully extirpated in the final stage. In this way damage to the ossicles because of blind drilling is prevented.

II: 1–2 mm cutting and diamond burrs
MIL: Body of incus, head of malleus

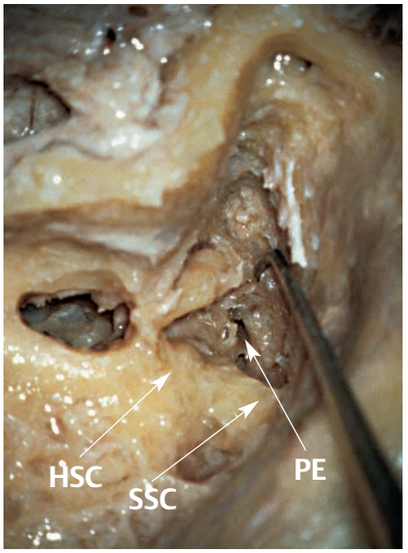
SLI: Superior ligament of incus



After full exposure of the body of the incus and the head of the malleus, the cells and the hard bone at the zygomatic root are further removed, going a couple of millimeters more anteriorly.

II: 3–4 mm cutting burr
MIL: Body of incus, head of malleus

IB: Incus body
MH: Malleus head
SPI: Short process of incus



The microsurgical instrument is pointing to the "cog." The region anterior to the cog is called the anterior epitympanum, i. e., supratubal recess, and the region posterior to the cog is called the posterior epitympanum. Another important surgical area on the medial wall of the epitympanum is the supralabyrinthine recess.

HSC: Horizontal semicircular canal
PE: Posterior epitympanum
SSC: Superior semicircular canal

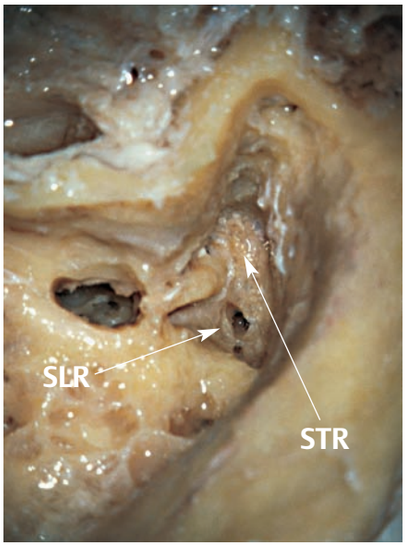
Definitions and Tips

- **Cog:** *Definition:* The bony spine extending from the anterosuperior area of the malleus to the tegmen tympani. *Tips:* The cog is roughly located next to the vertical crest intracranially. Extirpation of the cog allows access to the supratubal area.
- **Supratubal recess (anterior epitympanum):** *Definition:* The area located anterior to the cog and superior to the eustachian tube and tensor tympani muscle. *Tips:* Cholesteatoma and granulation tissue may be concealed in this recess.

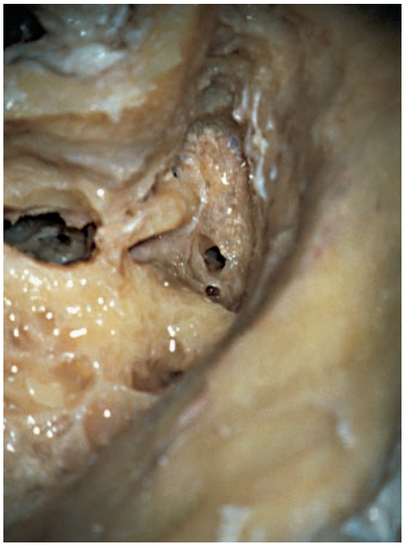
The cog has been extirpated and the cells in the supralabyrinthine area have been removed. Only a few small cells remain, close to the labyrinthine segment of the facial nerve.

II: 1–2 mm diamond burr
MIL: Tympanic and labyrinthine facial nerve

SLR: Supralabyrinthine recess
STR: Supratubal recess



The supratubal recess and the supralabyrinthine recess have become one combined cavity. The epitympanotomy has been completed. This close-up view shows the body of the incus, the head of the malleus and the skeletonized ampulla of the superior semicircular canal.

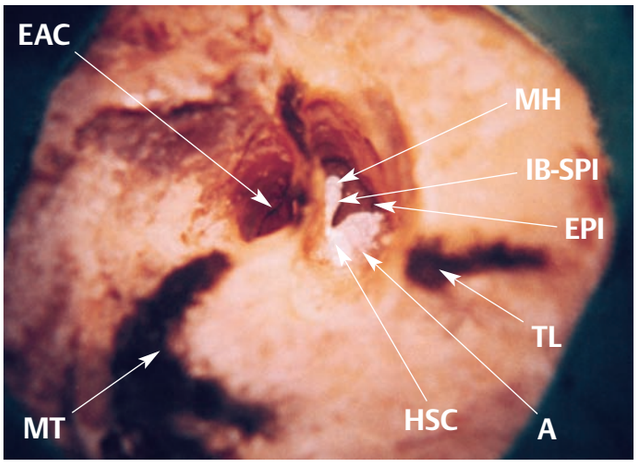


View of the surgical site following cortical mastoidectomy, posterior tympanotomy, and epitympanotomy. During the operation, an epitympanectomy may be carried out, depending on the needs of the case.

Definitions and Tips

- **Supralabyrinthine recess:** *Definition:* The area consisting of cells located on the medial wall of the epitympanum, around the cog. The recess is limited by the tympanic and labyrinthine segments of the facial canal inferiorly, the middle cranial fossa dura superiorly, and the horizontal and superior semicircular canal ampullae posteriorly. *Tips:* Cholesteatoma and granulation tissue may be concealed in this recess.

Surgical Anatomy



A dissected temporal bone in a cadaver. An isolated epitympanotomy without cortical mastoidectomy has been carried out, the important anatomical structures have been exposed and dyed for illustrative purposes.

A: Antrum
EAC: External auditory canal
EPI: Epitympanum (attic)
HSC: Horizontal semicircular canal
IB: Incus body
MH: Malleus head
MT: Mastoid tip
SPI: Short process of incus
TL: Temporal line

Definitions and Tips

- **Epitympanectomy:** *Definition:* Following an epitympanotomy, resection of the head of malleus, the incus, and the chorda-tensor fold, and drilling of the supratubal and supralabyrinthine recesses. *Tips:* An epitympanectomy may be required for removal of cholesteatoma.
- The epitympanum is limited superiorly by the tegmen tympani, which separates the tympanic cavity from the basal dura of the middle cranial fossa.
- The terms “attic” and “epitympanum” are synonyms. However, the terms derived from “epitympanum” are generally used in outside-in techniques, whereas the terms derived from “attic” are generally used in inside-out techniques.

9 Extended Cortical Mastoidectomy

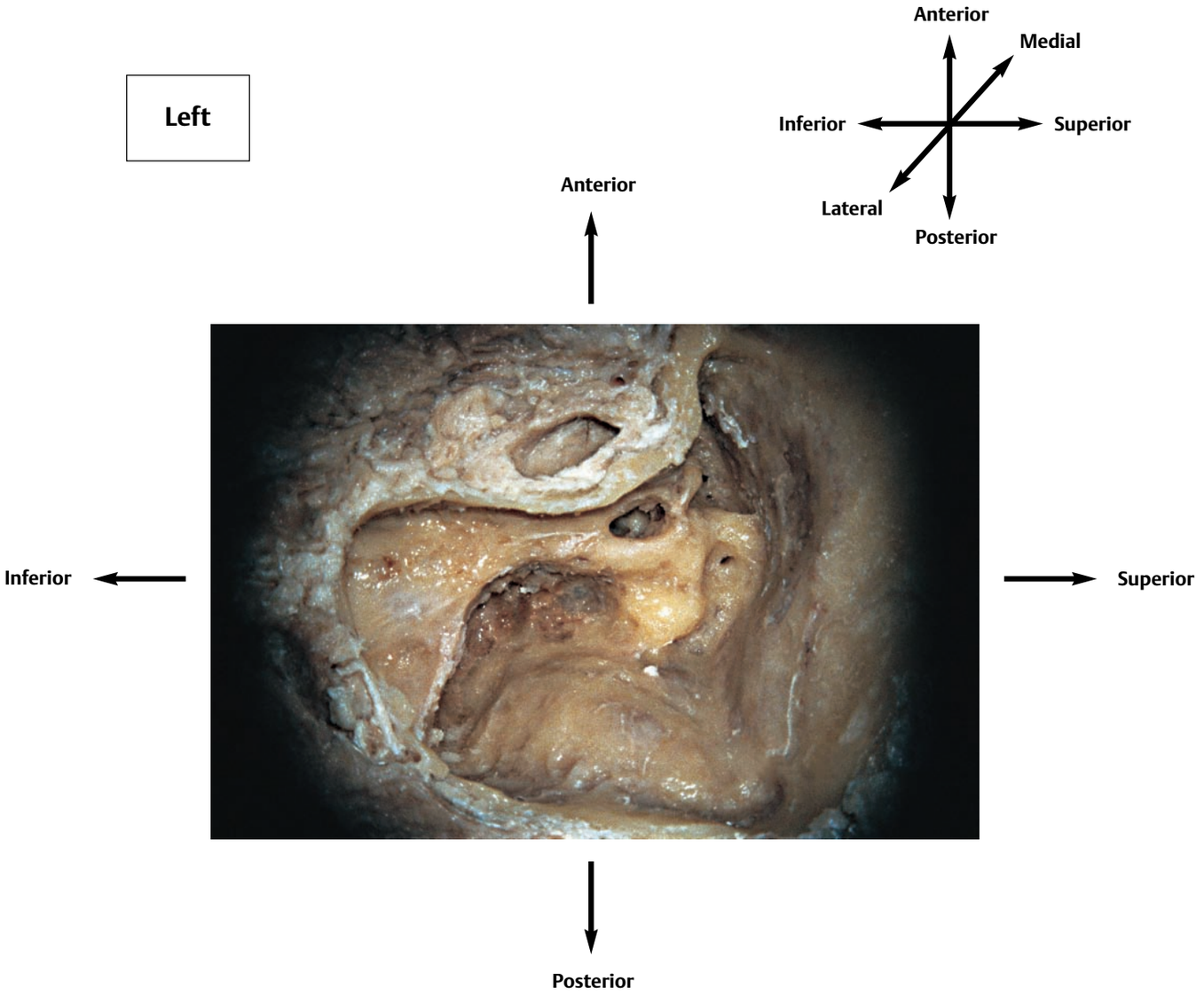
Definition

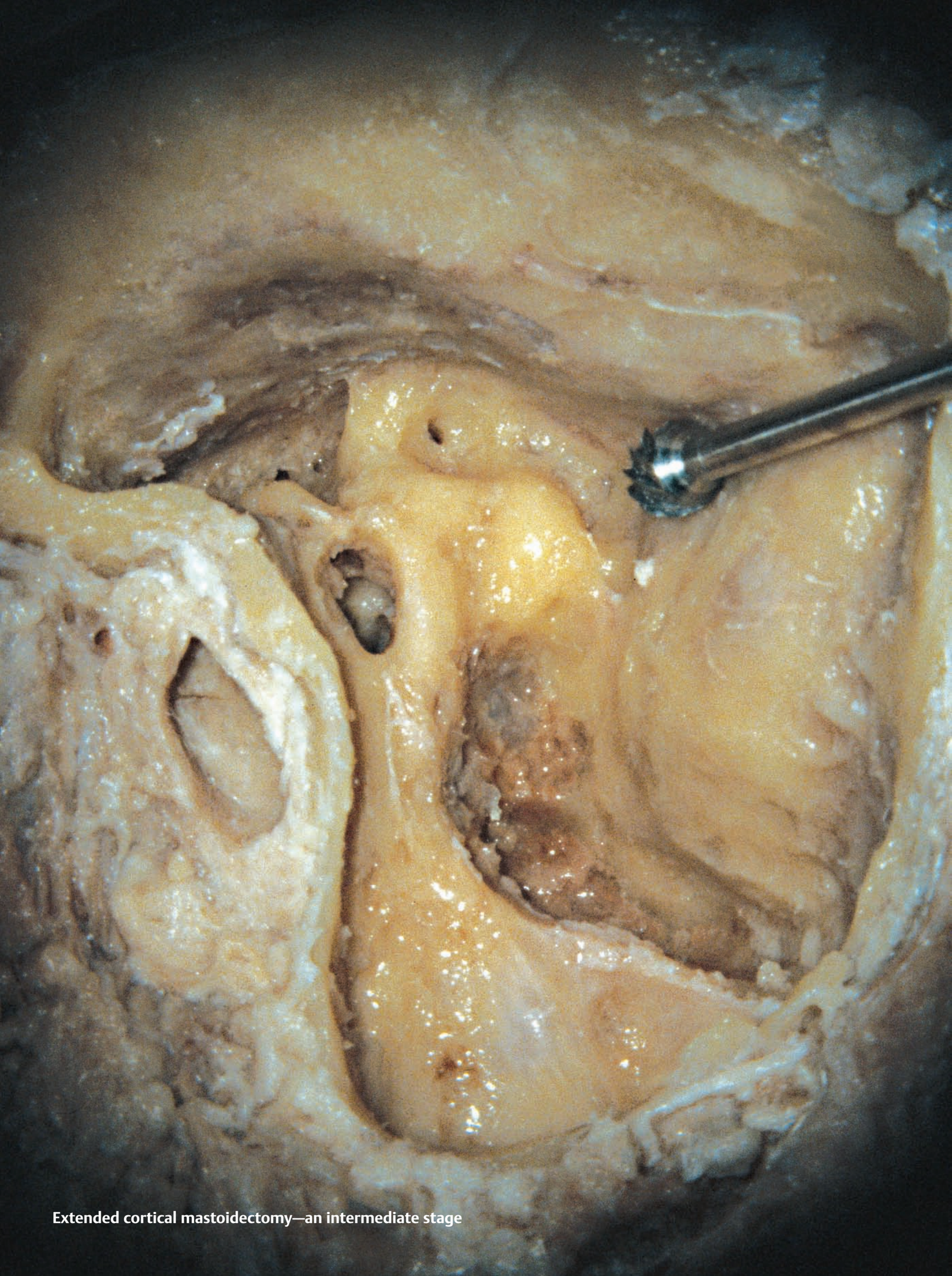
Enlargement of the cortical mastoidectomy until all the neighboring structures have been completely skeletonized. There is no specific classification or terminology for this procedure in the surgical literature. It may be called extended cortical mastoidectomy.

Indications

This procedure is an intermediate stage in neurotologic procedures such as translabyrinthine surgery. It may be also carried out during intact canal wall surgery for chronic otitis media.

Anatomical Orientation





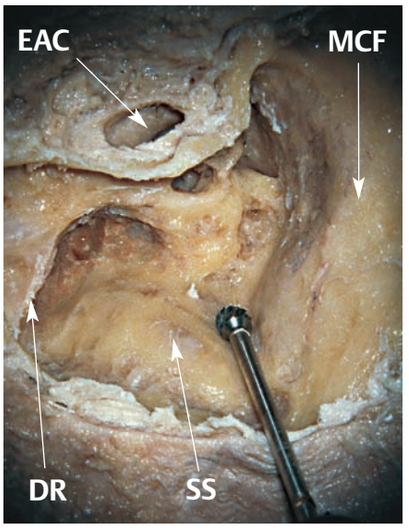
Extended cortical mastoidectomy—an intermediate stage

Surgical Steps

Dissection is continued in the same bone in which a cortical mastoidectomy, posterior tympanotomy and epitympanotomy have been carried out. The dural plates of the middle cranial fossa and sigmoid sinus, and the digastric ridge have already been exposed. The bone around the sinodural angle is carved out with a medium-sized cutting burr.

II: 3–4 mm cutting and diamond burrs
MIL: SS and MCF dural plates

DR: Digastric ridge
EAC: External auditory canal
MCF: Middle cranial fossa (dural plate)
SS: Sigmoid sinus (dural plate)



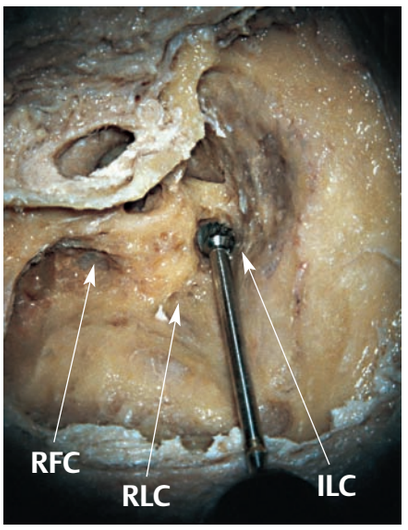
The bone at the sinodural angle has been drilled and the sinodural angle skeletonized. It is important to keep in mind that intracranially this angle corresponds to the superior petrosal sinus.

SDA: Sinodural angle

In the next stage, the interlabyrinthine, retrolabyrinthine, and retrofacial cells are exenterated by means of different-sized cutting burrs.

II: 2–3 mm cutting burr
MIL: Hard bone of labyrinth

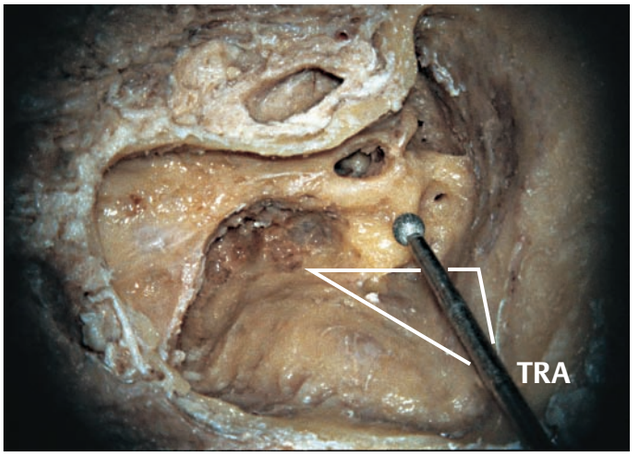
ILC: Interlabyrinthine cells
RFC: Retrofacial cells
RLC: Retrolabyrinthine cells



Definitions and Tips

- **Skeletonization:** *Definition:* By drilling: careful exposure of the last shell of bone covering the critical structures, which should be preserved. *Tips:* Skeletonization is a principal feature of surgery in otology and neurotology. Instead of steering clear of the critical structures, searching for and identifying them lowers the rate of complication, contrary to common belief.
- **Sinodural angle:** *Definition:* The longitudinal area limited by the dural plates of the sigmoid sinus and middle cranial fossa. *Tips:* This area is next to the superior petrosal sinus intracranially. Thorough delineation of this angle during mastoidectomy allows good exposure of the posterior labyrinth.

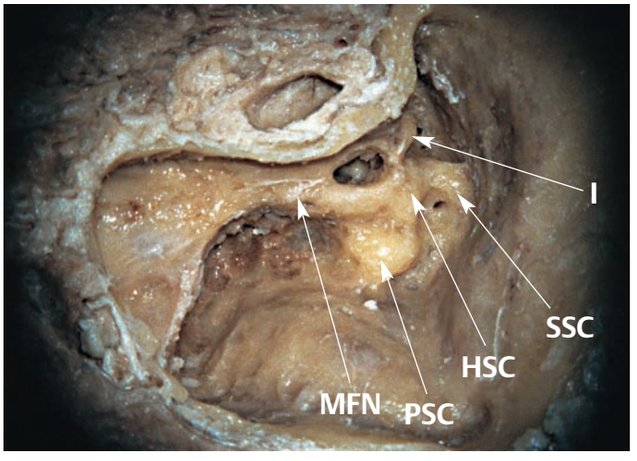
Continued exenteration of the interlabyrinthine, retrolabyrinthine, and retrofacial cells. The cutting burr that was being used previously has been replaced with a smaller one. Drilling with a cutting burr is completed when the smooth, hard bone of the semicircular canals has been identified.



Following this, a small diamond burr is used to complete skeletonization of the semicircular canals. This procedure also exposes the Trautmann triangle, posterior to the labyrinth.

II: 2–3 mm diamond burr
MIL: Hard bone of labyrinth

TRA: Trautmann triangle



The posterior labyrinth and the mastoid segment of the facial nerve have been skeletonized and the extended cortical mastoidectomy has been completed.

HSC: Horizontal semicircular canal
I: Incus
MFN: Mastoid facial nerve
PSC: Posterior semicircular canal
SSC: Superior semicircular canal

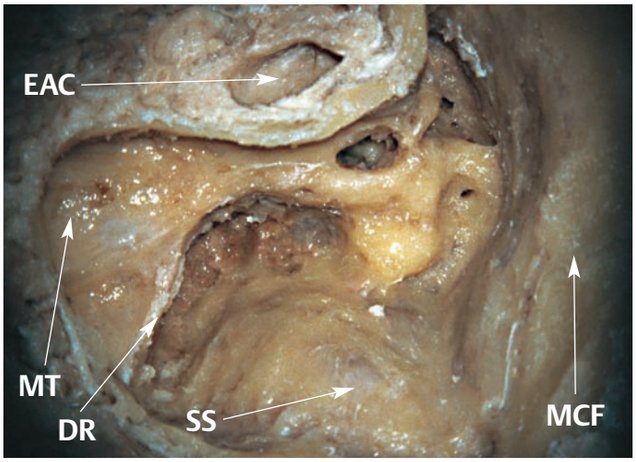
Definitions and Tips

- **Specific air cells:** *Definition:* Air cells that are of particular importance in otologic surgery. *Tips:* Although there are different classifications, these cells can be described as: supralabyrinthine, interlabyrinthine, retrolabyrinthine, retrofacial, presigmoid, retrosigmoid, apical, hypotympanic, infralabyrinthine, facial recess, peritubal, and petrosal. Apart from these specific cells, the temporal bone includes the superficial mastoid cells, the antrum, and the zygomatic root cells.
- **Trautmann triangle:** *Definition:* The triagonal area limited by the dural plate of the middle cranial fossa superiorly, horizontal and posterior semicircular canals anteriorly, and the dural plate of the sigmoid sinus posteriorly. *Tips:* This area consists of the retrolabyrinthine and presigmoid cells and is the access passageway to the posterior cranial fossa in the retrolabyrinthine approach.

The microsurgical instrument is pointing to the digastric ridge in the completed extended cortical mastoidectomy cavity. All the skeletonized structures, i. e., the dural plates of the middle cranial fossa and sigmoid sinus, the sinodural angle, the mastoid tip, the facial canal, and the three semicircular canals, can be seen.

A wide-angle view of the surgical site following the completed procedure; the main neighboring structures that have been skeletonized are shown.

DR: Digastric ridge
EAC: External auditory canal
MCF: Middle cranial fossa (dural plate)
MT: Mastoid tip
SS: Sigmoid sinus (dural plate)



Definitions and Tips

- A precise extended cortical mastoidectomy involves skeletonization of the dural plate of the middle cranial fossa superiorly, digastric ridge inferiorly, posterior wall of the external auditory canal anteriorly, dural plate of the sigmoid sinus posteriorly, and additionally the mastoid segment of the facial canal anteromedially, and posterior labyrinth posteromedially.
- The common mistakes made or complications encountered during a cortical mastoidectomy or radical mastoidectomy with regard to depth of drilling are as follows:
  - Difficulty in finding the antrum: The Koerner septum may cause confusion, the antrum may be small, the bone close to the tegmen mastoidea may not have been sufficiently extirpated, or the posterior wall of the external auditory canal may not have been sufficiently thinned.
  - Sigmoid sinus bleeding: Penetration of the sigmoid sinus with a sharp burr leads to this complication. It occurs more often during mastoidectomies in cases with an anteriorly located sigmoid sinus or contracted mastoid.
  - Cerebrospinal fluid leakage: Inadvertent damage to the dura of the middle or posterior cranial fossa dura with a sharp burr results in this complication.
  - Dislocating the incus: Drilling carelessly along the antrum and aditus lateral walls anteriorly can lead to this complication.
  - Sensorineural hearing loss and tinnitus: Touching the intact ossicular chain with the burr or suction tip carries this risk.
  - Facial nerve trauma: This complication can occur if there is bony dehiscence around the facial nerve at the facial prominence, or if the bone posterior to the pyramidal segment is drilled carelessly in an anterior direction, or if the digastric ridge is followed anteriorly by drilling zealously.
  - Damage to the semicircular canals: Novice drilling of the medial wall of the antrum holds this risk.

10 Canalplasty

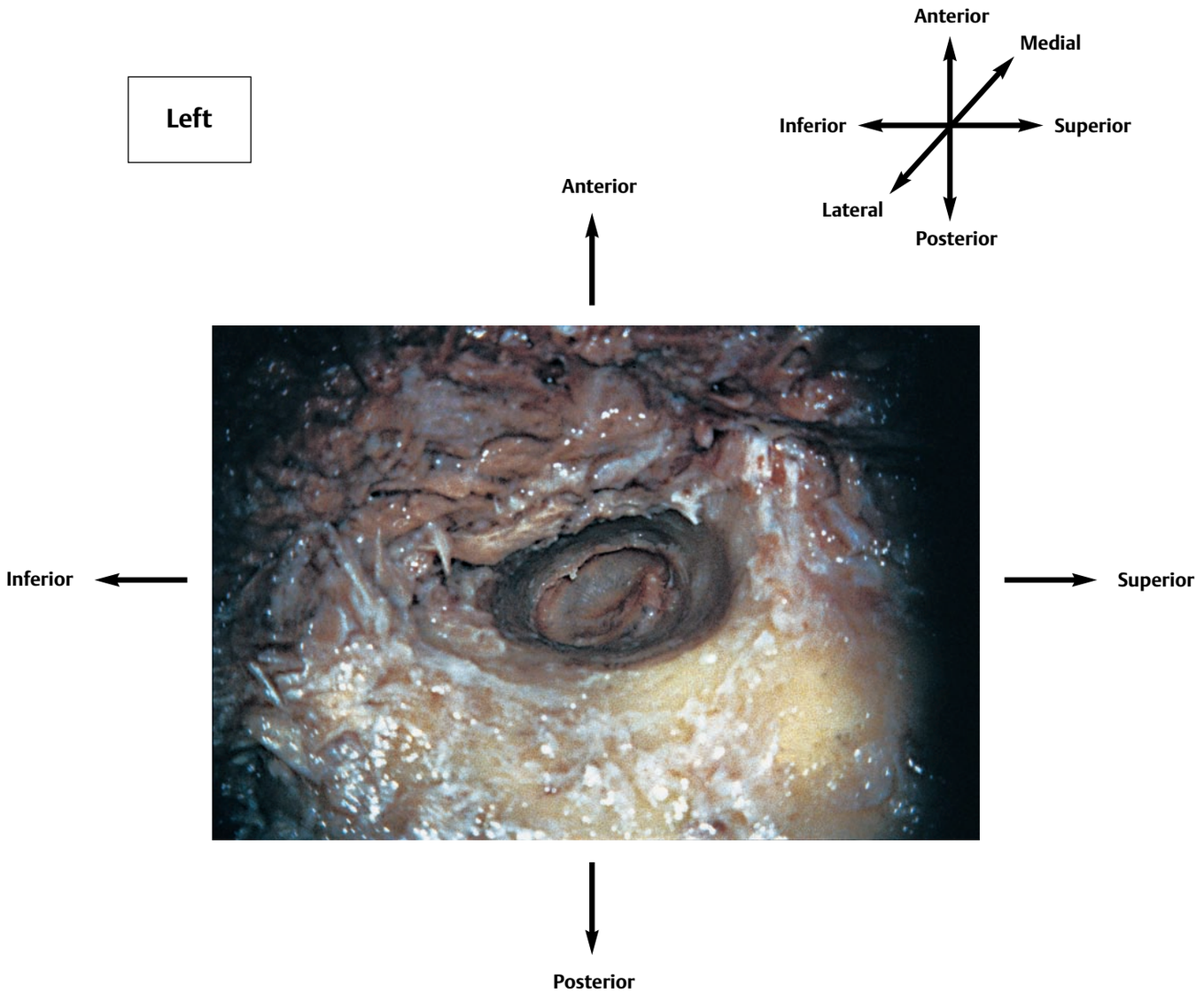
Definition

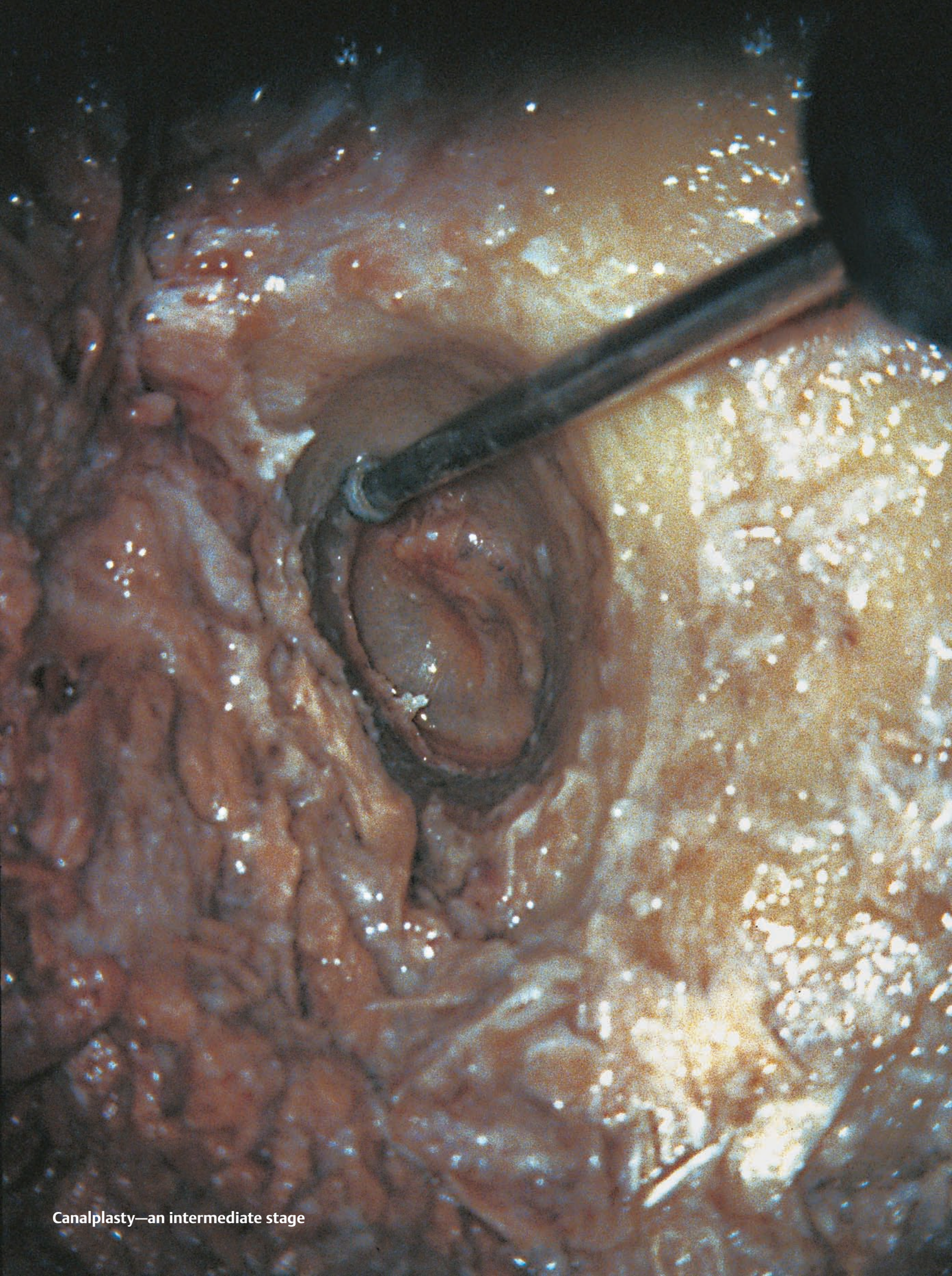
Enlargement of the external auditory canal by drilling all around the walls of the bony canal (360°). At the end of the procedure, the external auditory canal resembles a cut cone in shape.

Indications

The main indication is tympanic membrane perforation in which the anterior edge of the perforation cannot be observed sufficiently. It is also used as an intermediate stage to widen the exposure in cases such as primary cholesteatoma limited to the middle ear.

Anatomical Orientation



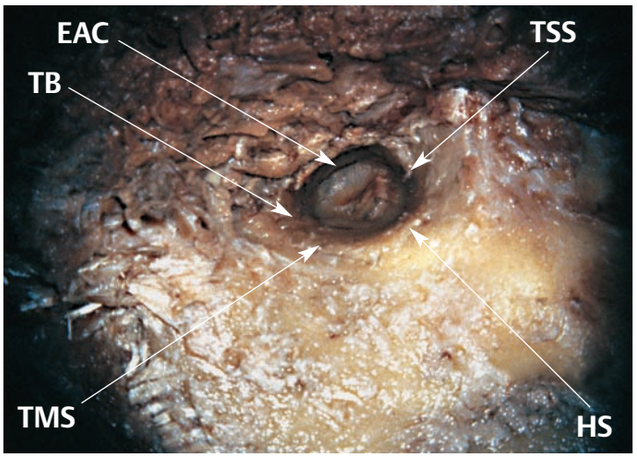


Canalplasty—an intermediate stage

Surgical Steps

The soft tissues have been elevated from the lateral surface of the temporal bone, exposing the external auditory canal and the mastoid. The critical structures are indicated in the figure.

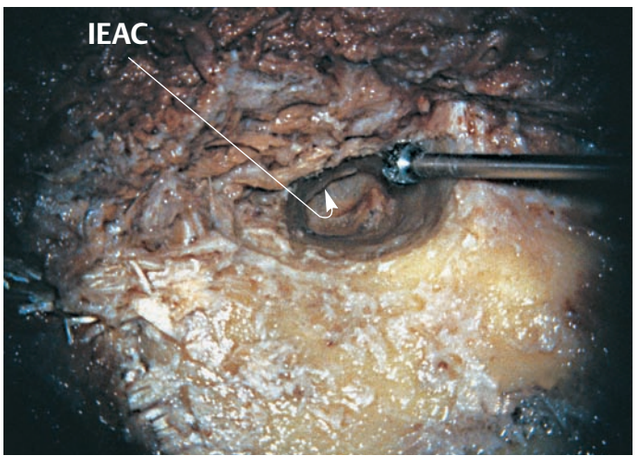
EAC: External auditory canal
HS: Henle spine
TB: Tympanic bone
TMS: Tympanomastoid suture
TSS: Tympanosquamous suture



Using a medium-sized cutting burr, the lateral part of the external auditory canal is drilled circumferentially. All the overhanging areas of bone, including the tympanomastoid and tympanosquamous sutures, are removed.

II: 3–4 mm cutting burr
MIL: Temporomandibular joint reflection

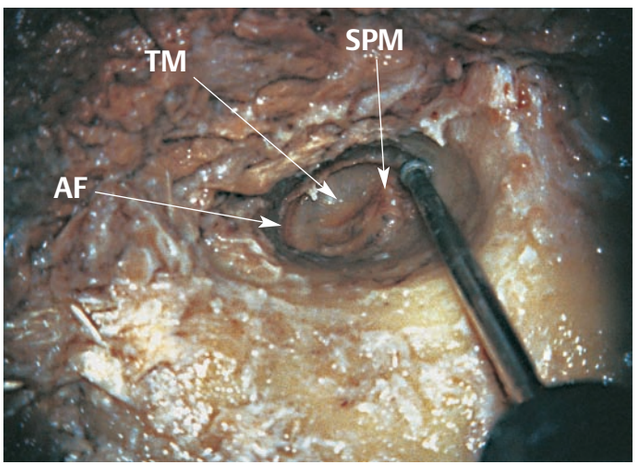
IEAC: Isthmus of external auditory canal



Next, the area of the external auditory canal close to the tympanic membrane is enlarged by means of a small diamond burr. It is especially important to remove the bony overhangs at the anterior and inferior walls of the external auditory canal.

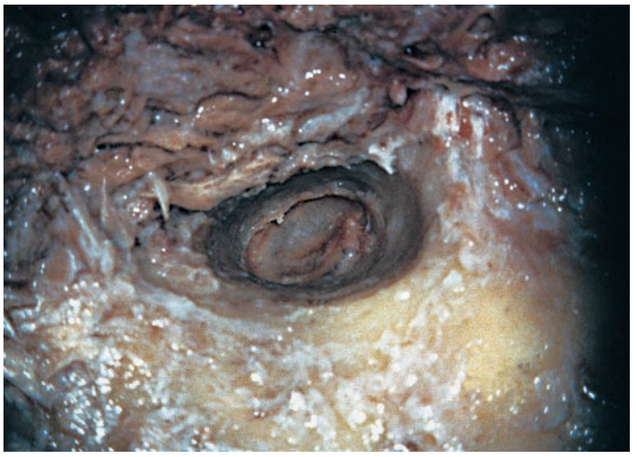
II: 1–2 mm diamond burr
MIL: Tympanic annulus

AF: Annulus fibrosis
SPM: Short process of malleus
TM: Tympanic membrane



Definitions and Tips

- **Tympanomastoid suture (fissura tympanomastoidea):** *Definition:* The suture on the junction of the tympanic and mastoid bones. *Tips:* The suture crosses the posterior wall of the external auditory canal. The inexperienced surgeon can use this suture as a rough landmark; the facial canal lies more medially, i. e., deeper to this suture.
- **Tympanosquamous suture (fissura tympanosquamosa):** *Definition:* The suture on the junction of the tympanic and squamous bones. *Tips:* The suture crosses the anterior part of the superior canal wall. Removal of this suture allows better exposure around the short process of malleus.
- The tympanomastoid and tympanosquamous sutures are formed by fusion of the tympanic bone with other parts of the temporal bone as a superior-facing crescent.



View of the surgical site after completion of canalplasty. The external auditory canal has been shaped like a cut cone. The entire circumference of the tympanic membrane can be seen in a single view through the microscope, which is the critical concept in canalplasty.

Definitions and Tips

- **Isthmus of the external auditory canal:** *Definition:* The bulge in the anterior canal wall approximately 5 mm lateral to the tympanic membrane. *Tips:* The external auditory canal narrows in this area and, medial to this bulge, forms the anterior recess. The anterior margin of a perforation may not be adequately seen due to this anterior bulge at the isthmus, thus requiring canalplasty. Also, in most cases, an inferior bulge accompanies the anterior bulge in this area.
- Various meatal and tympanomeatal flaps or grafts may be applied during canalplasty. Whichever technique is used, the aim should be to leave as few bare bony areas as possible at the end of the operation. Bare bony areas carry the risk of late, difficult, and uncontrolled healing, resulting in deformities and blunting of skin coverage.
- The position of the tympanic membrane is diagonal, meaning its anterior part lies deeper (more medially); furthermore, this anterior part is obscured by the anterior bulge at the isthmus. On the other hand, the posterior part of the tympanic membrane lies more superficially (more laterally), and is completely exposed because of the lack of a posterior bony bulge.
- Access to the posterior part of the tympanic membrane is not difficult to achieve. Access is difficult in the anterior part of the membrane. Because of this, the choice of appoach in middle ear surgery depends on the required anterior exposure. The degree of anterior exposure increases in the following approaches in ascending order:
  - transcanal tympanoplasty
  - endaural tympanoplasty
  - retroauricular tympanoplasty
  - endaural tympanoplasty with canalplasty
  - retroauricular tympanoplasty with canalplasty

11 Antrotomy

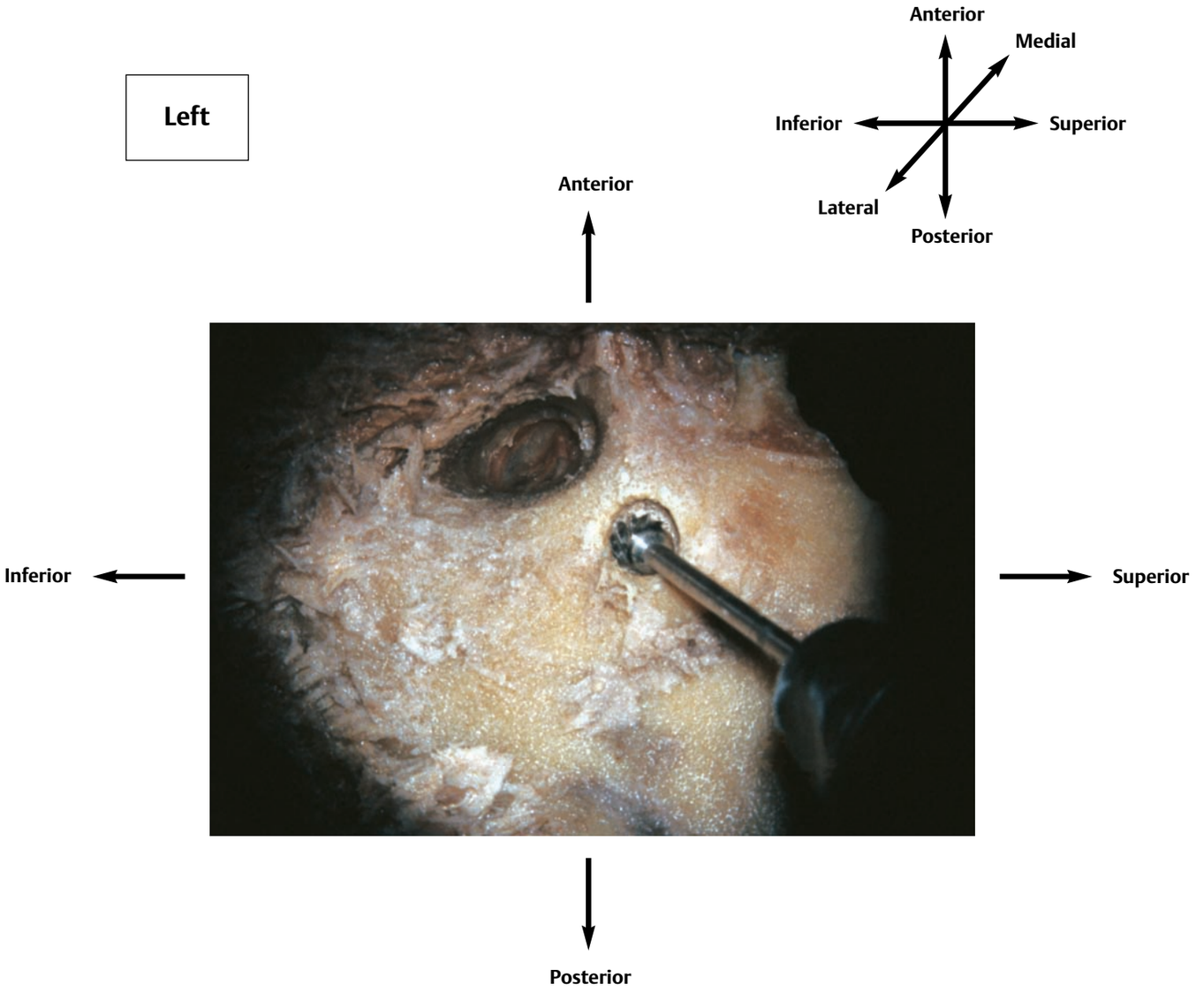
Definition

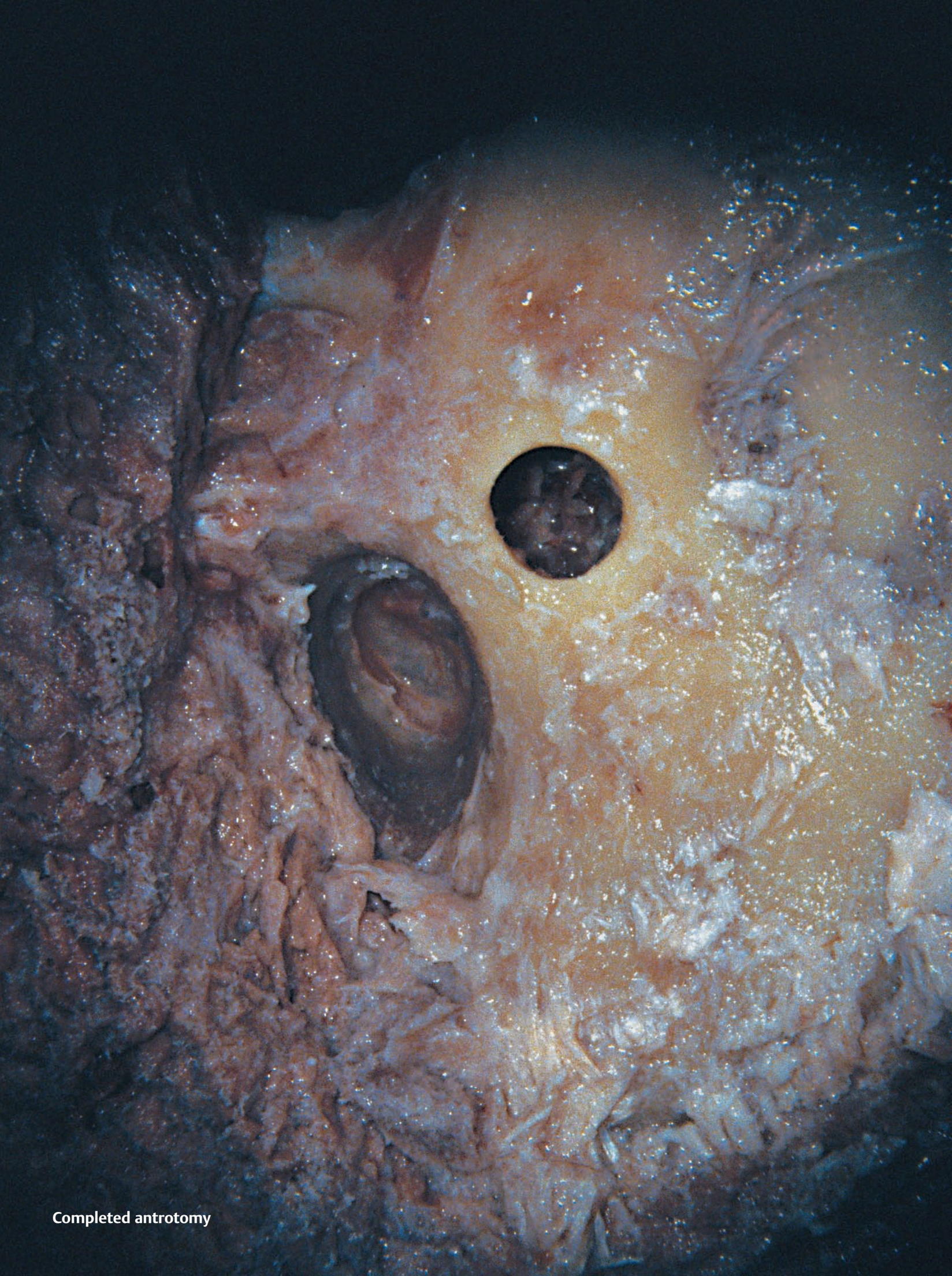
Transcortical exposure of the antrum through the tunnel, by drilling the cortical bone at the Macewen triangle.

Indications

An antrotomy may be used in chronic otitis media surgery to observe the antrum, to do a “fluid test,” and, depending on the needs of the case, to extend the procedure to a cortical mastoidectomy.

Anatomical Orientation



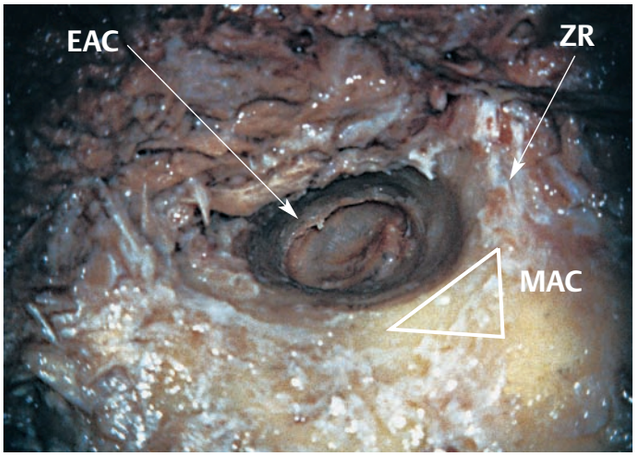


Completed antrotomy

Surgical Steps

An antrotomy will be carried out on the same temporal bone where a canalplasty has already been done. The critical Macewen triangle is shown in the figure.

EAC: External auditory canal
MAC: Macewen triangle
ZR: Zygomatic root

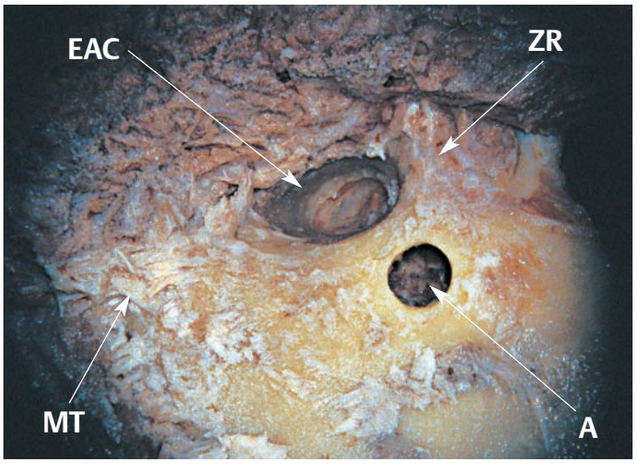


Having defined the Macewen triangle, the area is drilled using a 4–5 mm cutting burr. The direction of the burr shaft should be parallel to the posterosuperior wall of the external auditory canal, pointing slightly inferiorly. Pointing the burr superiorly may result in damage to the temporal lobe.

II: 4–5 mm cutting burr
MIL: Macewen triangle

The antrum is located approximately 1 cm deep, i. e., medial to the cortex. The antrotomy has been completed. The burr should not touch the bottom of the antrum because the horizontal semicircular canal is located there. The antrum can be visualized through the created tunnel, and a "fluid test" conducted.

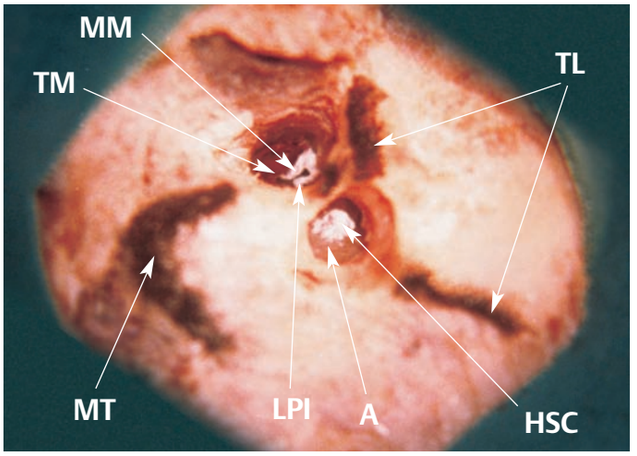
A: Antrum
EAC: External auditory canal
MT: Mastoid tip
ZR: Zygomatic root



Definitions and Tips

- **Macewen triangle (suprameatal triangle, mastoid fossa):** *Definition:* The cribriform area located posterosuperior to the spine of Henle and limited superiorly by the temporal line. *Tips:* This triangle is the area where the antrum is sought in transmastoidal procedures. In adults, the antrum lies approximately 1 cm deep (medially) to this triangle.
- **Fluid test:** *Definition:* Filling the antrum with fluid and then suctioning it through the tympanic cavity. *Tips:* If the fluid test is negative, it means that the connection between the tympanic cavity and the mastoid is blocked, in which case an extension of the procedure may be required.

Surgical Anatomy



A dissected temporal bone in a cadaver. An antrotomy has been carried out, and the important anatomical structures have been exposed and dyed for illustrative purposes.

A: Antrum
HSC: Horizontal semicircular canal
LPI: Long process of incus
MM: Manubrium mallei
MT: Mastoid tip
TL: Temporal line
TM: Tympanic membrane

Definitions and Tips

- If a canalplasty is required in a case where an antrotomy or cortical mastoidectomy will be carried out, the canalplasty is to be carried out first. If the antrotomy or cortical mastoidectomy is done first, the posterior wall of the external auditory canal becomes too thin to allow precise canalplasty.
- In the past, two other antrotomy techniques were described, which are no longer in routine use:
  - Wullstein: This involves opening a window to the antrum in the posterosuperior canal wall close to the tympanic annulus.
  - Plester: This involves opening a window to the antrum in the posterosuperior canal wall further away from the tympanic annulus.

12 Tympanoplasty

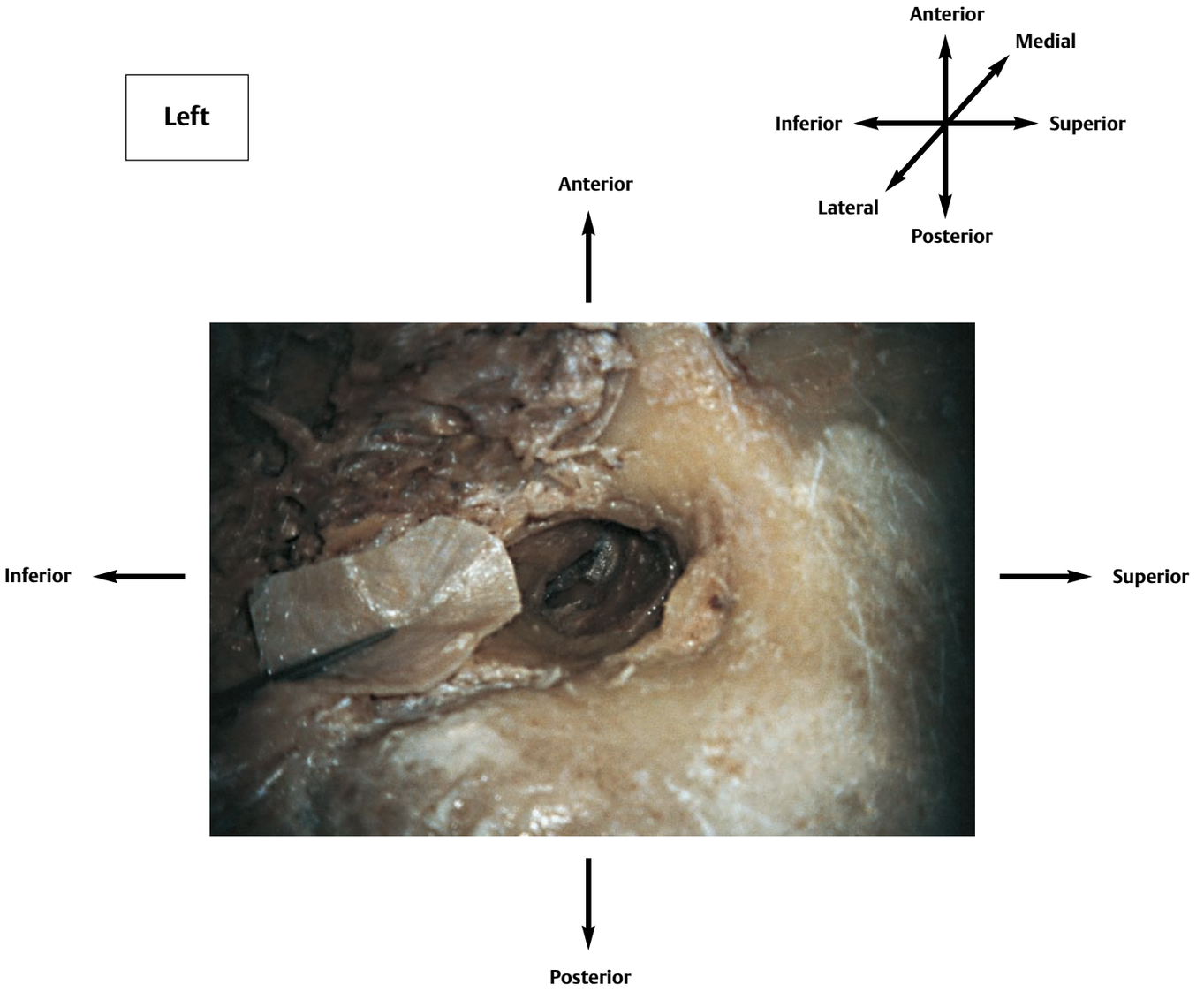
Definition

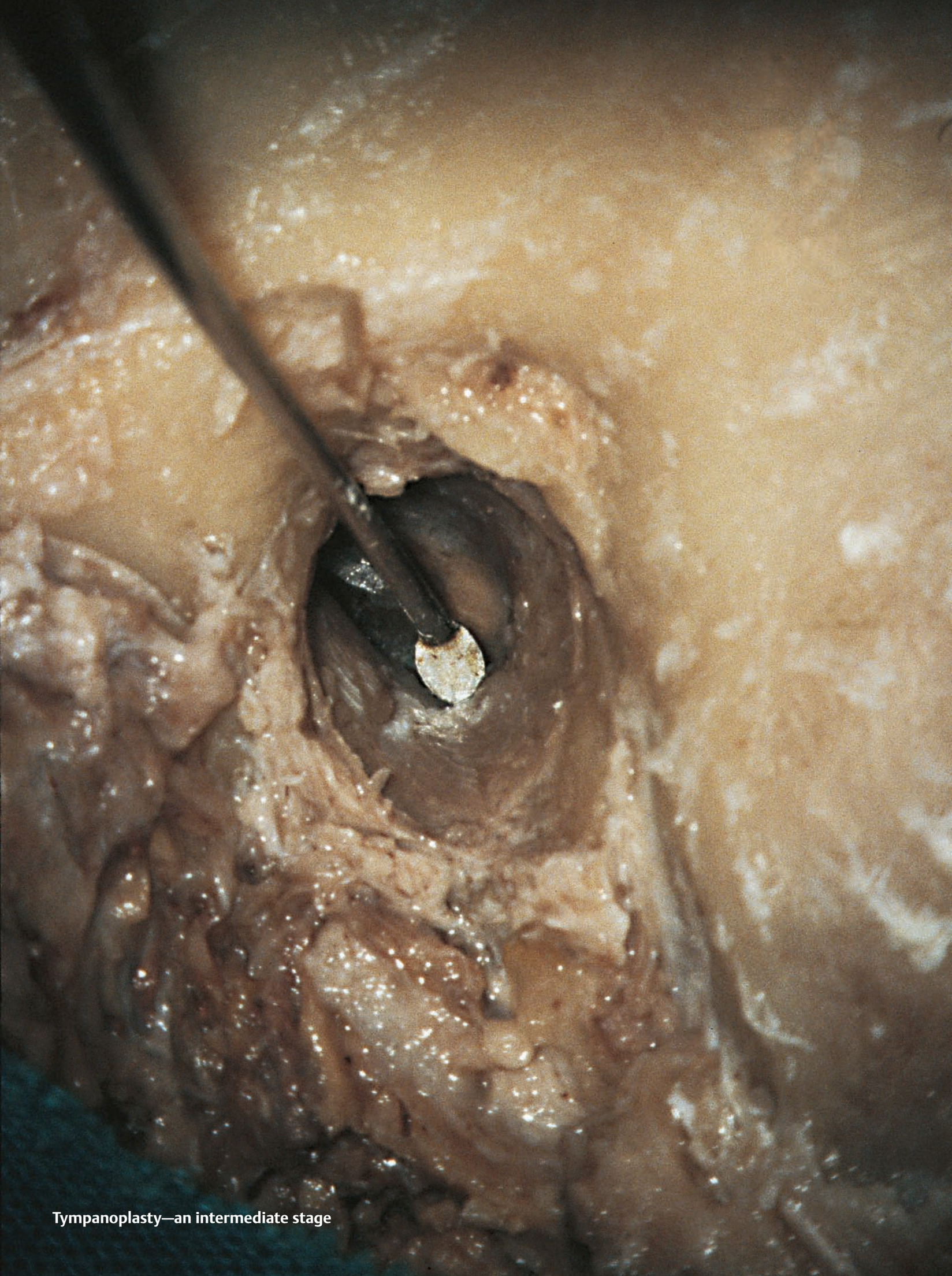
Tympanoplasty type 1, alternatively called myringoplasty, is the reconstruction of the perforated tympanic membrane using a material such as temporalis fascia.

Indications

Perforation of the tympanic membrane.

Anatomical Orientation



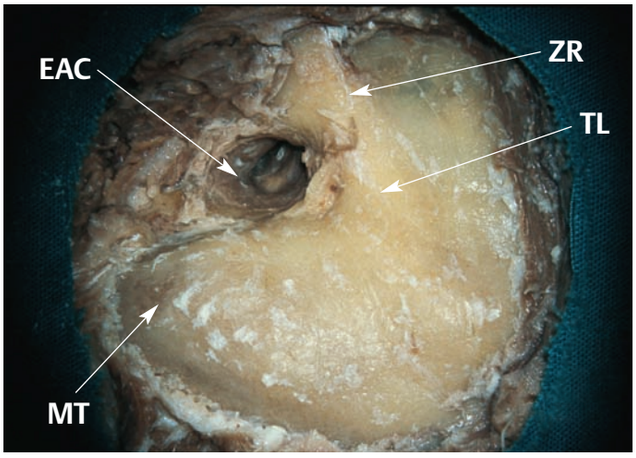


Tympanoplasty—an intermediate stage

Surgical Steps

Following dissection of the soft tissues, and exposure of the external auditory canal and mastoid, the temporal bone is ready for the procedure. Care has been taken to preserve the tympanic membrane and the skin of the external auditory canal.

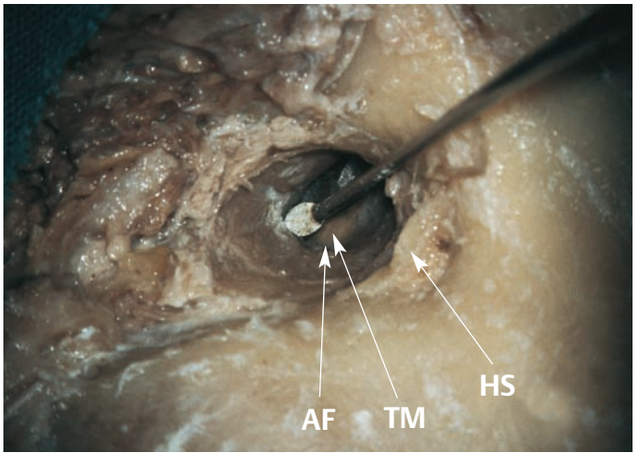
EAC: External auditory canal
MT: Mastoid tip
TL: Temporal line
ZR: Zygomatic root



Using a curved micro knife, an incision is made in the skin of the posterior wall of the external auditory canal, at a distance of 3–4 mm from the annulus fibrosis, parallel to it.

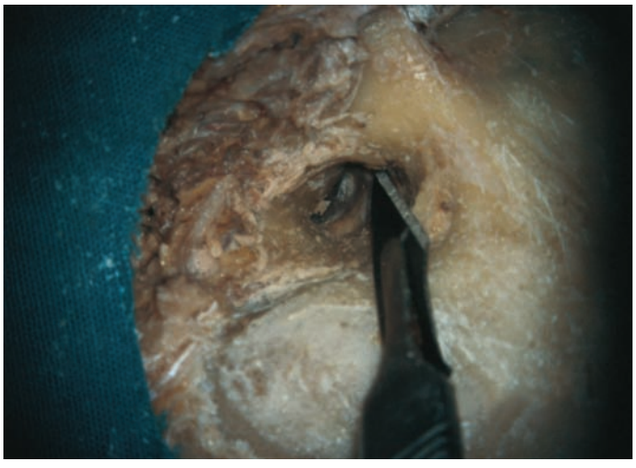
II: Curved micro knife
MIL: Annulus fibrosis

AF: Annulus fibrosis
HS: Henle spine
TM: Tympanic membrane



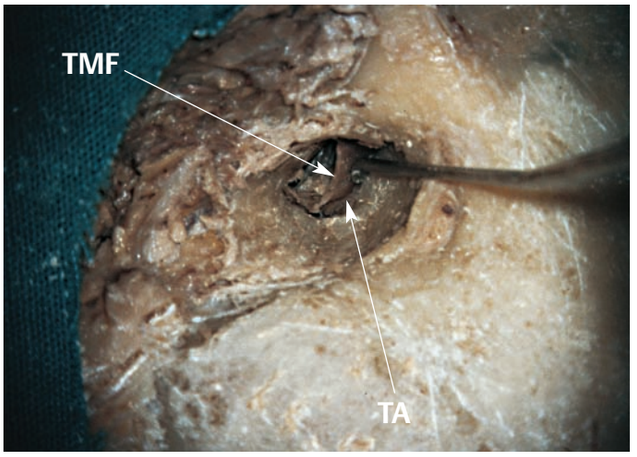
Next, a second incision is made superiorly using a No. 11 blade or sickle knife. This incision should begin just anterior to the short process of malleus medially, and join the superior edge of the first incision laterally.

II: No. 11 blade or sickle knife
MIL: Short process of malleus



Definitions and Tips

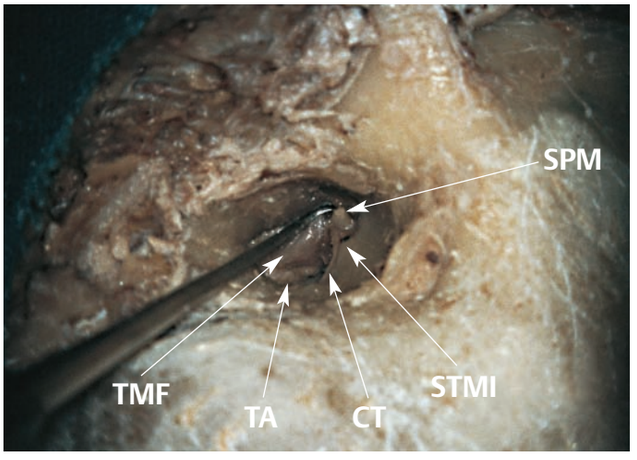
- **Annulus fibrosis (fibrous annulus, annulus fibrocartilaginous membrana tympani):** *Definition:* The fibrous tissue encircling the pars tensa of the tympanic membrane. *Tips:* The fibrous annulus is located in the sulcus of the tympanic annulus. The access passage for the exposure of the tympanic cavity is between the fibrous annulus and the tympanic annulus.
- The Wullstein classification comprises tympanoplasty types 1–5. In the half century following this classification, it has become insufficient. However, the concept of type 1 and type 3 tympanoplasty is still routinely applied in surgery:
  - type 1 tympanoplasty—tympanoplasty without ossiculoplasty
  - type 3 tympanoplasty—tympanoplasty with the graft positioned on the stapes head



Then the formed tympanomeatal flap is elevated toward the tympanic annulus by means of a micro elevator. The annulus fibrosis is separated from the tympanic annulus, and subsequently the tympanomeatal flap, including the annulus fibrosis, is positioned anteriorly.

II: Micro elevator
MIL: Spina tympanica minor

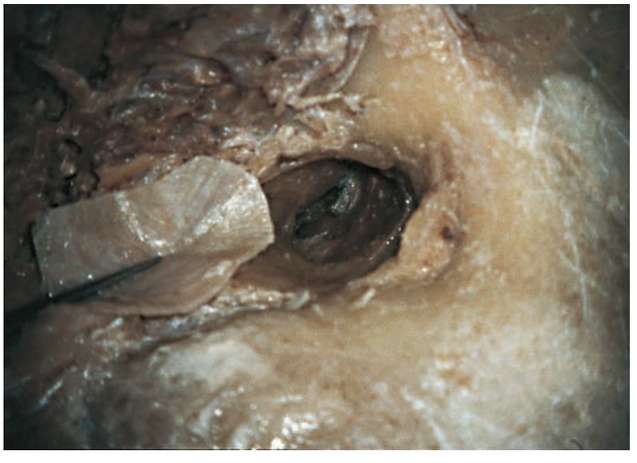
TA: Tympanic annulus
TMF: Tympanomeatal flap



Dissection and elevation of the tympanomeatal flap is completed superiorly when the short process of the malleus has been exposed, using a curved micro dissector. The inferior limit of the dissection is determined by the anterior margin of the perforation, or by the required exposure of the tympanic cavity.

II: Curved micro dissector
MIL: Chorda tympani

CT: Chorda tympani
SPM: Short process of malleus
STMI: Spina tympanica minor
TA: Tympanic annulus
TMF: Tympanomeatal flap



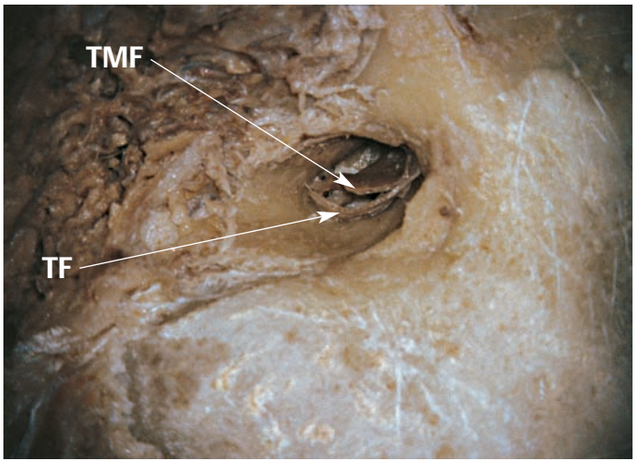
Following the exposure of the middle ear; the previously taken graft, i. e., the temporalis fascia, is grasped with a pair of forceps and introduced to the surgical site. Meticulous hemostasis is mandatory before the placement of the graft in the live operation.

Definitions and Tips

- **Tympanic annulus (annulus tympanicus, sulcus tympanicus, tympanic ring):** *Definition:* The bony sulcus in which lies the tympanic membrane with the annulus fibrosis. *Tips:* It forms the crescentic area inferior to the greater and lesser tympanic spines, and enables firm attachment of the pars tensa to the bone.
- There are various types of micro elevator, which is an indispensable instrument for raising tympanomeatal and meatal flaps. During this process, instruments with smaller and larger tips are needed alternately. The double-sided microsurgery instruments designed by the author provide both speed and convenience; only one maneuver of the fingers is required to change the tip thus enabling usage of the appropriate sized tip. See page 185.

The temporalis fascia is inserted into the tympanic cavity and positioned anteriorly under the tympanomeatal flap. In this way, the temporalis fascia is placed medial to the tympanic membrane and the "underlay" tympanoplasty procedure is completed.

TF: Temporalis fascia
TMF: Tympanomeatal flap



Definitions and Tips

- **Vascular strip:** *Definition:* The area between the tympanosquamous and tympanomastoid sutures that covers the deep, posterosuperior wall of the external auditory canal, where the skin becomes thick and more vascular. *Tips:* Preparation of tympanomeatal and meatal flaps in some tympanoplasty techniques is based on the preservation of the vascular strip, such as the onlay technique of Sheehy.
- Tympanoplasty consists of different procedures, and during a tympanoplasty, one or more of the following procedures are carried out (a myringoplasty is always executed):
  - myringoplasty—grafting of the perforated tympanic membrane
  - canalplasty—enlargement of the external auditory canal by drilling
  - exploration—exploring the ossicular chain, round window, mucosa, etc.
  - ossiculoplasty—reconstruction of the continuity of the ossicular chain
  - soft tissue procedures—resection of hyperplastic mucosa, granulation, etc.
- The tympanoplasties are classically divided into two groups, depending on the position of the graft:
  - underlay—positioning the graft under (medially) the tympanic membrane remnant or fibrous annulus
  - overlay—positioning the graft over (laterally) the tympanic membrane remnant or fibrous annulus, after having removed the squamous epithelium in the area to be grafted

13 Stapedotomy

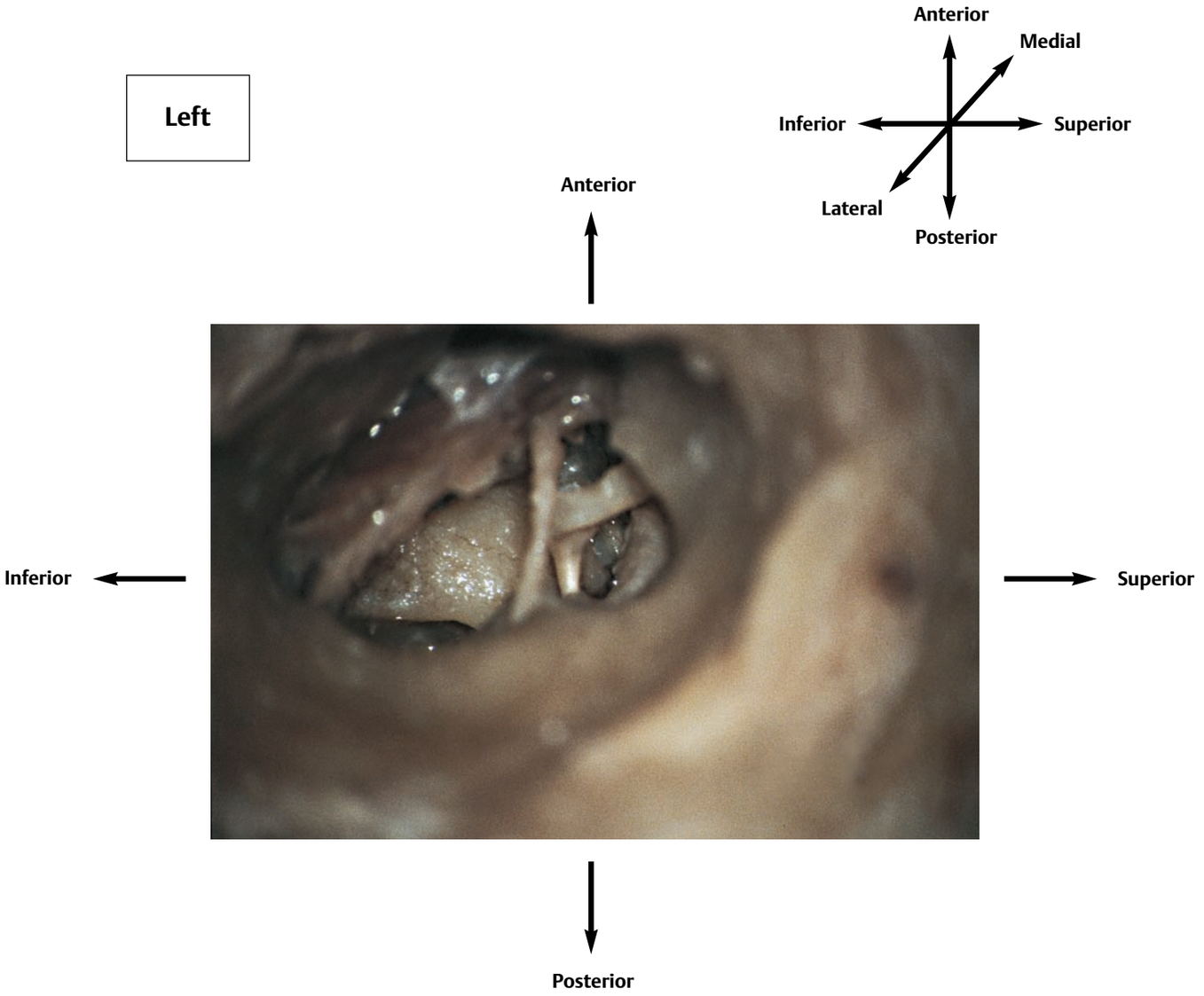
Definition

Replacement of the stapes ossicle with a prosthesis following removal of the stapes arch and making an opening in the stapes footplate. Alternatively, the footplate may be removed completely. In this case, the procedure is called a stapedectomy.

Indications

The main indication is otosclerosis surgery. However, this procedure is also used in tympanosclerosis and chronic otitis media surgery.

Anatomical Orientation



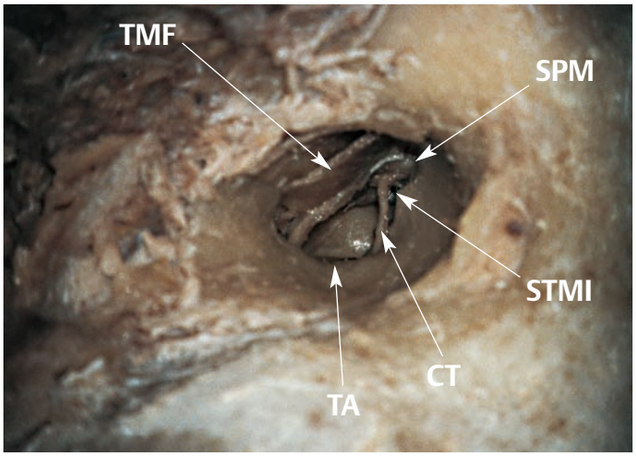
Stapedotomy—an intermediate stage

Surgical Steps

The tympanomeatal flap has been elevated and the lesser tympanic spine, chorda tympani, and short process of malleus have been exposed. During the operation, there is no need to expose the inferior part of the tympanic cavity too extensively.

II: Micro elevator
MIL: Tympanic annulus

CT: Chorda tympani
SPM: Short process of malleus
STMI: Spina tympanica minor
TA: Tympanic annulus
TMF: Tympanomeatal flap

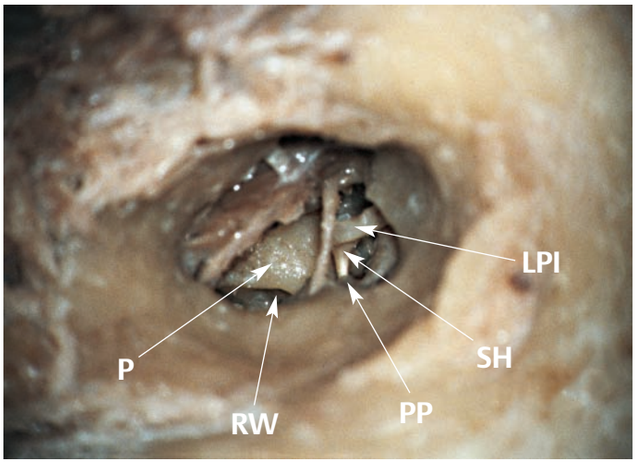


Using a small curette or small diamond burr, a “stapedotomy drilling” is carried out in the area of the lesser tympanic spine. A common mistake is drilling too anteriorly and thus exposing the body of the incus. This is called partial atticotomy and has no place in a stapedotomy procedure.

II: Small curette
MIL: Lesser tympanic spine

Under higher magnification, the critical structures are observed. During “stapedotomy drilling” the chorda tympani is easily damaged accidentally. To prevent this, the direction of drilling or maneuvering of the curette should be away from the chorda tympani.

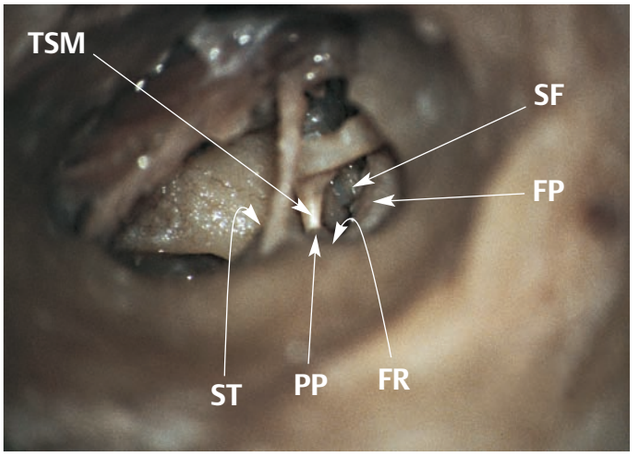
LPI: Long process of incus
P: Promontory
PP: Pyramidal process
RW: Round window
SH: Stapes head



Definitions and Tips

- **Spina tympanica minor (lesser tympanic spine):** *Definition:* The bony spine located posteriorly between the tympanic annulus and incisura tympanica. *Tips:* This is the landmark used in the first stage of any type of middle ear procedure, such as a tympanoplasty or stapedotomy.
- **Stapedotomy drilling (stapedotomy notch):** *Definition:* Drilling away the bone around the lesser tympanic spine. *Tips:* This procedure is mainly performed in stapedotomy and in chronic otitis media surgery to get a good exposure of the facial prominence and pyramidal process. It involves only limited removal; drilling of the area located more anterosuperiorly transforms the procedure into a partial atticotomy.

The tympanosquamous suture is removed. If exposure of the surgical site is inadequate, the surgeon should not hesitate to remove the tympanosquamous suture. A good exposure is one of the keys to successful surgery.



The temporal bone is now ready for the main steps of the stapedotomy procedure. Being ready means first having exposed the facial prominence superiorly, and second the pyramidal process posteriorly. All the critical structures encountered at this stage are indicated in the figure.

FP: Facial prominence
FR: Facial recess
PP: Pyramidal process
SF: Stapes footplate
ST: Sinus tympani
TSM: Tendon of stapedius muscle

In the next stage, an opening is made in the footplate, with a perforator. During this process, the facial prominence should be observed carefully. It should not be forgotten that this prominence may have bony dehiscence, and the facial nerve may be easily damaged in this area.

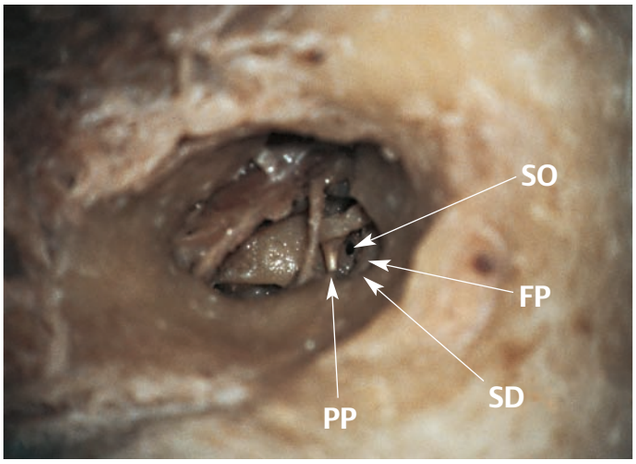
II: Perforator
MIL: Facial prominence

Definitions and Tips

- **Facial prominence (prominentia canalis facialis):** *Definition:* The bony bulge of the distal part of the tympanic facial nerve, in the tympanic cavity superior to the stapes. *Tips:* This is one of the main landmarks in stapedotomy or chronic otitis media surgery. The rate of facial canal dehiscence is quite high in this area.
- **Pyramidal process (eminentia pyramidalis):** *Definition:* The bony bulge of the stapedius muscle, in the tympanic cavity posterior to the stapes. *Tips:* This is one of the main landmarks in stapedotomy or chronic otitis media surgery. The tendon of the stapedius muscle extends from the pyramidal process to the neck of stapes.

The most critical part of the stapedotomy has been completed. Following this, the tendon will be cut and the stapes arch will be removed. (This has not been done to preserve the structural integrity for the subsequent demonstrations.)

FP: Facial prominence
PP: Pyramidal process
SD: Stapedotomy drilling
SO: Stapedotomy opening



Definitions and Tips

- In modern day surgery, two related, alternative techniques are used in case of a fixed stapes:
  - stapedotomy: removing the stapes suprastructure, i. e., stapes head and anterior and posterior crus of stapes, and creating a small hole in the stapes footplate
  - stapedectomy: removing the whole stapes, i. e., stapes head and anterior and posterior crus of stapes, and additionally the stapes footplate
- A stapedotomy may be performed in two different ways. The first is the classical technique—the stapes suprastructure is extirpated, followed by careful puncturing of the stapes footplate and application of the prosthesis. The second is the reverse technique—the stapes footplate is punctured and the prosthesis is applied, followed by the removal of the stapes suprastructure. In the procedure described in this chapter, a reverse stapedotomy, except for the last steps, has been executed.

14 Intact Bridge Atticotomy

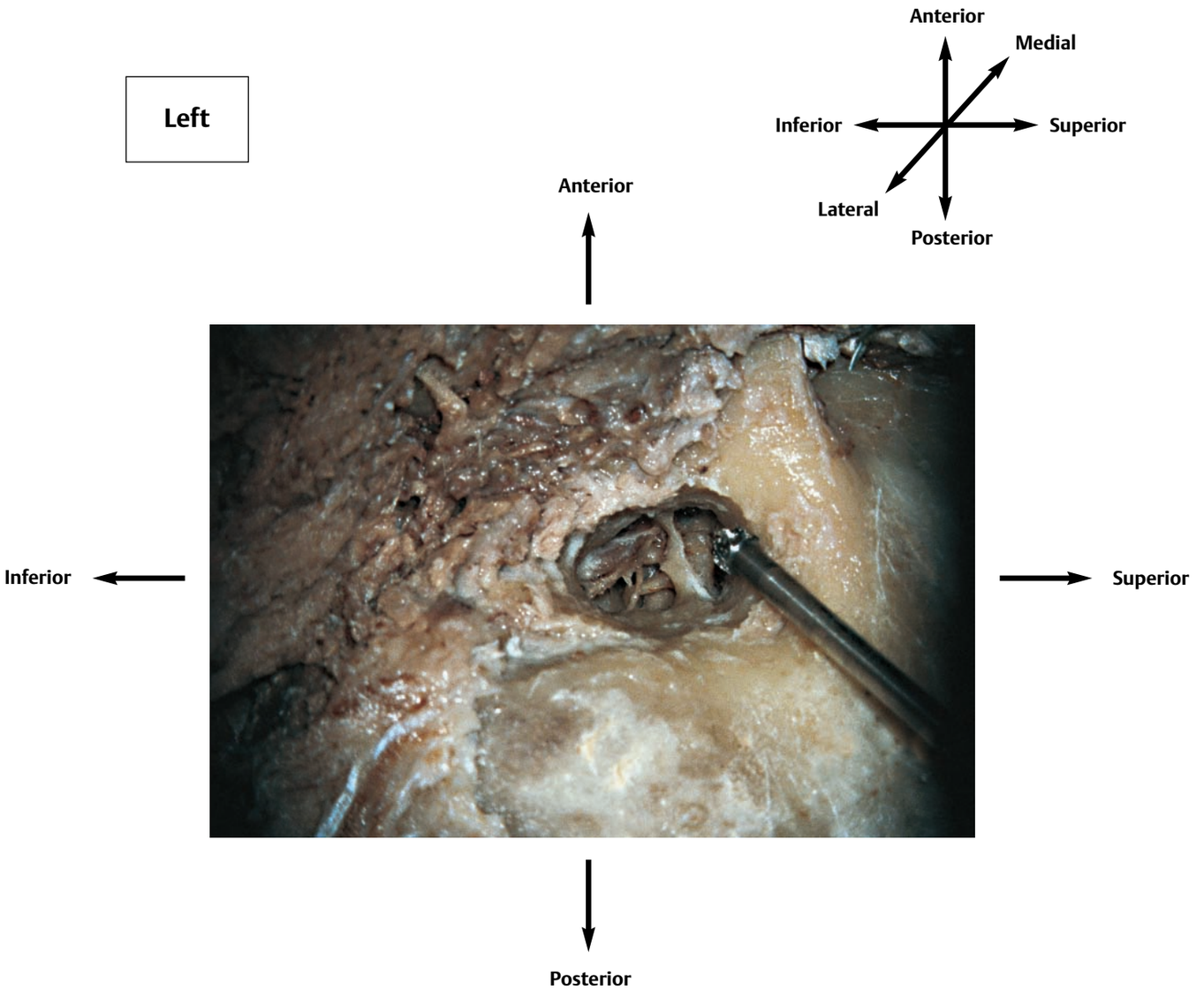
Definition

Exposure of the attic by removal of its lateral wall through the enlarged external auditory canal, while creating a bony bridge close to the tympanic membrane.

Indications

An intact bridge atticotomy is mainly used in the surgery for chronic otitis media with cholesteatoma.

Anatomical Orientation

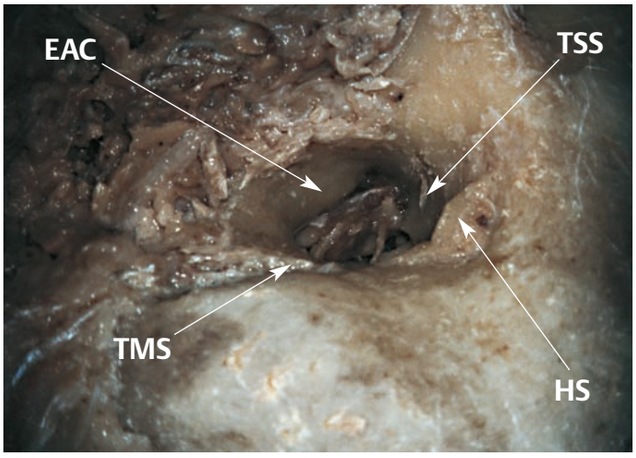


Completed intact bridge atticotomy

Surgical Steps

The soft tissues have been dissected from the lateral surface of the temporal bone, exposing the external auditory canal. The temporal bone is ready for the intact bridge atticotomy procedure. The bony sutures and spine encountered during this approach are indicated in the figure.

EAC: External auditory canal
HS: Henle spine
TMS: Tympanomastoid suture
TSS: Tympanosquamous suture



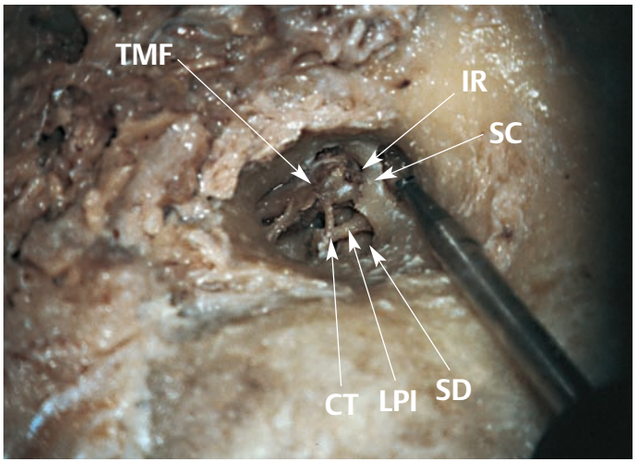
Using a medium-sized cutting burr, Henle spine and the tympanosquamous suture are removed. The lateral part of the superior wall of the external auditory canal is drilled, as in the canalplasty procedure, resulting in the enlargement of the canal superiorly.

II: 3–4 mm cutting burr
MIL: Henle spine

Next, the lateral wall of the attic is drilled and a small opening into the attic is made anteriorly, by means of a small cutting or diamond burr. During this stage, it is extremely important not to let the burr touch the ossicles in the attic.

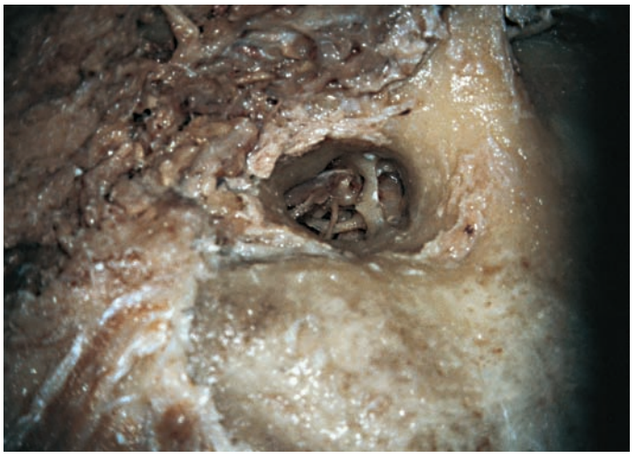
II: 1–2 mm cutting or diamond burr
MIL: Incisura Rivini

CT: Chorda tympani
IR: Incisura Rivini
LPI: Long process of incus
SC: Scutum
SD: Stapedotomy drilling
TMF: Tympanomeatal flap

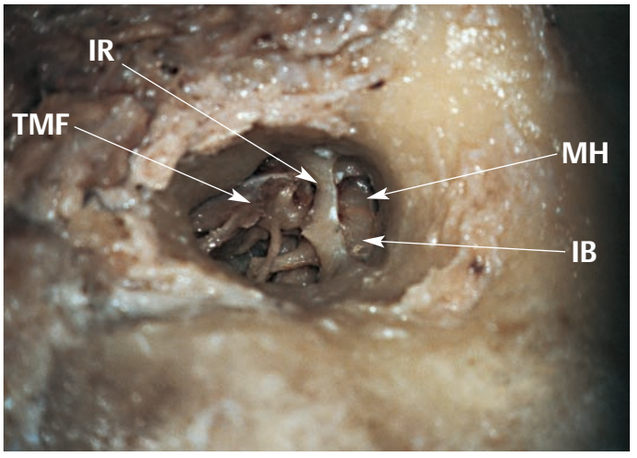


Definitions and Tips

- **Scutum (Shield):** *Definition:* The bony area superior to the incisura Rivini, forming the lateral wall of the attic. It is the deepest area on the superior wall of the external auditory canal adjacent to the tympanic membrane. *Tips:* The scutum is the area where procedures of different extents are executed in atticotomy-related techniques.
- On the bone dissected in this chapter, “stapedotomy drilling” has also been carried out. In fact, during the operation, stapedotomy drilling is often executed along with an atticotomy, to gain better exposure of the ossicular chain.

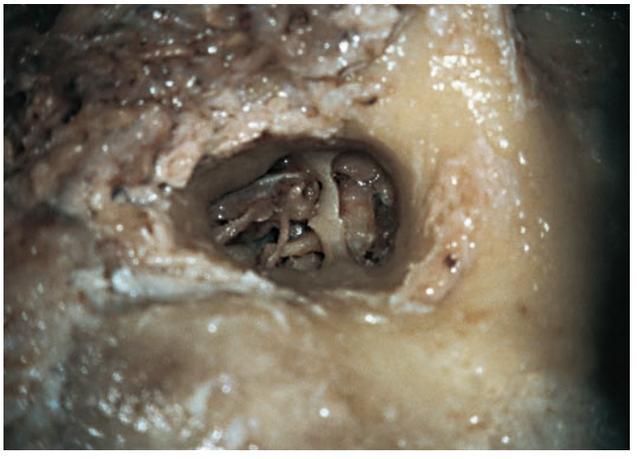


The opening created in the lateral attic wall is enlarged posteriorly. During this stage, to prevent contact of the burr with the ossicles, the drill is used on a slow rotation setting and the burr is moved under firm control, avoiding unrestrained movements.



A closer view of the surgical site. Through the window that has been created, the head of malleus and the body of incus have been exposed. Note the position of the bridge in relation to the incisura Rivini.

IB: Incus body
IR: Incisura Rivini
MH: Malleus head
TMF: Tympanomeatal flap



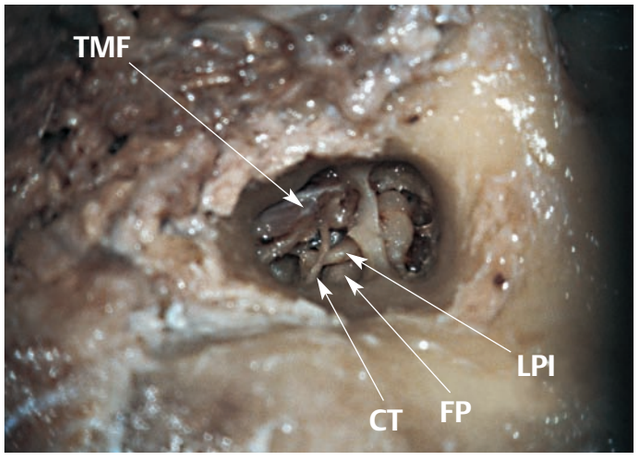
In the next stage, the atticotomy opening is widened. Throughout this procedure, the lateral part of the external auditory canal is also drilled alternately toward the dura of the middle cranial fossa, with the intention of achieving better exposure.

Definitions and Tips

- **Incisura Rivini (incisura tympanica):** *Definition:* The crescentic bony edge located superiorly between the lesser and greater tympanic spines. *Tips:* After removal of the tympanic membrane, a bony circular margin within the temporal bone is observed, which is separated into two parts by the greater and lesser tympanic spines. The smaller, superior part is called the incisura Rivini, and the larger, inferior part is called the tympanic annulus. The incisura Rivini is an important structure during all types of middle ear procedures.
- **Spina tympanica major (greater tympanic spine):** *Definition:* The relatively larger bony spine located anteriorly between the tympanic annulus and incisura tympanica. *Tips:* This spine may be used as a landmark in cases in which cholesteatoma extends into the supratubal recess or the eustachian tube.

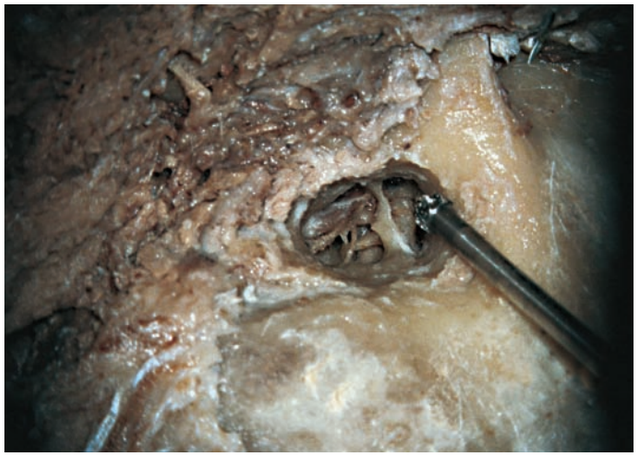
Another view of the procedure. Some of the critical structures in the middle ear, i. e., the chorda tympani, long process of incus and the facial prominence, are indicated on the figure.

CT: Chorda tympani
FP: Facial prominence
LPI: Long process of incus
TMF: Tympanomeatal flap



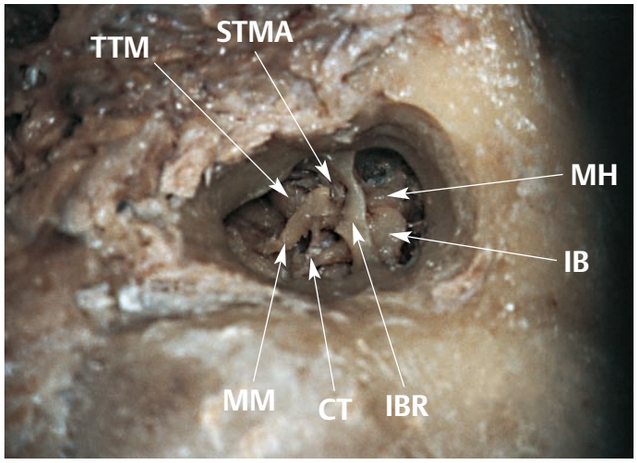
Following the rule not to work when the view of the surgical site is impaired, the exenteration of the lateral part of the superior canal wall is continued. A medium-sized cutting burr is used for this stage.

II: 3–4 mm cutting burr
MIL: Middle cranial fossa dural plate



The head of malleus and body of incus have been exposed entirely, and the intact bridge atticotomy completed. To demonstrate the anatomy in this area, the remaining tympanic membrane has been removed; consequently, the ossicles can be observed in their entirety in the tympanic cavity and attic.

CT: Chorda tympani
IB: Incus body
IBR: Intact bridge
MH: Malleus head
MM: Manubrium mallei
STMA: Spina tympanica major
TTM: Tensor tympani muscle



Definitions and Tips

- **Tympanic cavity (middle ear):** *Definition:* The middle ear. *Tips:* The tympanic cavity can be divided into five regions: epitympanum (attic), the superior part; mesotympanum, the middle part; hypotympanum, the inferior part; protympanum, the anterior part; and retrotympanum, the posterior part.
- The techniques for approaching the mastoid and middle ear are classified in different ways. With respect to the direction of access, they are classified as:
  - Outside-in techniques: In these techniques, drilling is executed inward starting from the exterior, such as in a classical cortical mastoidectomy.
  - Inside-out techniques: In these techniques, drilling is executed outward starting from the interior, such as in atticotomy-related procedures. These are also called retrograde techniques.

15 Partial Bridge Atticotomy

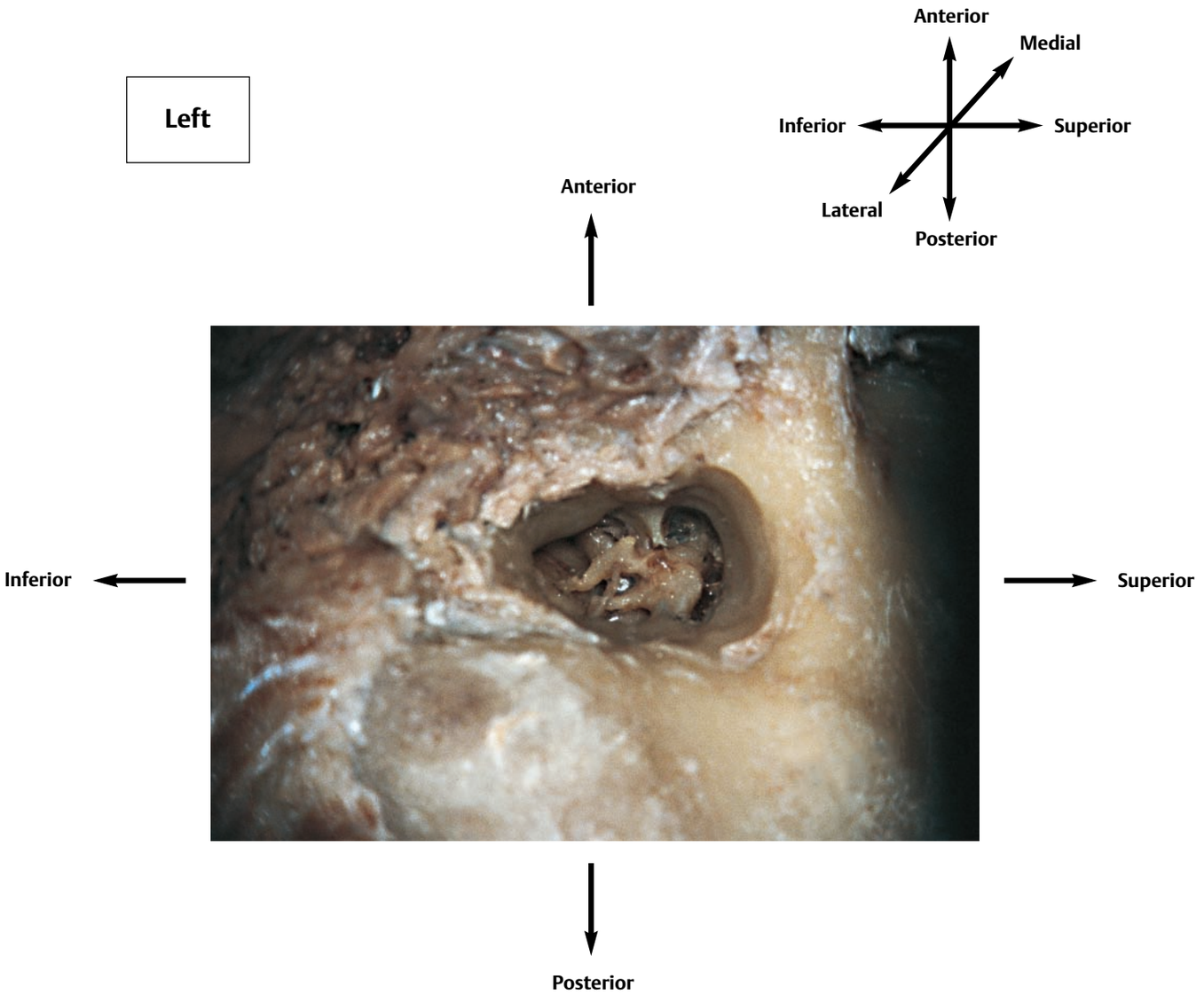
Definition

Carrying out an atticotomy by leaving only a bony spike at the anterior buttress, through the enlarged external auditory canal. In fact, because this area, in most instances, is damaged by cholesteatoma, pathology dictates that this particular procedure must be executed.

Indications

A partial bridge atticotomy is mainly used in the surgery for chronic otitis media with cholesteatoma.

Anatomical Orientation

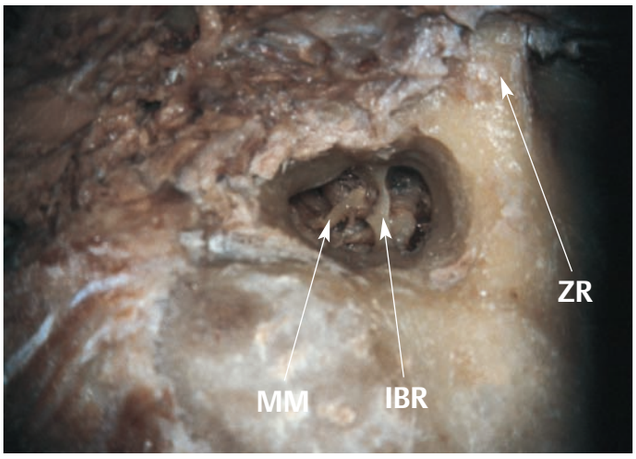


Completed partial bridge atticotomy

Surgical Steps

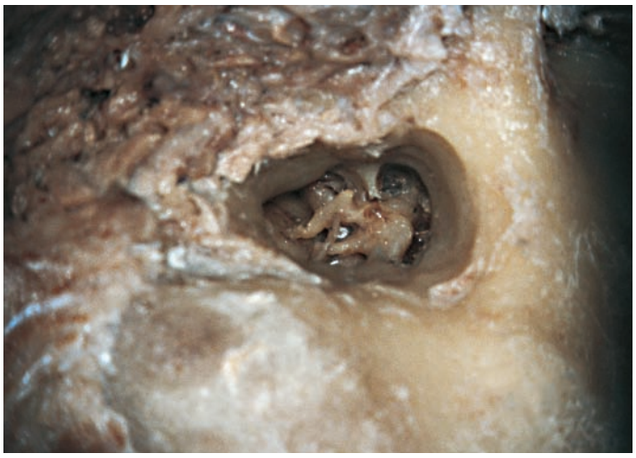
The intact bridge atticotomy has been completed and the temporal bone is ready for partial bridge atticotomy. The critical structures for orientation are indicated in the figure.

IBR: Intact bridge
MM: Manubrium mallei
ZR: Zygomatic root



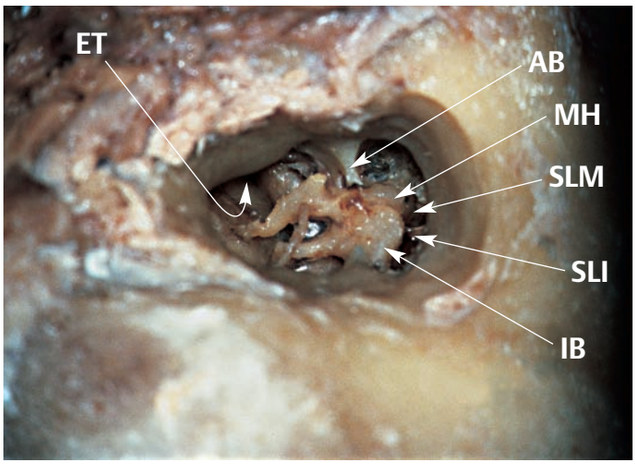
At this stage, the bony bridge is drilled using a small cutting or diamond burr. Removal of the posterior portion of the bony bridge leaves only a bony spike at the anterior buttress. In the operation, the area where the intended bridge would be may already have been partially destroyed by cholesteatoma, and so partial bridge atticotomy may be the only alternative.

II: 1–2 mm cutting or diamond burr
MIL: Anterior buttress



The partial bridge atticotomy has been completed. This close-up view shows the exposed ossicles and ligaments, i. e., the superior ligament of malleus and superior ligament of incus. Note also the position of the created anterior buttress, and the eustachian tube.

AB: Anterior buttress
ET: Eustachian tube
IB: Incus body
MH: Malleus head
SLI: Superior ligament of incus
SLM: Superior ligament of malleus



Definitions and Tips

- **Anterior buttress:** *Definition:* The surgically created buttress, a couple of millimeters in size, extending posteriorly from the anterosuperior edge of the tympanic annulus. *Tips:* The buttress should be preserved in partial bridge atticotomy and removed in classical atticotomy.
- The intact and partial bridge atticotomy procedures are the less extensive approaches in the group of inside-out techniques.

16 Atticotomy

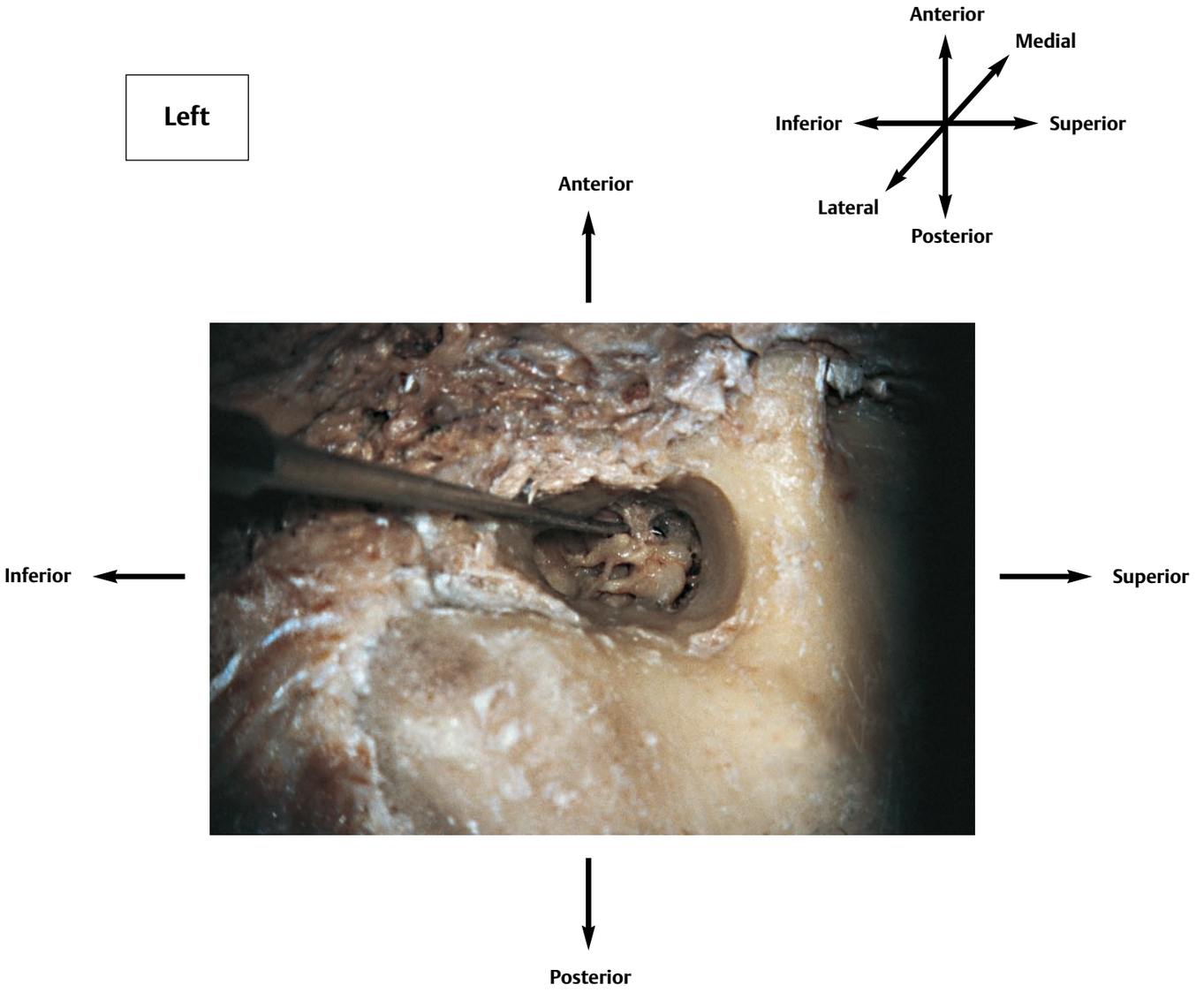
Definition

Exposure of the entire attic through the enlarged external auditory canal, having removed the whole lateral wall of the attic cavity.

Indications

An atticotomy is mainly used in the surgery for chronic otitis media with cholesteatoma.

Anatomical Orientation

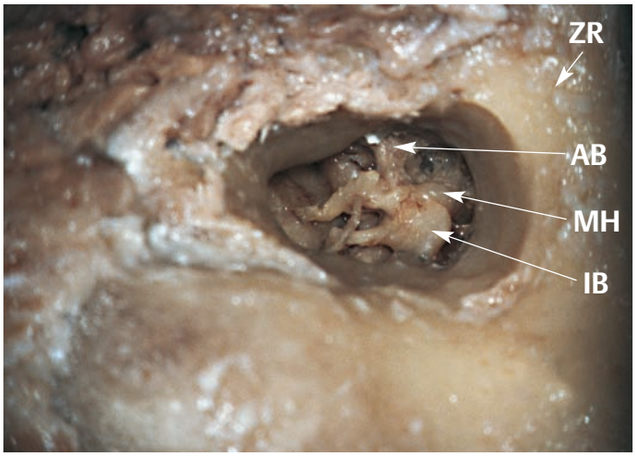


Completed atticotomy

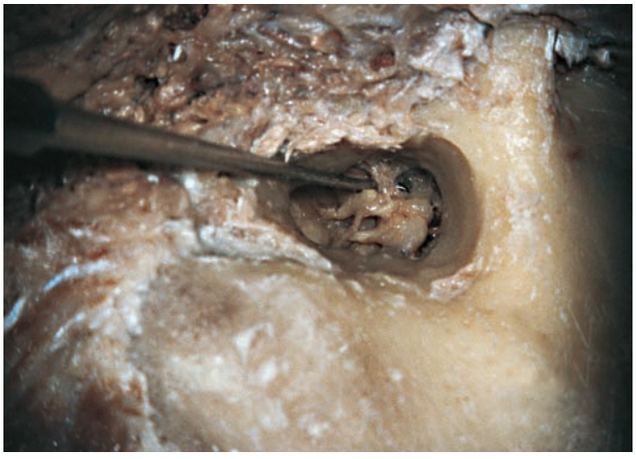
Surgical Steps

The partial bridge atticotomy has been completed and the temporal bone is ready for the atticotomy procedure. The critical structures are indicated in the figure.

AB: Anterior buttress
IB: Incus body
MH: Malleus head
ZR: Zygomatic root

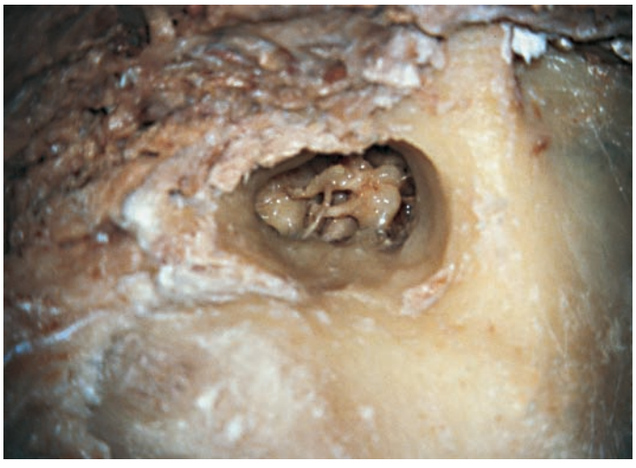


The curved micro dissector is under the anterior buttress. The body of the instrument is in the tympanic cavity and the tip is in the attic. Because the ossicles can be accessed in their entirety, in the operation, the atticotomy-related procedures allow removal of cholesteatoma without damaging the integrity of the ossicles in suitable cases.



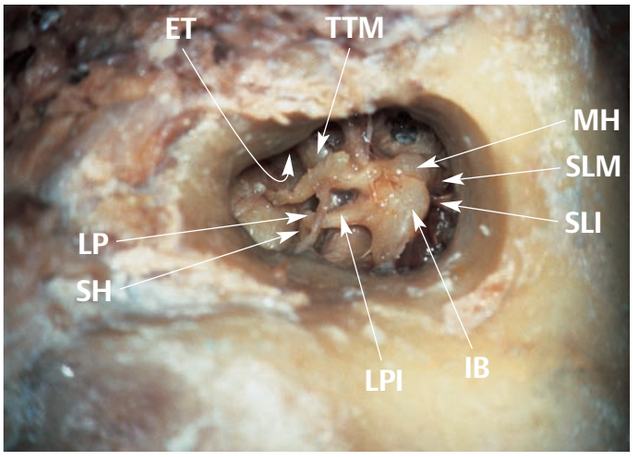
Drilling of the anterior buttress with a small cutting burr completes the atticotomy. This view shows the surgical site after completion of the atticotomy.

II: 1–2 mm cutting burr
MIL: Semicanal of tensor tympani muscle



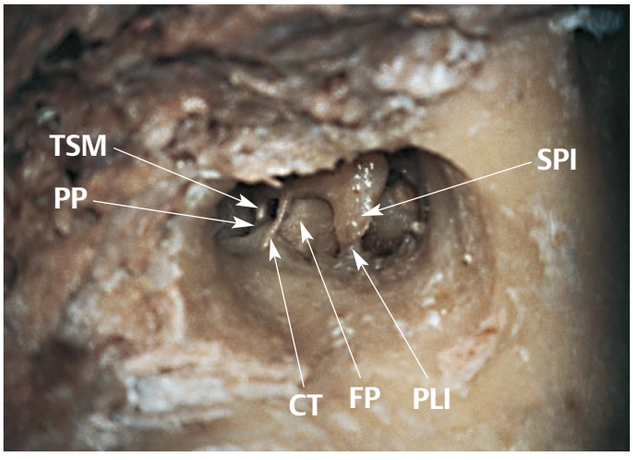
Definitions and Tips

- All the procedures executed on the attic carry the risk of sensorineural hearing loss and tinnitus, which can happen if the burr or suction tip comes in contact with the intact ossicular chain. However, because the long process of incus is already damaged in most cases of cholesteatoma, this complication does not often occur. In case of an intact ossicular chain, temporary separation of the incudostapedial joint with a micro hook would avoid this risk.



A close-up view of the anterior part of the completed atticotomy. All the critical structures in the combined tympanic and attic cavities are indicated. Note the semicanal of the tensor tympani muscle.

ET: Eustachian tube
IB: Incus body
LP: Lenticular process
LPI: Long process of incus
MH: Malleus head
SH: Stapes head
SLI: Superior ligament of incus
SLM: Superior ligament of malleus
TTM: Tensor tympani muscle



A close-up view of the posterior part of the completed atticotomy. The critical structures in the posterior part of the combined cavity are indicated. Note the posterior ligament of the incus and the chordal prominence, where the chorda tympani runs.

CT: Chorda tympani
FP: Facial prominence
PLI: Posterior ligament of incus
PP: Pyramidal process
SPI: Short process of incus
TSM: Tendon of stapedius muscle

Definitions and Tips

- The ossicular chain is attached to the epitympanum by the following five ligaments:
  - superior ligament of incus
  - posterior ligament of incus
  - superior ligament of malleus
  - lateral ligament of malleus
  - anterior ligament of malleus
- The ossicular chain is attached to the mesotympanum at the following four points:
  - via the tensor tympani muscle tendon to the cochleariform process
  - via the stapedial tendon to the pyramidal process
  - via the manubrium mallei to the tympanic membrane
  - via the stapes footplate to the labyrinth

17 Atticoaditotomy

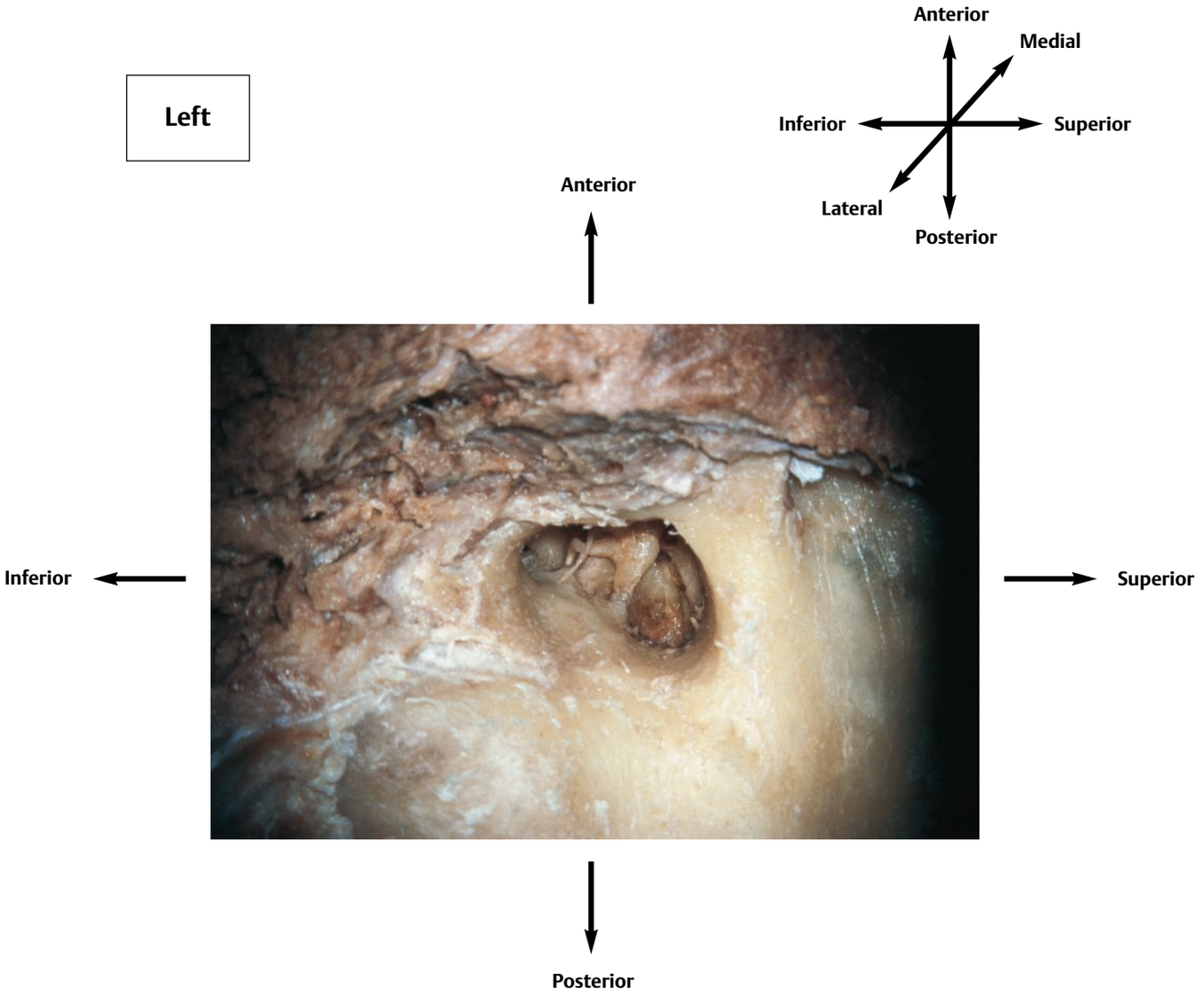
Definition

Complete exposure of the attic and aditus, having removed the entire lateral wall of these cavities, through the enlarged external auditory canal.

Indications

An atticoaditotomy is mainly used in the surgery for chronic otitis media with cholesteatoma.

Anatomical Orientation

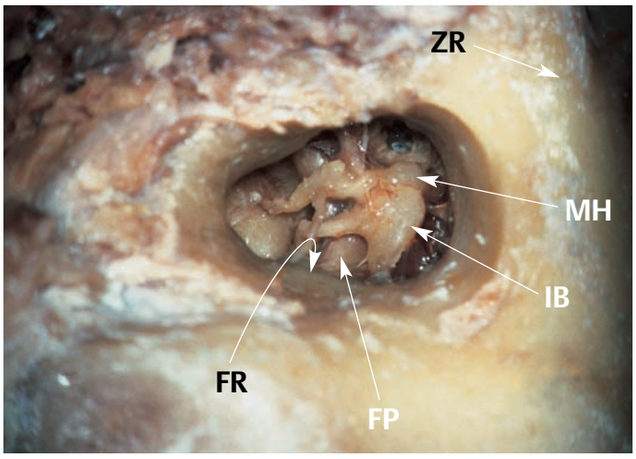


Atticoaditotomy—an intermediate stage

Surgical Steps

The atticotomy has been completed and the temporal bone is ready for the atticoaditotomy procedure. The critical structures are indicated in the figure.

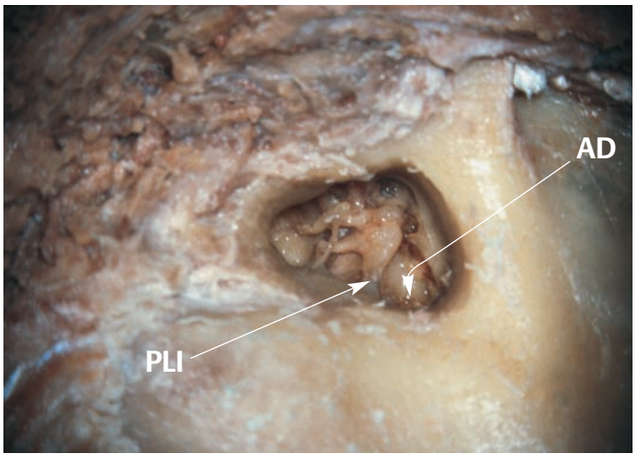
FP: Facial prominence
FR: Facial recess
IB: Incus body
MH: Malleus head
ZR: Zygomatic root



The lateral wall of the aditus is drilled using a small cutting burr. Care should be taken not to let the burr touch the medial wall of the aditus. During the operation, if the view is restricted by the cholesteatoma, the posterior ligament of the incus is a good indicator in identifying the location of the horizontal semicircular canal.

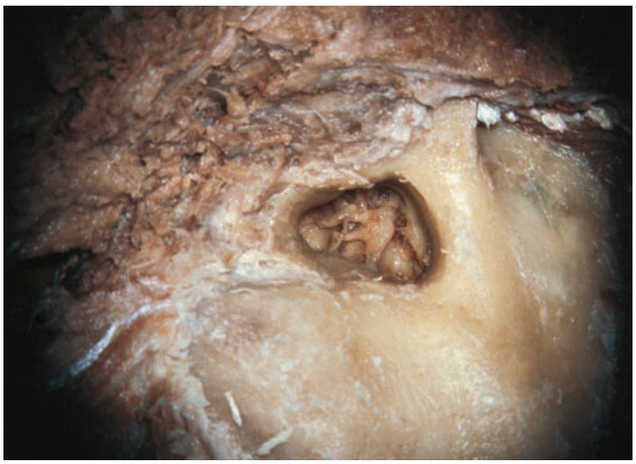
II: 2–3 mm cutting burr
MIL: Posterior ligament of incus

AD: Aditus
PLI: Posterior ligament of incus



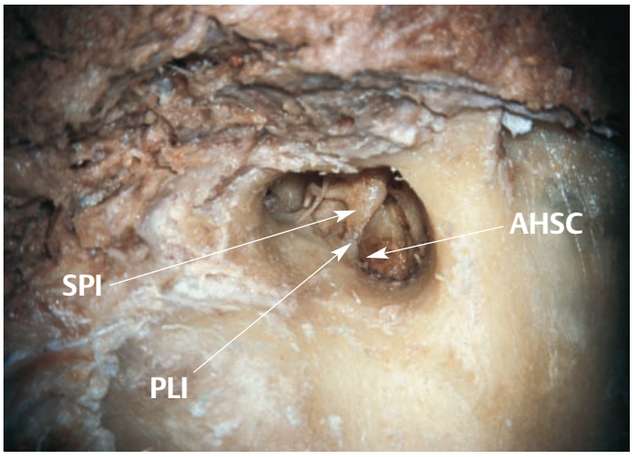
Removal of the lateral wall of the aditus continues posteriorly. The same cutting burr is used. It is mandatory to pay diligent attention to the horizontal semicircular canal, which is located at the medial wall of the aditus.

II: 2–3 mm cutting burr
MIL: Horizontal semicircular canal



Definitions and Tips

- **Aditus (aditus ad antrum):** *Definition:* The short tunnel connecting the attic to the antrum. *Tips:* The medial wall of the aditus is formed by the horizontal semicircular canal. The lateral aditus wall should be extirpated carefully because of its close proximity to the medial wall, i. e., to the horizontal semicircular canal. The horizontal semicircular canal is the most important landmark in most types of tympanomastoid surgery.



The atticoaditotomy procedure has been completed, and the posterior ligament of incus and the ampulla of the horizontal semicircular canal have been exposed. The critical structures in the aditus area are indicated in the figure.

AHSC: Ampulla of horizontal semicircular canal
PLI: Posterior ligament of incus
SPI: Short process of incus

A curved micro dissector has been inserted into the aditus. The tip of the instrument is inside the antrum, out of view.

Definitions and Tips

- The inside-out techniques are based on the principle of following the path of the disease. They are mainly used in surgery for chronic otitis media with cholesteatoma. These techniques follow on from one to the next until the entire extent of the cholesteatoma has been identified and extirpated. As an example, if the margins of the cholesteatoma can be reached by an atticoaditotomy, the procedure is stopped at this stage, if not, the procedure is extended to an atticoantrotomy.
- Covering the exposed area with a piece of tragal cartilage following an intact bridge atticotomy, partial bridge atticotomy, atticotomy or atticoaditotomy, results in a near to normal external auditory canal, obviating the need for a meatoplasty.

18 Atticoantrotomy

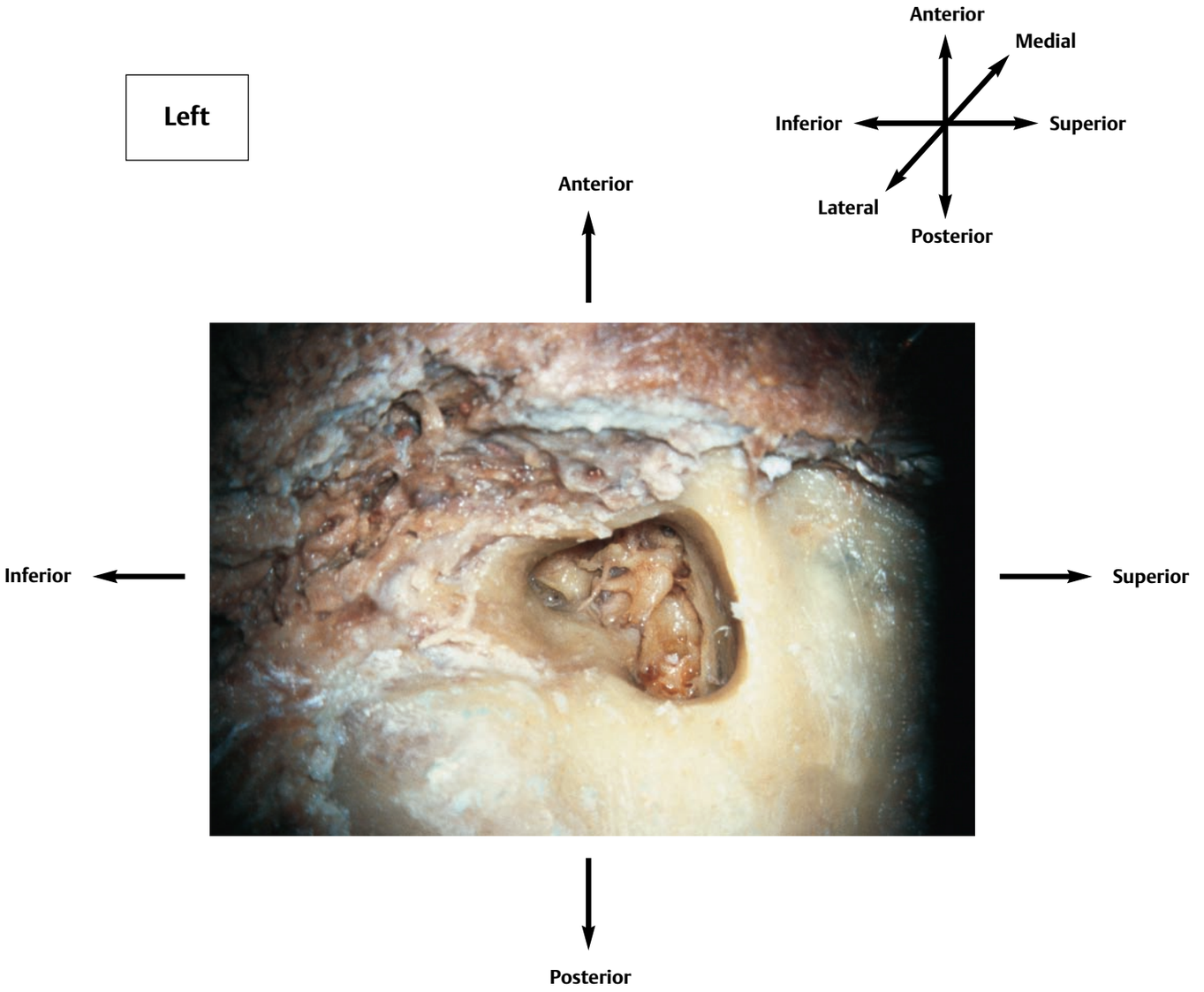
Definition

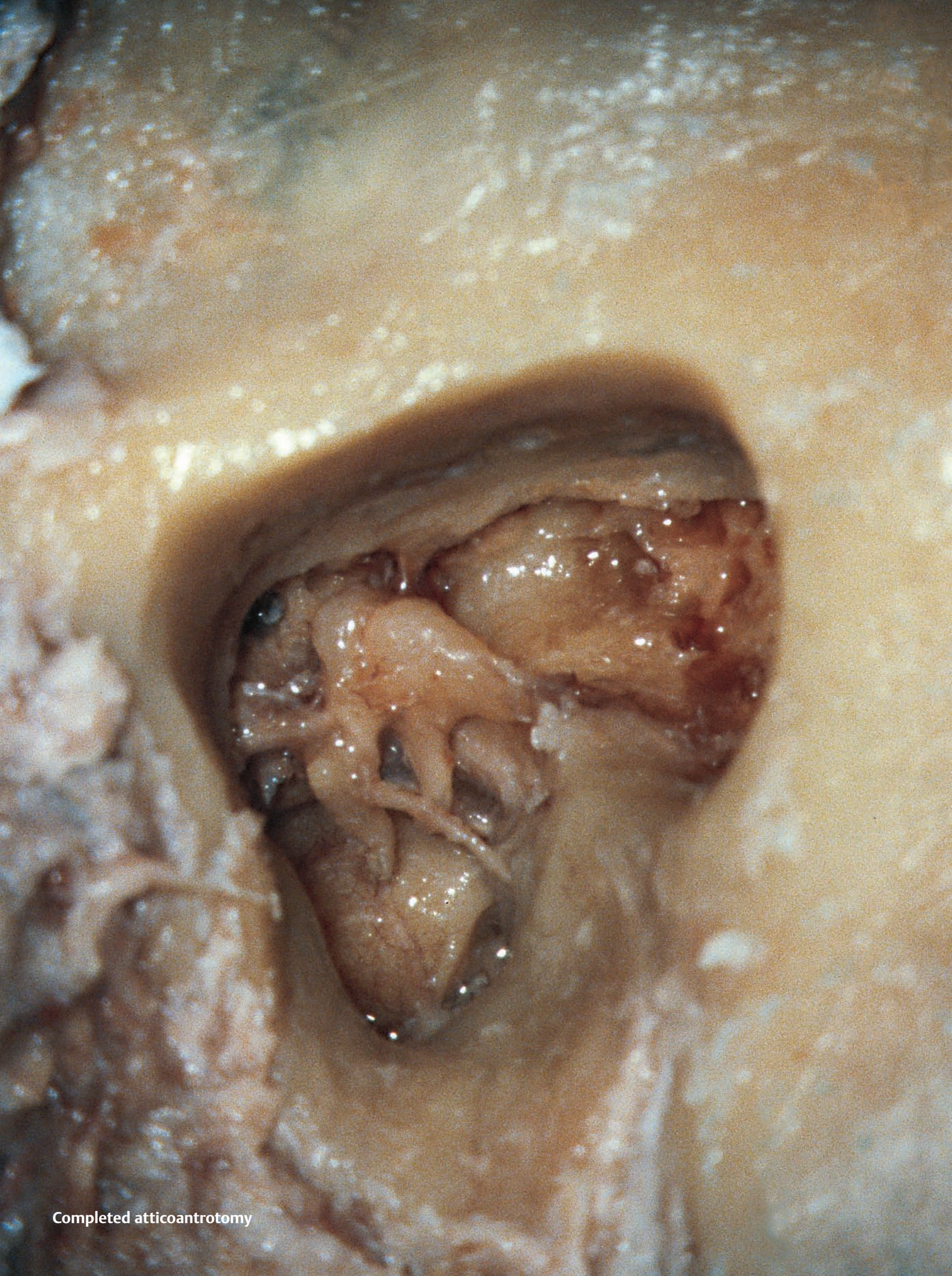
Complete exposure of the attic and antrum, having removed the entire lateral wall of these cavities. The superior and posterior walls of the external auditory canal have to be drilled extensively during this procedure.

Indications

An atticoantrotomy is mainly used in the surgery for chronic otitis media with cholesteatoma.

Anatomical Orientation





Completed atticoantrotomy

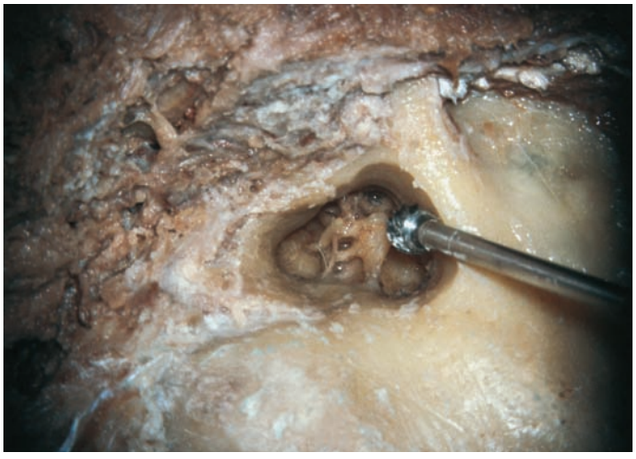
Surgical Steps

The atticoaditotomy has been completed and the temporal bone is ready for the atticoantrotomy procedure. The critical structures are indicated in the figure.

PLI: Posterior ligament of incus
SPI: Short process of incus
ZR: Zygomatic root

As with all inside-out techniques, first the lateral part of bone is drilled, which prevents working blindly more medially, and the created cavity is enlarged extensively toward the dura of the middle cranial fossa.

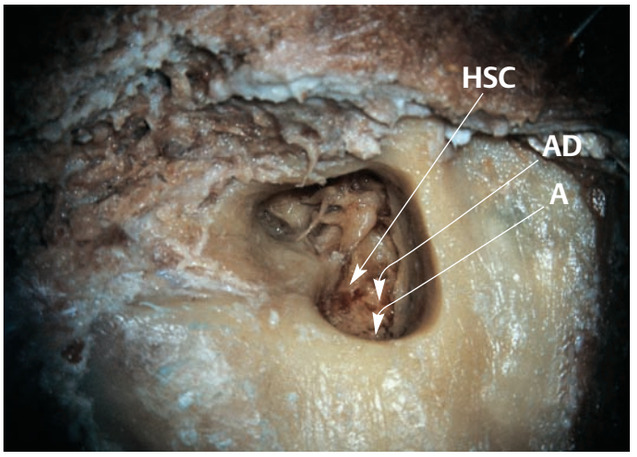
II: 3–4 mm cutting burr
MIL: Middle cranial fossa dural plate



The next step is removal of the lateral wall of the antrum. The same medium-sized cutting burr is used. It should not be forgotten that the dura of the middle cranial fossa could be located low, especially in contracted mastoids.

Definitions and Tips

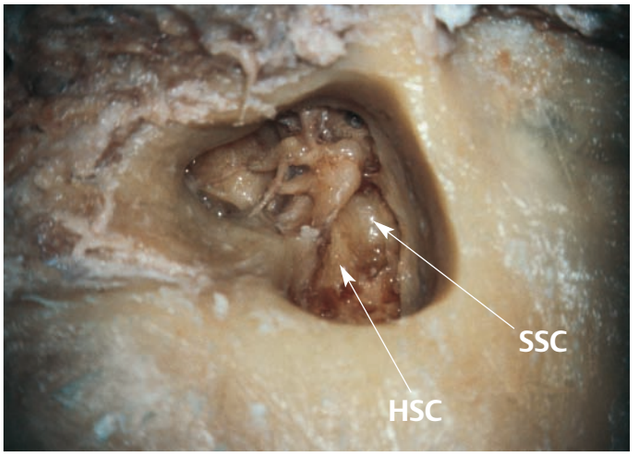
- Besides the inside-out atticotomy-atticoantrotomy, the intact canal wall and the canal wall down approaches, other techniques have also been described. The transposed canal wall tympanomastoidectomy, which was described by the author, is a one-stage, planned, outside-in technique resulting in a small anterior tympanomastoidectomy cavity, twice the size of a normal external auditory canal and affording safe cholesteatoma removal and restoration of the hearing mechanism. See page 183.
- **Antrum (mastoid antrum, antrum mastoideum):** *Definition:* The largest of the mastoid cells. *Tips:* The antrum is located approximately 1 cm deep (medially) to the Macewen triangle in adults, and more superficially in children. It is an important intermediate stage landmark in all transmastoidal procedures.



The removal of the lateral wall of the antrum continues step by step. The horizontal semicircular canal should be kept under constant observation during this procedure, which enables work to continue safely.

II: 2–3 mm cutting burr
MIL: Horizontal semicircular canal

A: Antrum
AD: Aditus
HSC: Horizontal semicircular canal



The atticoantrotomy procedure has been completed. Besides the ossicles, the ampulla of the superior semicircular canal and the entire horizontal semicircular canal have been exposed. The critical structures in the surgical site are indicated in the figure.

HSC: Horizontal semicircular canal
SSC: Superior semicircular canal

Definitions and Tips

- Atticoantrotomy differs from the previous inside-out, i. e., retrograde, techniques with regards to the cavity size. Following an atticoantrotomy, the cavity may be narrowed by means of some cartilage; however, because a large cavity is created, there is a future risk of a retraction of the placed cartilage and other graft materials. Therefore, a routine classical meatoplasty should be performed at the end of the atticoantrotomy.
- Alternate working is the main principle in inside-out techniques—lateral and medial drilling should be done alternately. This is the best method of preventing inadvertent damage to critical structures because of inadequate exposure.
- In inside-out techniques, extension of an atticoantrotomy is always possible; this maneuver transforms the procedure into a conservative radical (or modified radical) mastoidectomy.

19 Middle Cranial Fossa Approach

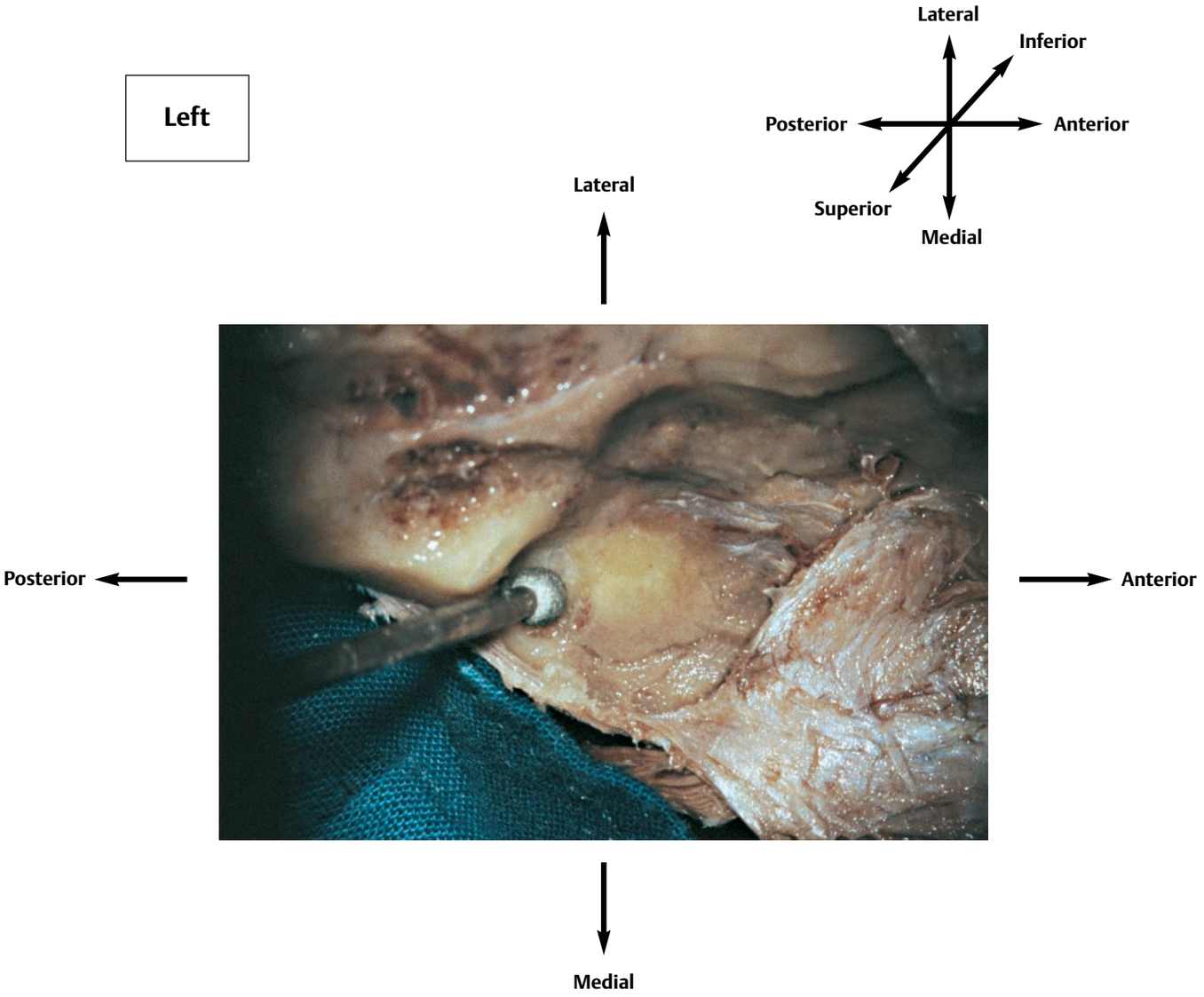
Definition

Following an approximately 4×4 cm craniotomy and retraction of the dura of the temporal lobe, exposure of the superior surface of the petrous bone and performance of procedures on the petrous bone or brainstem.

Indications

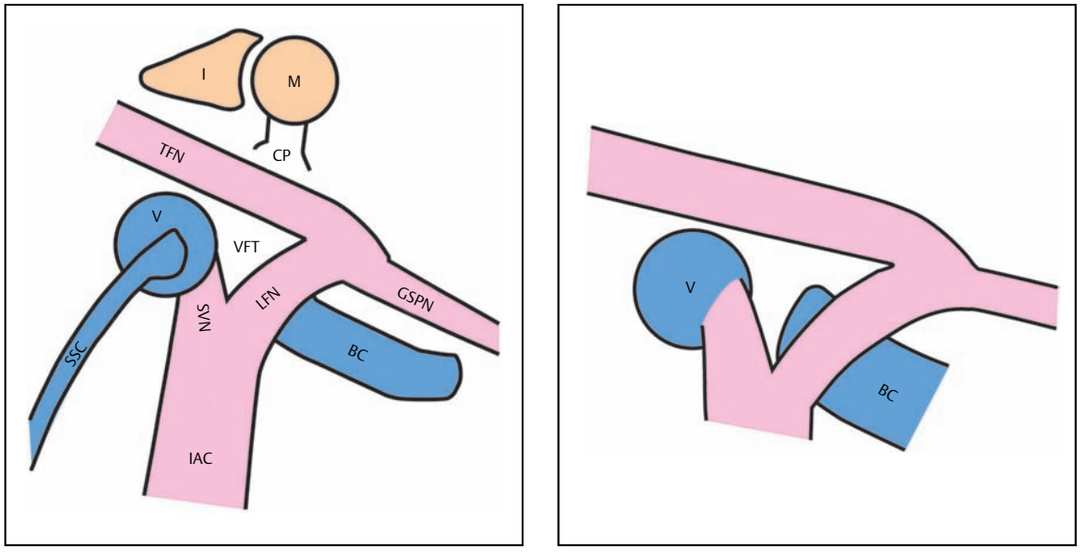
A middle cranial fossa procedure is undertaken for facial paralysis due to a longitudinal fracture, or for Bell palsy; it is also carried out in different neurotologic procedures such as acoustic neuroma surgery.

Anatomical Orientation



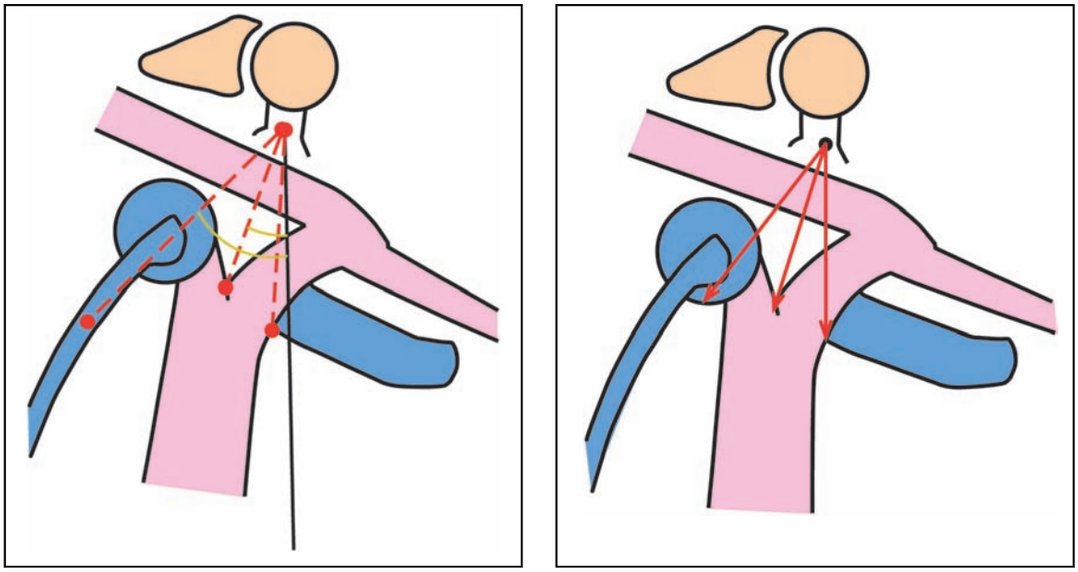
The middle cranial fossa approach—an intermediate stage

Surgical Anatomical Orientation



The critical anatomical structures in the middle cranial fossa approach are indicated in the diagrams. The relationship of these critical structures to one another is highlighted. The diagrams show the superior view, as in the approach through the middle cranial fossa, of the anatomical structures in the left surgical site.

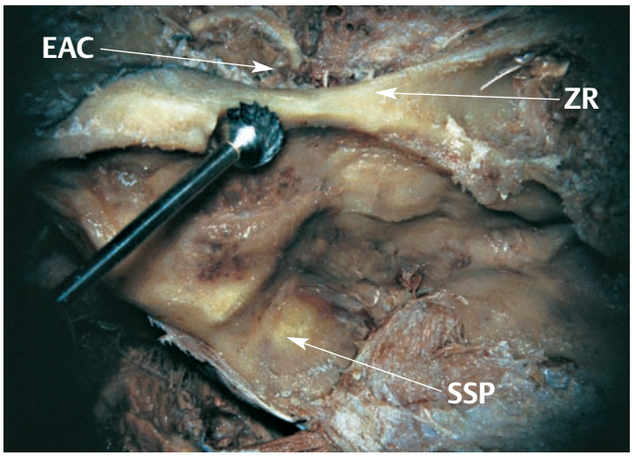
BC: Basal turn of cochlea
CP: Cochleariform process
GSPN: Greater superficial petrosal nerve
I: Incus
IAC: Internal auditory canal
LFN: Labyrinthine facial nerve
M: Malleus
SSC: Superior semicircular canal
SVN: Superior vestibular nerve
TFN: Tympanic facial nerve
V: Vestibule
VFT: Vestibulofacial triangle



Definitions and Tips

- The author showed in a study that the cochleariform process (CP) can be used as a reliable landmark in middle cranial fossa surgery, alone or in conjunction with other landmarks: The vertical crest lies at a 20° angle from the CP to the coronal plane, and at a distance of 5–6 mm from the CP; the point at which the medial margin of the basal turn of cochlea crosses the labyrinthine segment of the facial nerve is at a 0° angle from the CP to the coronal plane, and at a distance of 6.5–7.5 mm from the CP; finally, the superior semicircular canal is at a 45° angle from the CP to the coronal plane. It is not only a landmark limited to these structures; taking the CP as a reference enables one to define the exact location of each structure in the petrous bone. One should not hesitate to open the tegmen tympani and use the CP as a landmark if difficulties arise in middle cranial fossa surgery. See page 184.

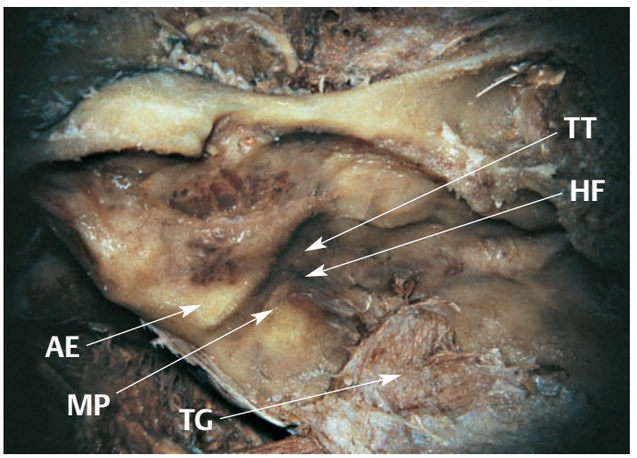
Surgical Steps



Following dissection of the soft tissues, the temporal bone is ready for the procedure. In the first stage, the cortical bone at the zygomatic root is drilled with a large burr. During the operation, the craniotomy and temporal lobe retraction must be done beforehand.

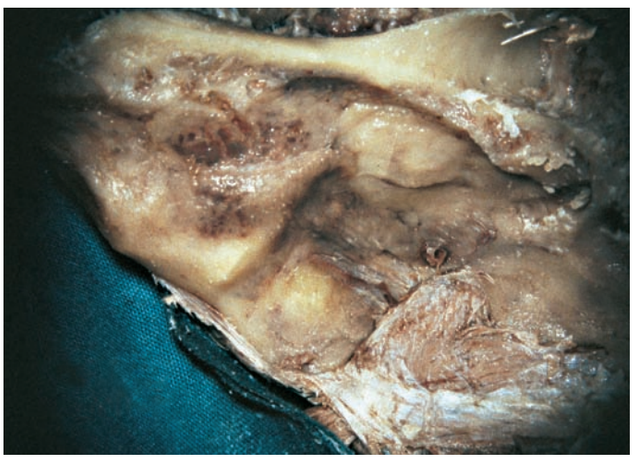
II: 7 mm cutting burr
MIL: Zygomatic root

EAC: External auditory canal
SSP: Superior surface of petrous bone
ZR: Zygomatic root



The anterior part of the cortical bone at the zygomatic root has been removed. The important anatomical areas and structures located on the superior surface of the petrous bone are indicated in the figure.

AE: Arcuate eminence
HF: Hiatus facialis
MP: Meatal plane
TG: Trigeminal ganglion
TT: Tegmen tympani

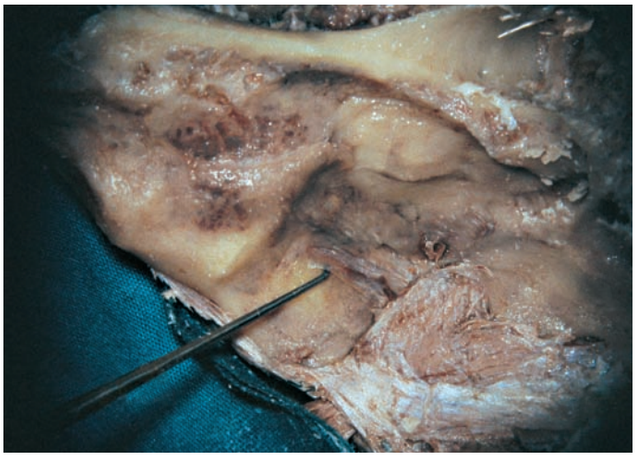


Working with the same burr, the posterior part of the cortical bone at the zygomatic root is extirpated. In this way, the cortical bone of the squamosa is brought to the same level as the superior surface level of the petrous bone, allowing better exposure of the deep structures, and in the operation, less retraction of the temporal lobe.

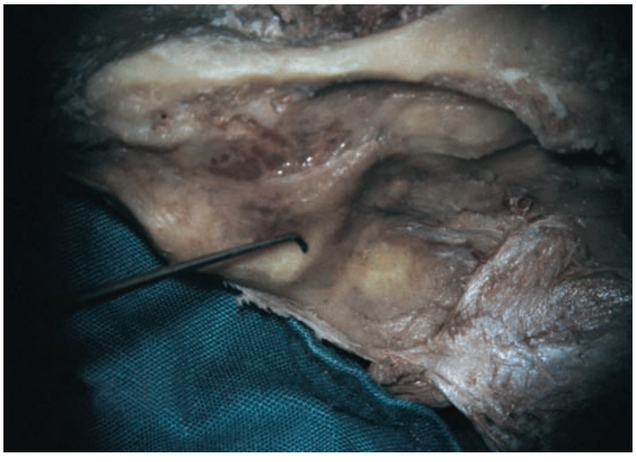
Definitions and Tips

- The middle cranial fossa approach is one with which otorhinolaryngologists are unfamiliar. Rather than sitting next to the patient during the operation, the surgeon carries out the operation from a sitting position at the top of the patient's head. Besides this, a craniotomy is needed and in most instances a dural incision of some size as well.
- Middle cranial fossa surgery principally consists of craniotomy in the temporal region, elevation of the dura of the temporal lobe, and the required procedures on the petrous bone or cerebellopontine angle.

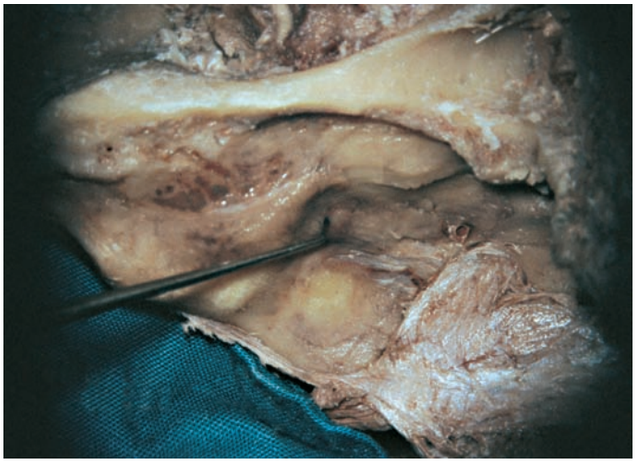
The next step is the identification of the natural landmarks on the superior surface of petrous bone. The microsurgical instrument in the figure is pointing to the greater superficial petrosal nerve running from the hiatus facialis anteriorly. It should be kept in mind that in some cases the geniculate ganglion may not be covered with bone.



There are very few recognizable surgical landmarks in middle cranial fossa approach because the anatomical structures are hidden within the bone. For this reason, each additional landmark is important. The microsurgical instrument in the figure is pointing to one of these landmarks, the arcuate eminence.

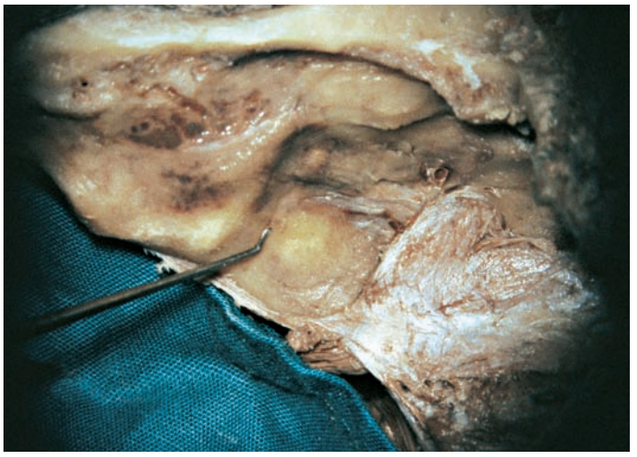


The tegmen tympani, which is located lateral and posterior to the hiatus facialis, is another key landmark to be noted in this procedure. The microsurgical instrument in the figure is pointing to this landmark.

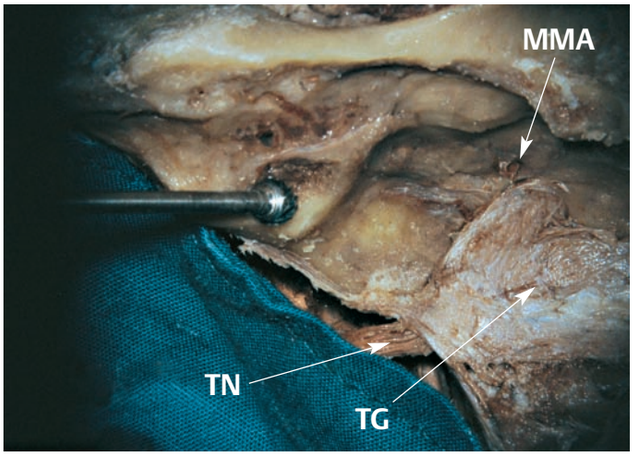


Definitions and Tips

- **Arcuate eminence (eminentia arcuata)**: *Definition:* The bony bulge on the superior surface of the petrous bone which also contains the superior semicircular canal. *Tips:* It is one of the main landmarks in middle cranial fossa surgery.
- **Tegmen tympani (roof of tympanum)**: *Definition:* The thin bony plate covering the roof of the epitympanum. *Tips:* It is the thin bone that separates the middle ear and the basal dura of the temporal lobe. Sometimes, the roof of the antrum and mastoid are also mistakenly called the tegmen tympani. The correct terminology should include the tegmen tympani, the tegmen antri, and the tegmen mastoideum.



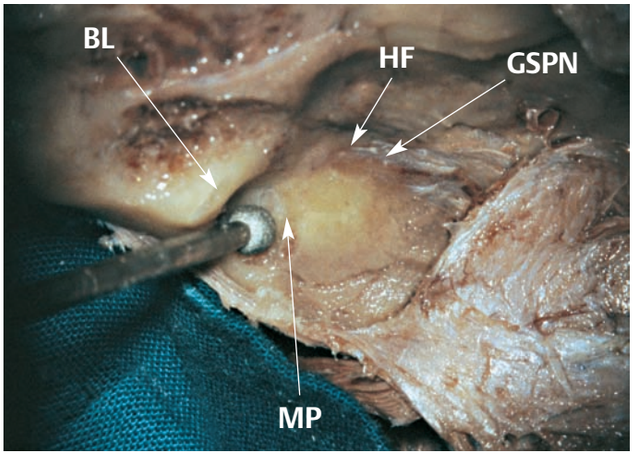
Another superficial landmark on the petrous bone is the meatal plane, which is located anterior to the arcuate eminence. The microsurgical instrument in the figure is pointing to the meatal plane. The middle meningeal artery is also an indicator in this surgery although it is difficult to use as a precise landmark to define the hidden structures inside the petrous bone. The relationship of this artery with other structures can be observed in this and in the following figures.



The blue-line technique will be carried out on this temporal bone. Using first a medium-sized cutting burr and then a diamond burr, the arcuate eminence is drilled beginning posteriorly and going anteriorly, and the blue line of the superior semicircular canal is identified.

II: 3–4 mm cutting and diamond burrs
MIL: Arcuate eminence

MMA: Middle meningeal artery
TG: Trigeminal ganglion
TN: Trigeminal nerve



The next step is identification of the internal auditory canal. Using the blue line of superior semicircular canal as the main landmark, the bone anteromedial to it is drilled and the internal auditory canal is sought at a 60° angle from the blue line.

II: 3–4 mm cutting and diamond burrs
MIL: Blue line of SSC

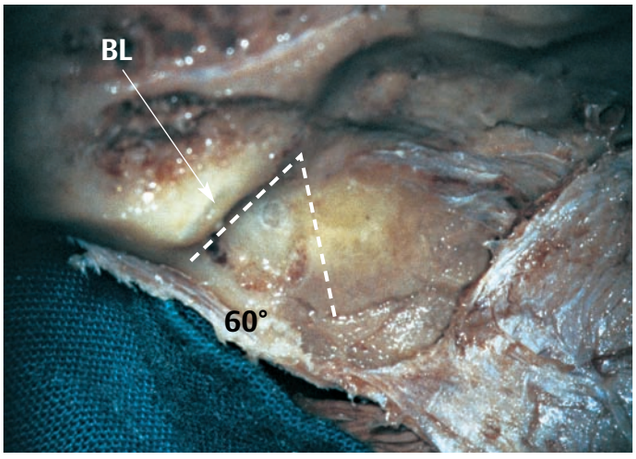
BL: Blue line (of SSC)
GSPN: Greater superficial petrosal nerve
HF: Hiatus facialis
MP: Meatal plane

Definitions and Tips

- **Meatal plane**: *Definition:* The flat plane on the superior surface of the petrous bone, anterior to the arcuate eminence. *Tips:* It is one of the reference points used in middle cranial fossa surgery. The internal auditory canal is found 0.5–1 cm deep (inferior) to this plane.
- **Blue line of the superior semicircular canal**: *Definition:* Execution of the blue-line technique on the superior semicircular canal, which was performed for fenestration of the horizontal semicircular canal in otosclerosis surgery in the pre-stapedectomy era. *Tips:* Identification of the blue line of the superior semicircular canal, followed by a search for the internal auditory canal at its anterior 60° angle, is one of the main techniques used in middle cranial fossa surgery.

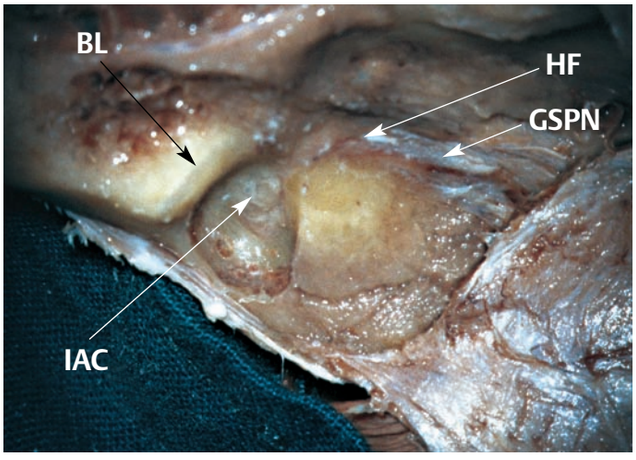
The dura of the internal auditory canal has been exposed in a limited area close to the vertical crest. Drilling is continued with a small diamond burr. It should not be forgotten that the superior part of the basal turn of the cochlea is located directly adjacent anteriorly. The 60° angle is marked on the figure.

BL: Blue line (of SSC)

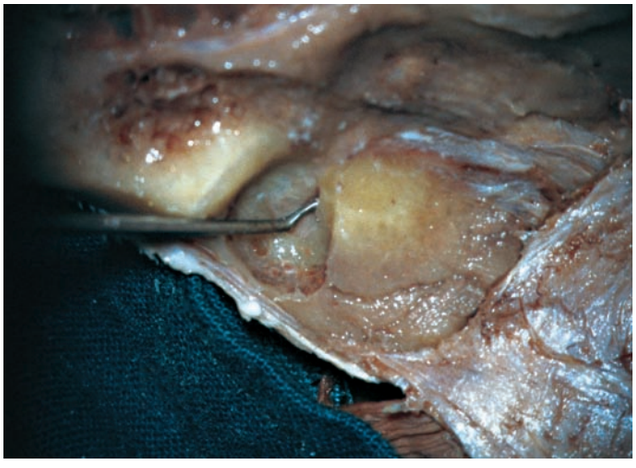


The dura of the internal auditory canal is exposed completely using different sized diamond burrs. To gain good exposure, it is important to drill as close as possible to the blue line of superior semicircular canal. The critical structures are indicated in the figure.

BL: Blue line (of SSC)
GSPN: Greater superficial petrosal nerve
HF: Hiatus facialis
IAC: Internal auditory canal

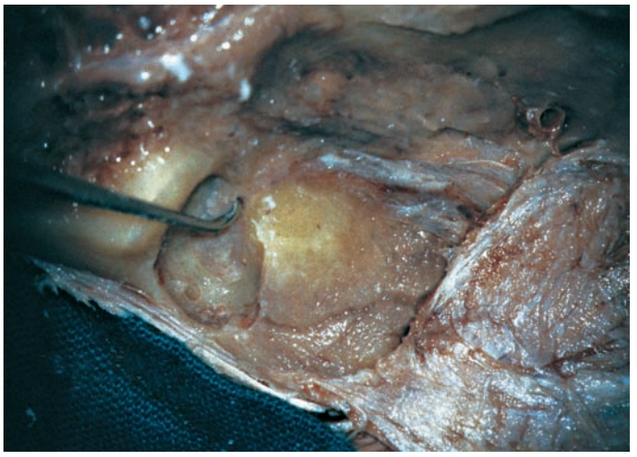


In the next stage, a curved micro dissector is used to separate the dura of the internal auditory canal from the bone anteriorly. The same procedure is repeated posteriorly.

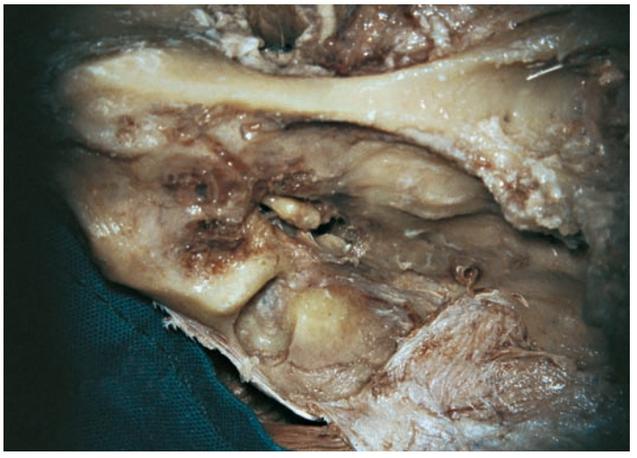


Definitions and Tips

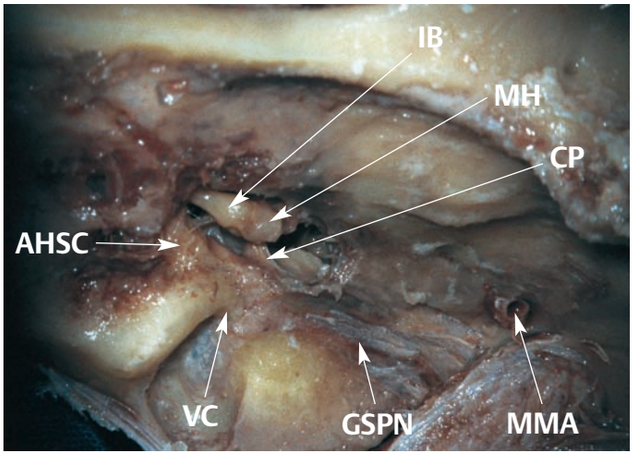
- The superior surface of the petrous bone can be approached using techniques other than the middle cranial fossa procedure. The zygomatic root approach, which was described by the author, provides improved intraoperative exposure of the key areas around the geniculate ganglion, without a craniotomy, and combines the advantages of the middle cranial fossa and transmastoid extralabyrinthine approaches. See Page 181.
- **Vertical crest (Bill bar)**: *Definition:* The bony spine that divides the superior portion of the fundus of the internal auditory canal into two parts—the anterior part with the facial nerve and the posterior part with the superior vestibular nerve. *Tips:* Although the vertical crest is anatomically very small, because of the exposure of the bone behind the proximal labyrinthine facial nerve during drilling, it becomes larger. This is an indispensable reference point in middle cranial fossa surgery.



The vertical crest is indicated with the curved micro dissector. The vertical crest is the most important landmark in the subsequent stages of procedures carried out in the internal auditory canal and related structures.



At this stage, the tegmen tympani is drilled and malleus and incus are exposed. In facial nerve surgery, this step is mandatory. In other neurotologic procedures, exposure of the epitympanum is up to the individual judgment of the surgeon.



A close-up view of the exposed tympanic cavity from above. The critical structures encountered in the middle cranial fossa approach are shown.

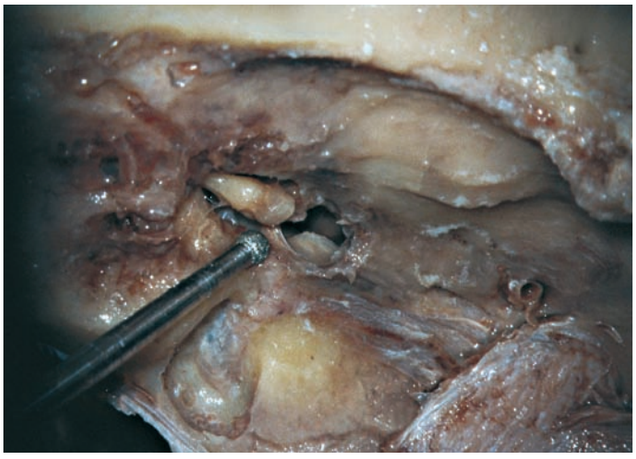
AHSC: Ampulla of horizontal semicircular canal
CP: Cochleariform process
GSPN: Greater superficial petrosal nerve
IB: Incus body
MH: Malleus head
MMA: Middle meningeal artery
VC: Vertical crest

Definitions and Tips

- **Cochleariform process (processus cochleariformis)**: *Definition:* The bony prominence where the tendon of the tensor tympani muscle comes out at a 90° angle from the muscle. *Tips:* The cochleariform process extends toward the neck of the malleus. It is a reference point for the tympanic facial nerve, oval window, and other middle ear structures. In addition, it may be used as a landmark in middle cranial fossa surgery. See page 184.
- **Vestibulofacial triangle**: *Definition:* The triagonal area surrounded by the tympanic and labyrinthine segments of the facial nerve and the superior vestibular nerve. *Tips:* This is the bony area that extends from the vertical crest laterally. Parts of the vestibule and basal turn of the cochlea are located deep, i. e., inferior to this triangle.

In facial nerve surgery, through the middle cranial fossa approach, the labyrinthine and proximal tympanic segments of the facial nerve should be exposed, explored, and decompressed. With this intention, first, the bone covering these segments of the facial nerve is drilled using a small diamond burr.

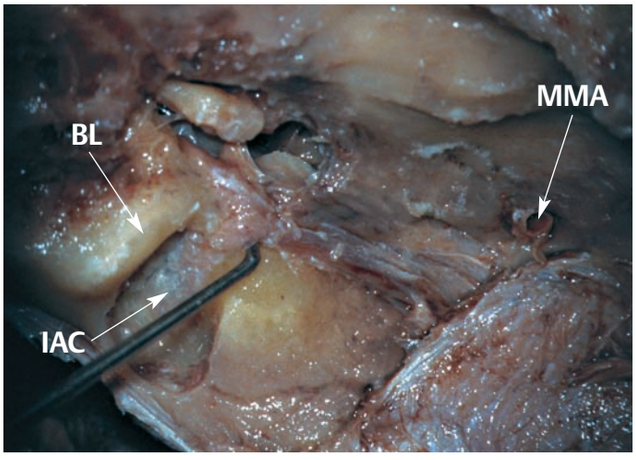
II: 1–2 mm diamond burr
MIL: Hiatus facialis



Following this, the eggshell-thin bone covering the nerve is removed by means of a curved micro dissector. The elevation and removal of bone pieces at the geniculate ganglion is shown in the figure.

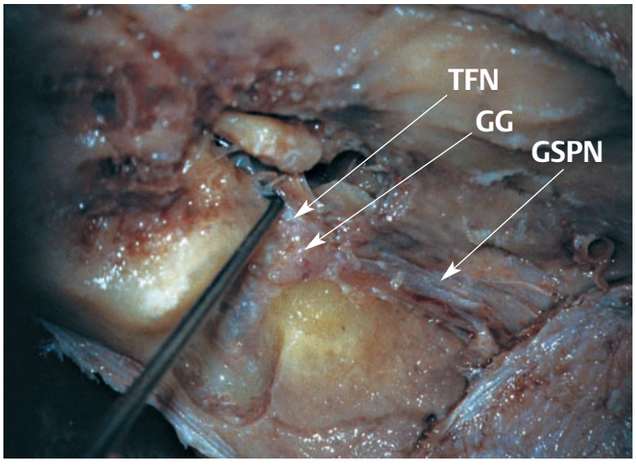
II: Curved micro dissector
MIL: Facial nerve

BL: Blue line (of SSC)
IAC: Internal auditory canal
MMA: Middle meningeal artery



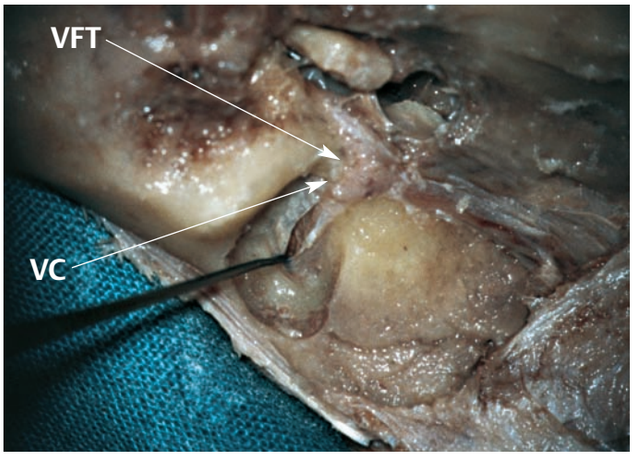
The same procedure is carried out on the thin bone covering the labyrinthine and proximal tympanic segments of the facial nerve. It is extremely important not to compress the facial nerve with the shoulder of the instrument tip during this maneuver.

GG: Geniculate ganglion
GSPN: Greater superficial petrosal nerve
TFN: Tympanic facial nerve



Definitions and Tips

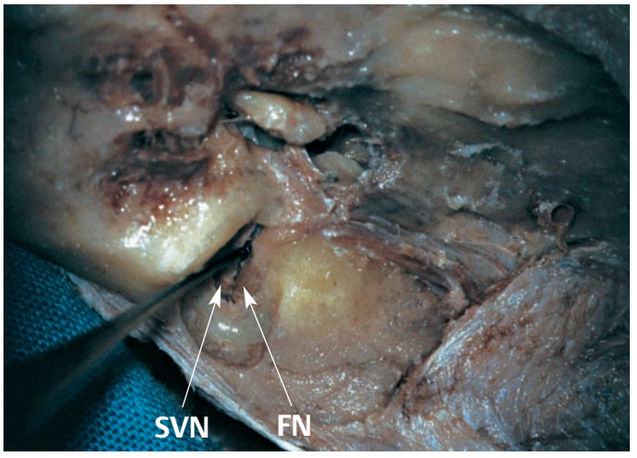
- **Hiatus facialis (hiatus canalis facialis, facial hiatus)**: *Definition:* The foramen on the superior surface of the petrous bone, which continues with a fissure in a posteroanterior direction. *Tips:* The greater superficial petrosal nerve runs through the hiatus facialis from the geniculate ganglion toward the dura. The hiatus facialis is one of the main landmarks in middle cranial fossa surgery.
- In the surgery of traumatic facial nerve paralysis, the author showed in a study on procedures through the middle cranial fossa approach, isolated, or combined with a mastoidectomy, that, contrary to common belief, there is no deterioration of the results if the surgery is done within the first 3 months of the onset of facial paralysis. (Ulug T, Arif Ulubil S. Management of facial paralysis in temporal bone fractures: a prospective study analyzing 11 operated fractures. *Am J Otolaryngol* 2005;26:230–238.)



In the next stage, the dura of the internal auditory canal is incised with a sickle knife. The anterior or posterior position of this incision depends on the pathology and surgical needs.

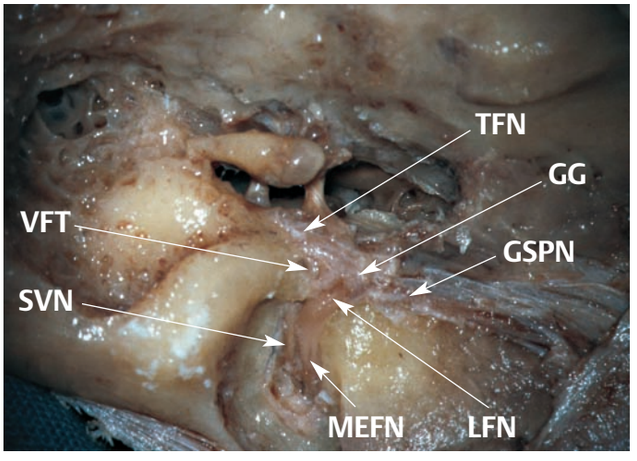
II: Sickle knife
MIL: Dura of internal auditory canal

VC: Vertical crest
VFT: Vestibulofacial triangle



At this point, a surgical needle is inserted between the meatal segment of the facial nerve and the superior vestibular nerve, and the two nerves are separated from one another. Both nerves are indicated in the figure.

FN: Facial nerve
SVN: Superior vestibular nerve



In this way, the meatal, labyrinthine, and proximal tympanic segments of the facial nerve are fully exposed, i. e., decompressed. The superior vestibular nerve is also exposed in the internal auditory canal. The decision regarding which regions and structures should be exposed during the operation is made according to the needs of each individual neurotologic procedure.

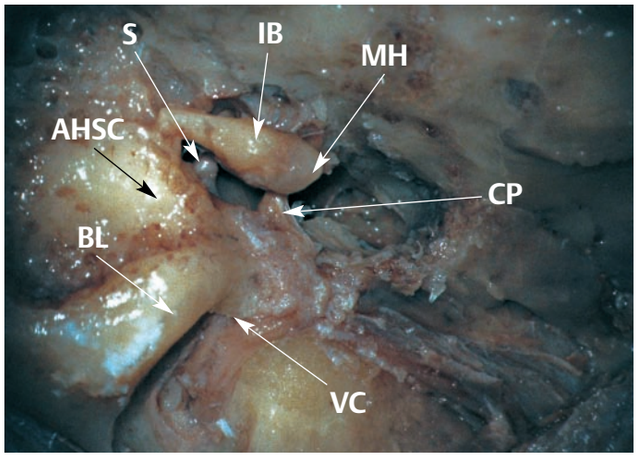
GG: Geniculate ganglion
GSPN: Greater superficial petrosal nerve
LFN: Labyrinthine facial nerve
MEFN: Meatal facial nerve
SVN: Superior vestibular nerve
TFN: Tympanic facial nerve
VFT: Vestibulofacial triangle

Definitions and Tips

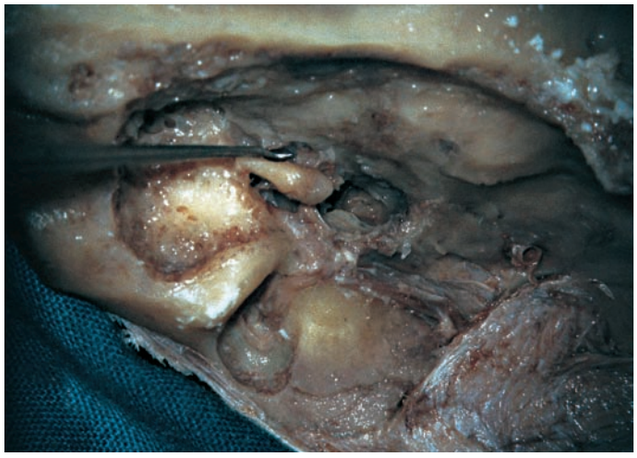
- In the classical lateral procedures, such as the translabyrinthine approach, the posterior aspect of the internal auditory canal is exposed, which means that the nerves that are encountered are the superior vestibular nerve posterosuperiorly and the inferior vestibular nerve posteroinferiorly. In contrast, in the middle cranial fossa approach, the superior aspect of the internal auditory canal is exposed, which means that the nerves that are encountered are the facial nerve anterosuperiorly and the superior vestibular nerve posterosuperiorly. Each surgeon should have an extensive knowledge of these different perspectives and be able to mentally visualize the labyrinth and the internal auditory canal three-dimensionally.

The middle cranial fossa approach has been completed. The facial nerve can be seen in detail in this close-up view. Note the positions of the cochleariform process and stapes, as well as the relation between the cochleariform process and vertical crest.

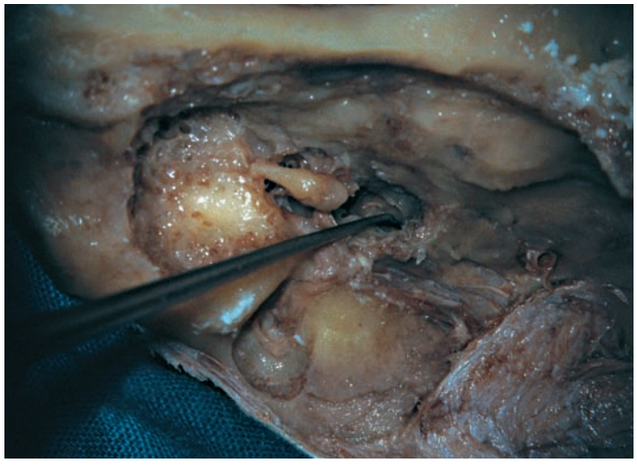
AHSC: Ampulla of horizontal semicircular canal
BL: Blue line (of SSC)
CP: Cochleariform process
IB: Incus body
MH: Malleus head
S: Stapes
VC: Vertical crest



A wide-angle view of the surgical site showing the exposed internal auditory canal and tympanic cavity. The microsurgical instrument is pointing to the medial surface of the tympanic membrane adjacent to malleus.



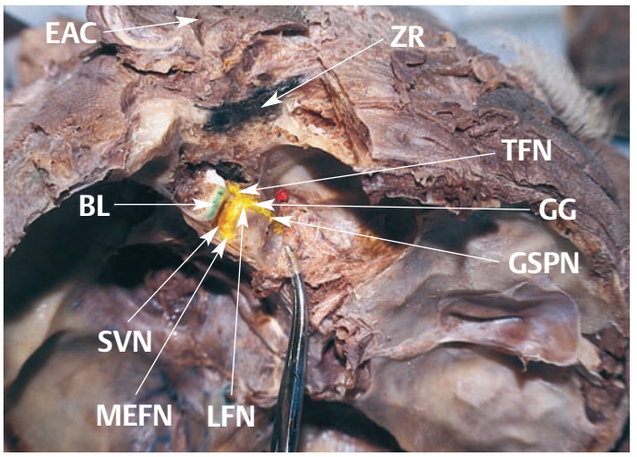
The same view of the surgical site, with a curved micro dissector inserted into the supratubal recess. The eustachian tube is located inferior to the supratubal recess.



Definitions and Tips

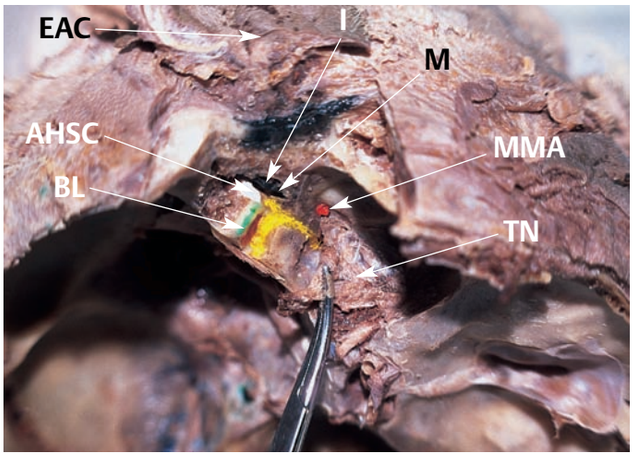
- Drilling the tegmen tympani exposes the epitympanum. This is a superior view of the middle ear, and is quite different from the classical lateral view. Each surgeon should have the ability to visualize the middle ear three-dimensionally.
- The location of the incision on the internal auditory canal dura depends on the purpose:
  - If the purpose is to carry out procedures on the facial nerve, the incision is located anteriorly.
  - If the purpose is to carry out procedures on the vestibular nerves, the incision is located posteriorly.

Surgical Anatomy



Dissection carried out on the left-hand side of a cadaver skull. A middle cranial fossa approach has been accomplished. The important anatomical structures have been exposed and dyed for illustrative purposes.

BL: Blue line (of SSC)
EAC: External auditory canal
GG: Geniculate ganglion
GSPN: Greater superficial petrosal nerve
LFN: Labyrinthine facial nerve
MEFN: Meatal facial nerve
SVN: Superior vestibular nerve
TFN: Tympanic facial nerve
ZR: Zygomatic root



Another view of the same cadaver skull.

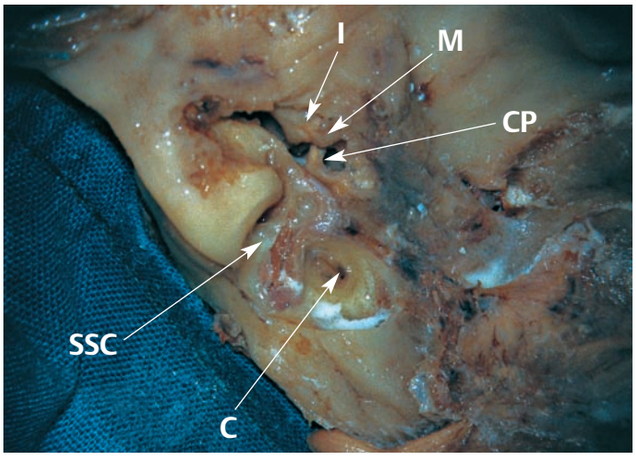
AHSC: Ampulla of horizontal semicircular canal
BL: Blue line (of SSC)
EAC: External auditory canal
I: Incus
M: Malleus
MMA: Middle meningeal artery
TN: Trigeminal nerve

Definitions and Tips

- The center of the craniotomy is the zygomatic root, slightly anterior to a line drawn superiorly from the external auditory canal. The reason for this slight anterior position of the craniotomy can be understood by taking the anteromedial axis of the petrous bone into consideration.
- The inferior margin of the craniotomy should be approximately 0.5–1 cm superior to the temporal line; this is because the cortical bone becomes thicker close to the temporal line.

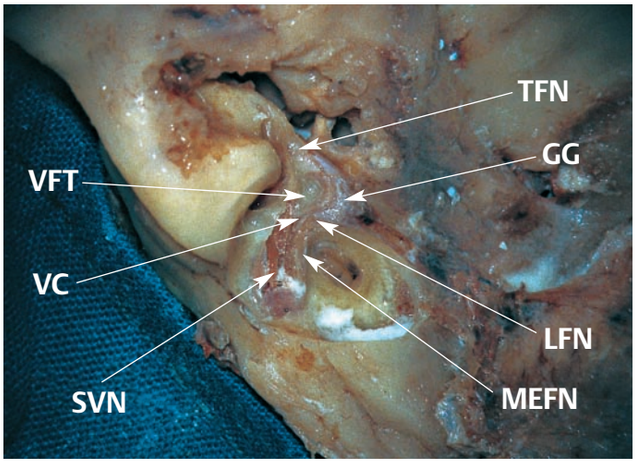
Dissected left temporal bone in another cadaver. A middle cranial fossa approach has been carried out. The important anatomical structures, including the lumens of the superior semicircular canal and cochlea, have been exposed for illustrative purposes.

C: Cochlea
CP: Cochleariform process
I: Incus
M: Malleus
SSC: Superior semicircular canal



Another view of the same cadaveric temporal bone.

GG: Geniculate ganglion
LFN: Labyrinthine facial nerve
MEFN: Meatal facial nerve
SVN: Superior vestibular nerve
TFN: Tympanic facial nerve
VC: Vertical crest
VFT: Vestibulofacial triangle



Definitions and Tips

- It is not necessary to expose the labyrinthine facial nerve in acoustic neuroma surgery through the middle cranial fossa. However, it may be done with the intention of decompressing the facial nerve during this procedure.
- One of the main reasons for difficulties when undertaking middle cranial fossa surgery is that the anatomical structures, i. e., the references, are indiscernible. Because of this, the use of landmarks is very important. The landmarks which may be used in the middle cranial fossa approach are:
  - foramen spinosum (middle meningeal artery)
  - hiatus facialis (greater superficial petrosal nerve)
  - arcuate eminence (superior semicircular canal)
  - blue line of the superior semicircular canal
  - ossicular chain
  - cochleariform process

20 Translabyrinthine Approach

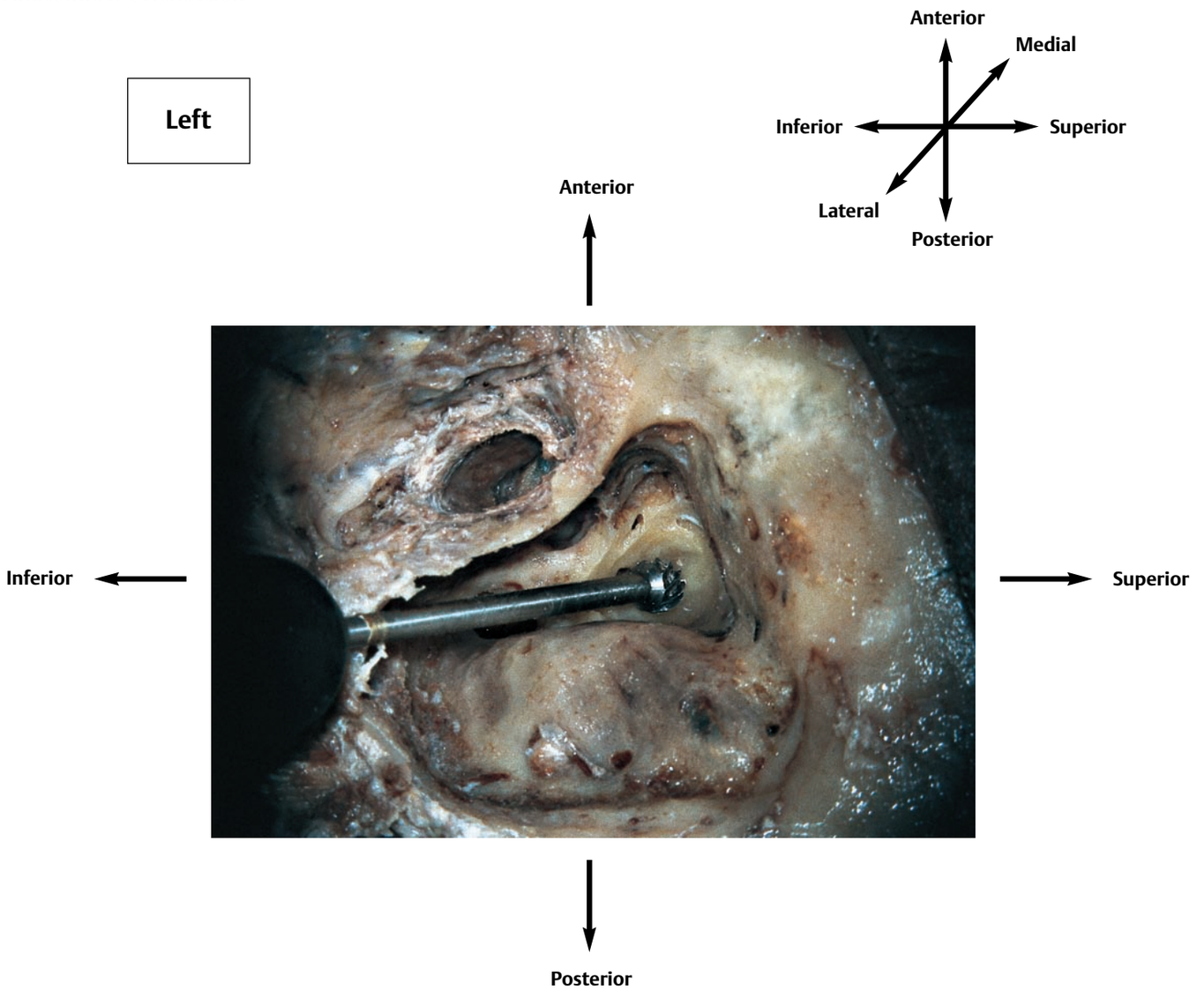
Definition

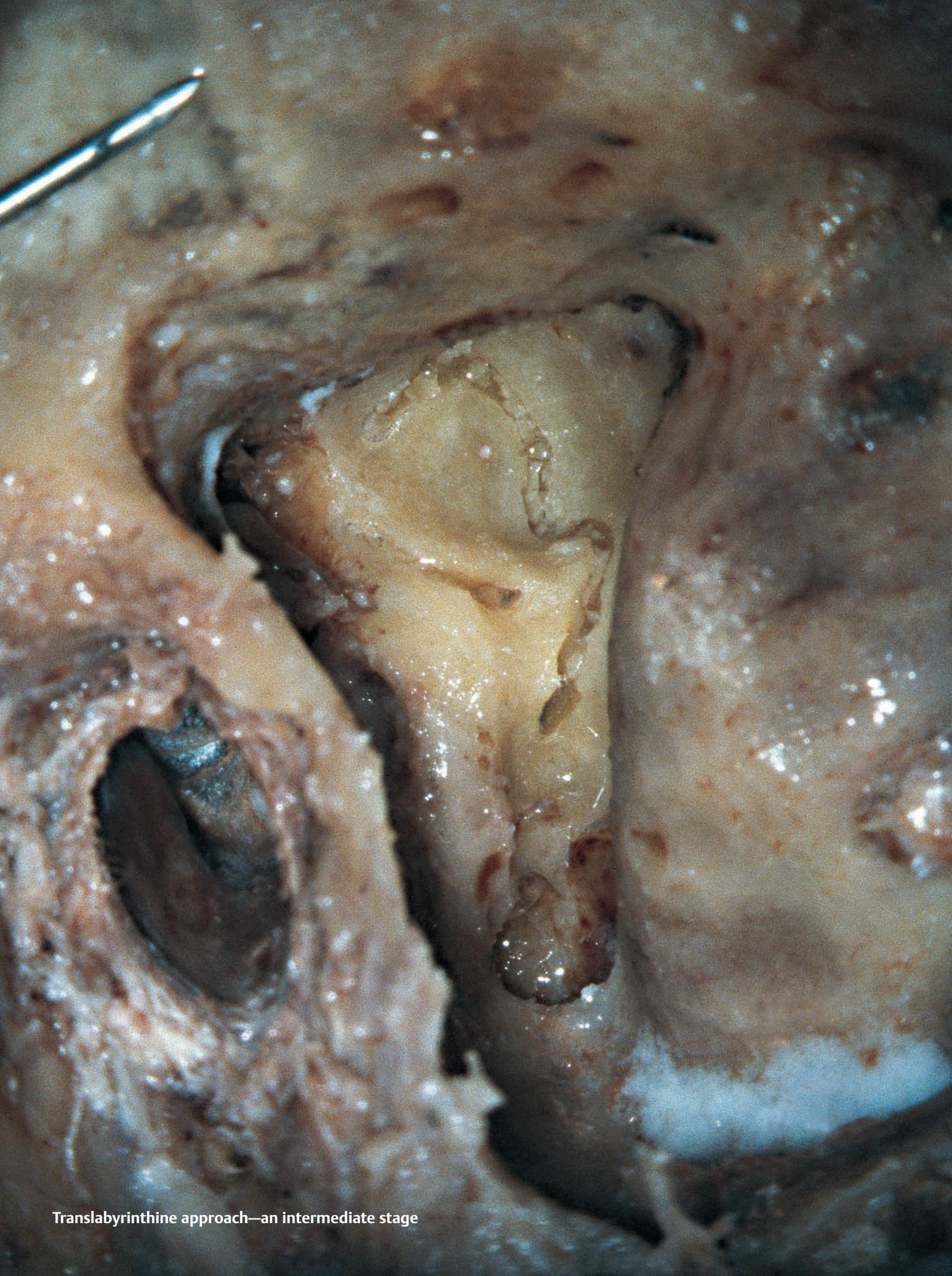
Following the extended cortical mastoidectomy and exenteration of the posterior part of the labyrinth, exposure of the internal auditory canal, and cerebellopontine angle through the posterior cranial fossa.

Indications

The main indication of this technique is in acoustic neuroma surgery where the hearing is not of concern. However, it may also be carried out for different neurotologic procedures.

Anatomical Orientation



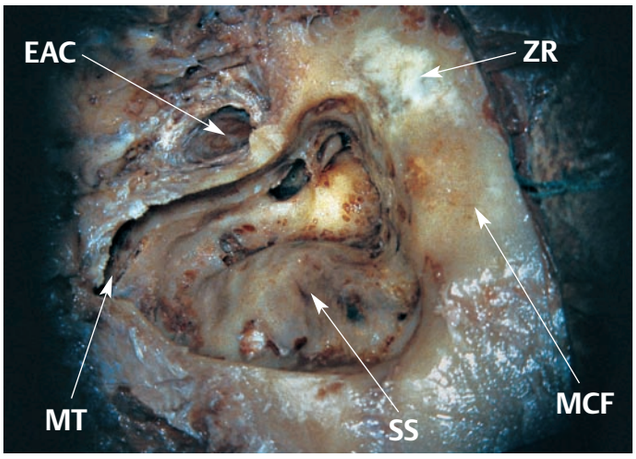


Translabyrinthine approach—an intermediate stage

Surgical Steps

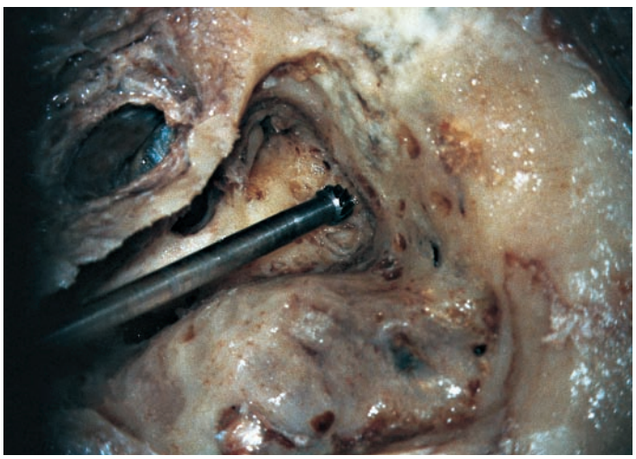
A classical cortical mastoidectomy, including posterior tympanotomy has been carried out. The temporal bone is ready for the main steps of the translabyrinthine approach. The limits of the approach are indicated in the figure.

EAC: External auditory canal
MCF: Middle cranial fossa (dural plate)
MT: Mastoid tip
SS: Sigmoid sinus (dural plate)
ZR: Zygomatic root



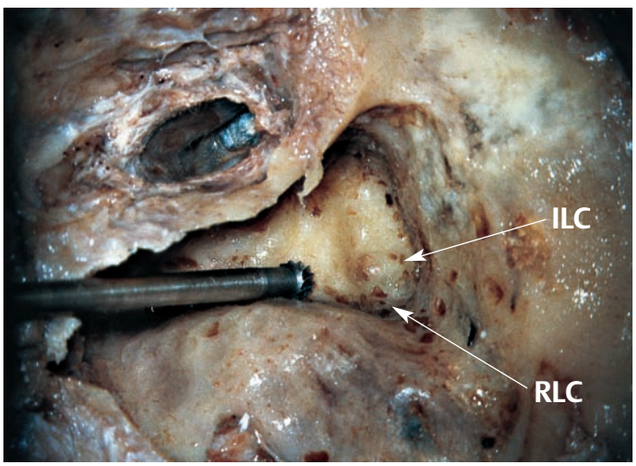
First, the interlabyrinthine cells are drilled away using a medium-sized cutting burr. Note that the mastoid in this temporal bone is contracted, which means that the sigmoid sinus is located anteriorly and the dura of the middle cranial fossa is located inferiorly.

II: 3–4 mm cutting burr
MIL: Posterior labyrinth (HSC, SSC, PSC)



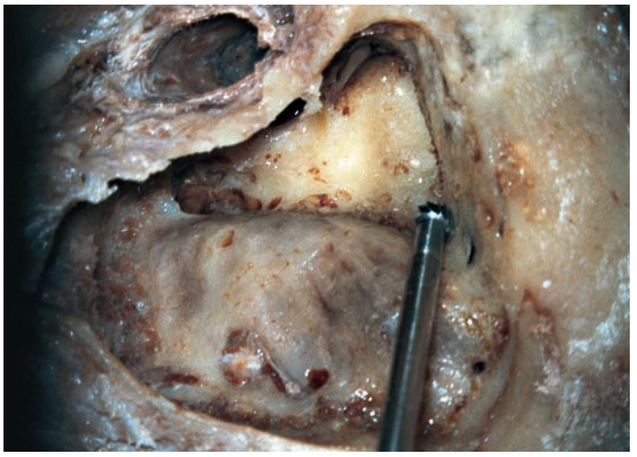
Next, the retrolabyrinthine cells are exenterated using the same cutting burr. In such a contracted mastoid, turning the temporal bone toward the surgeon in the laboratory or tilting the operating table during surgery, would prevent having to work blindly.

ILC: Interlabyrinthine cells
RLC: Retrolabyrinthine cells



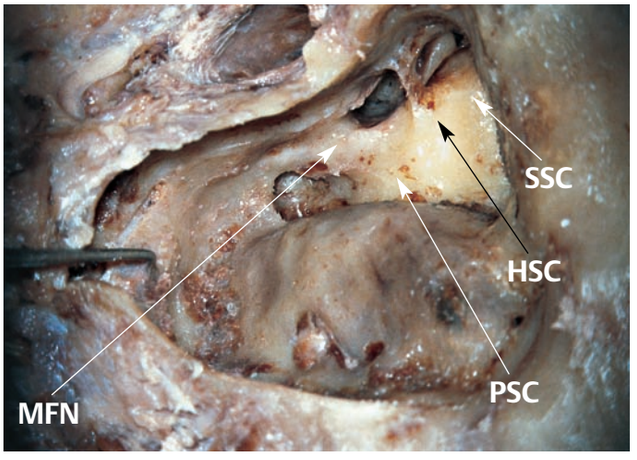
Definitions and Tips

- Lateral skull base surgery can be perceived as an extension of the classical tympanomastoid procedures. In this manner, the translabyrinthine approach is an extension of a cortical mastoidectomy and the transotic approach is an extension of a radical mastoidectomy.
- **Labyrinth (otic capsule)**: *Definition:* The inner ear. *Tips:* The labyrinth is traditionally described as consisting of two parts; the anterior labyrinth and the posterior labyrinth. The anterior labyrinth, i. e., the anterior otic capsule, is formed by the cochlea. The posterior labyrinth, i. e., the posterior otic capsule, is formed by the vestibule and semicircular canals.



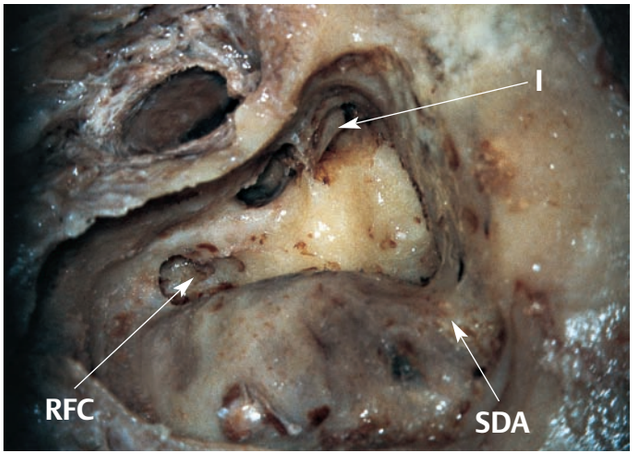
The sinodural angle is delineated by first using a medium-sized cutting burr, then a diamond burr. The superior petrosal sinus, which runs along the sinodural angle inside the dura, should always be kept in mind and the drilling executed with care.

II: 3–4 mm cutting and diamond burrs
MIL: Sinodural angle



The microsurgical instrument is pointing to the exposed digastric ridge. The three semicircular canals are also displayed in this figure, where the next steps of the approach will be carried out.

HSC: Horizontal semicircular canal
MFN: Mastoid facial nerve
PSC: Posterior semicircular canal
SSC: Superior semicircular canal



Following complete exenteration of the interlabyrinthine, retrolabyrinthine, and retrofacial cells and delineation of the neighboring structures, the cavity has been enlarged from a classical cortical mastoidectomy to an extended cortical mastoidectomy. Note that the facial canal and all the semicircular canals have been skeletonized.

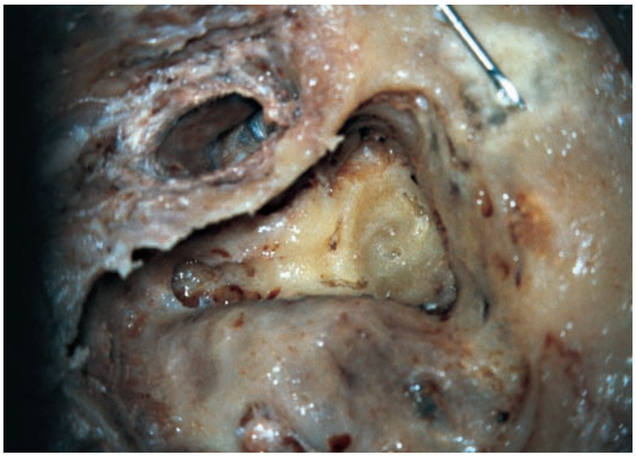
I: Incus
RFC: Retrofacial cells (removed)
SDA: Sinodural angle

Definitions and Tips

- In the translabyrinthine approach, each anatomical structure should be used as a reference for locating the subsequent structure. Otology-neurotology and skull base surgery is based on moving from one landmark to the other. Ulug et al. showed that each anatomical structure of the cranium can be used as a landmark to define the next structure. (Ulug T, Sahinoglu K, Ozturk A, Ari Z. Surgical landmarks during mastoidal and petrosal operations. *Okajimas Folia Anat Jpn* 1998;75:163–166.)

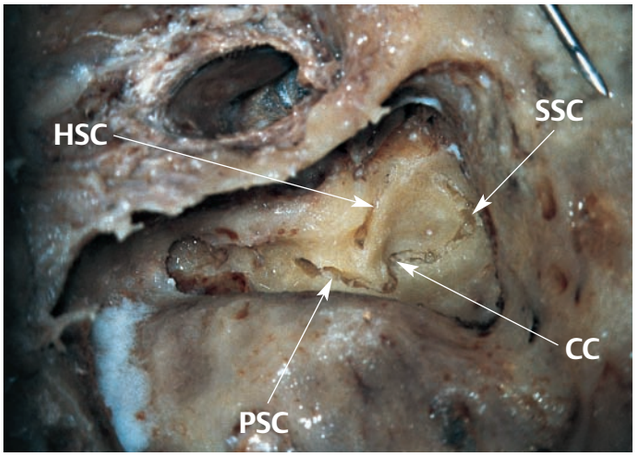
The next stage is exenteration of the semicircular canals. Each semicircular canal is drilled separately and carefully with a medium-sized cutting burr, to expose their lumens. The movement of the burr should be parallel to each semicircular canal. The instrument seen at the top right of the figure is the needle used for irrigation.

II: 3–4 mm cutting burr
MIL: The three semicircular canals



With progressive drilling, the lumen of each of the semicircular canals, including the common crus, is exposed completely. The opened horizontal, superior, and posterior semicircular canals are indicated in the figure.

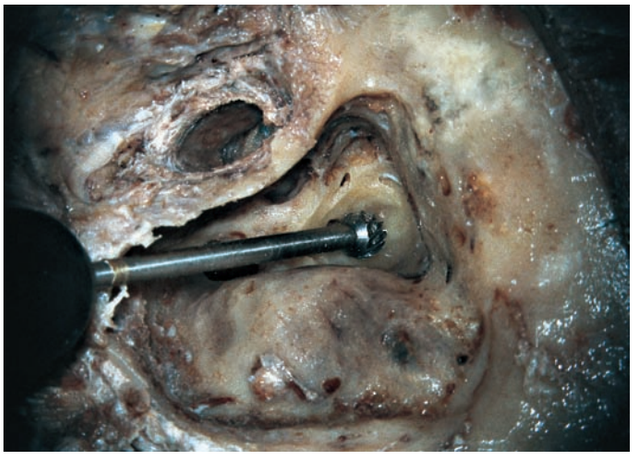
CC: Common crus
HSC: Horizontal semicircular canal
PSC: Posterior semicircular canal
SSC: Superior semicircular canal



During this procedure, it is important not to drill carelessly inferior to the horizontal semicircular canal or anterior to the inferior part of the posterior semicircular canal, otherwise the facial nerve could be damaged. The figure shows a wide-angle view of this stage.

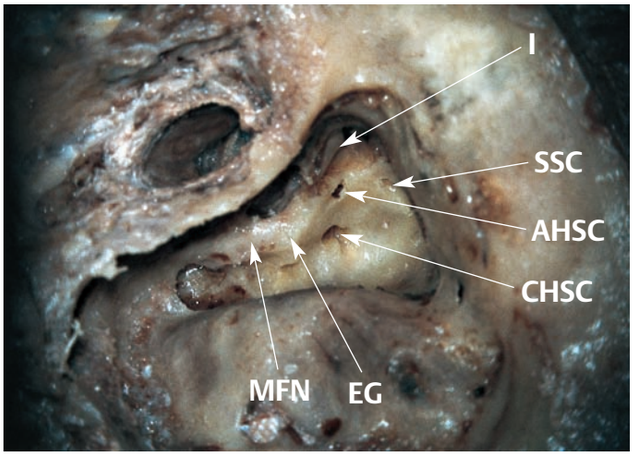
Definitions and Tips

- **Subarcuate artery**: *Definition:* The artery that runs through the hard bone in the arc of the superior semicircular canal. *Tips:* Knowing the location of the subarcuate artery may enhance accuracy during the drilling process, and it may also be used as an additional reference point in subsequent stages of the procedure.
- The anterior wall of the horizontal semicircular canal should be preserved until the subsequent stages of the procedure; preservation of this wall means preservation of the facial canal in this area. As the procedure continues, the anterior wall of the horizontal semicircular canal is removed and the facial nerve is skeletonized.



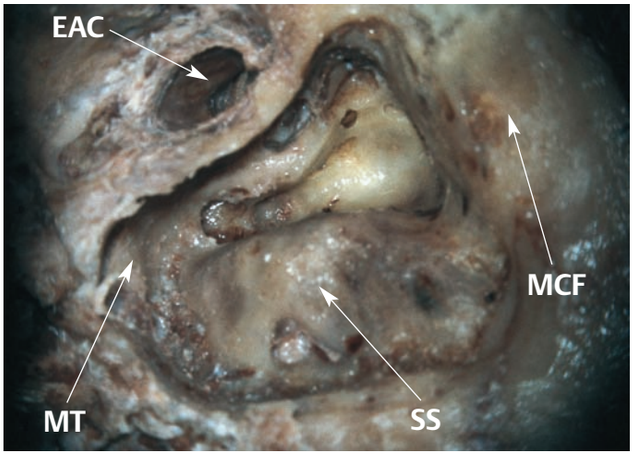
In the next stage, the internal auditory canal will be exposed. The remaining solid bone of the semicircular canals is drilled with medium-sized cutting burrs. Initially, the inferior limit of the exenteration should be the lumen of the horizontal semicircular canal, and the superior limit should be the ampulla of the superior semicircular canal.

II: 3–4 mm cutting burr
MIL: Horizontal semicircular canal



The greater part of the semicircular canals has been extirpated, however, the ampulla and the last part of crus of the horizontal semicircular canal remain intact. The ampulla of the superior semicircular canal has been left untouched so that it can be used as a landmark during subsequent steps of the approach.

AHSC: Ampulla of horizontal semicircular canal
CHSC: Crus of horizontal semicircular canal
EG: External genu
I: Incus
MFN: Mastoid facial nerve
SSC: Superior semicircular canal



Following drilling of the ampulla of the horizontal semicircular canal, the vestibule is entered. Note the bulge of the facial canal. The drilling should continue with a diamond burr if more work is required inferiorly.

II: 2–3 mm cutting and diamond burrs
MIL: Horizontal semicircular canal ampulla

EAC: External auditory canal
MCF: Middle cranial fossa (dural plate)
MT: Mastoid tip
SS: Sigmoid sinus (dural plate)

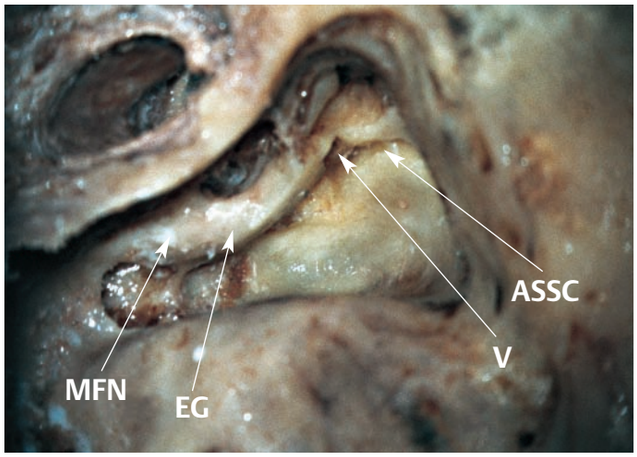
Definitions and Tips

- The technique in all the procedures requiring labyrinthectomy is based on exposure of the lumens of the semicircular canals and following these to the vestibule. Hasty drilling of the hard bone of the posterior labyrinth leads to the creation of “snake eyes,” resulting in difficulties when deciding in which direction to proceed with the drilling.
- The internal auditory canal is located medial to the tympanic segment of the facial nerve and adjacent to the vestibule. The inexperienced surgeon incorrectly expects to find the internal auditory canal more posteriorly. It should be kept in mind that the medial wall of the vestibule also forms the lateral wall of the fundus of the internal auditory canal.

Proceeding with the drilling, the vestibule is exposed completely. At this point, the elliptical and spherical recesses, located on the medial wall of the vestibule, can be observed. The superior semicircular canal ampulla is still preserved as a landmark.

II: 2–3 mm cutting and diamond burrs
MIL: Superior semicircular canal ampulla

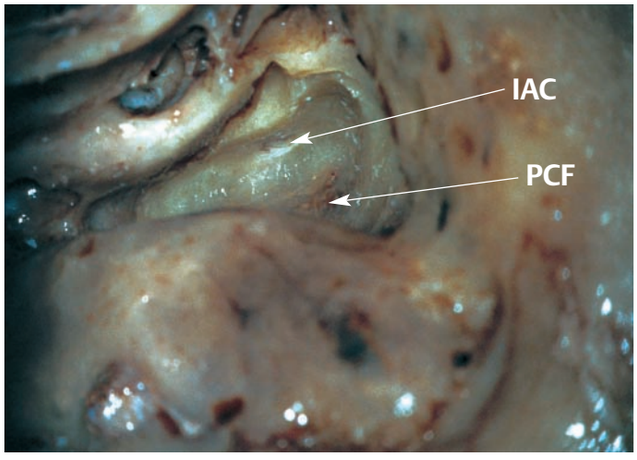
ASSC: Ampulla of superior semicircular canal
EG: External genu
MFN: Mastoid facial nerve
V: Vestibule



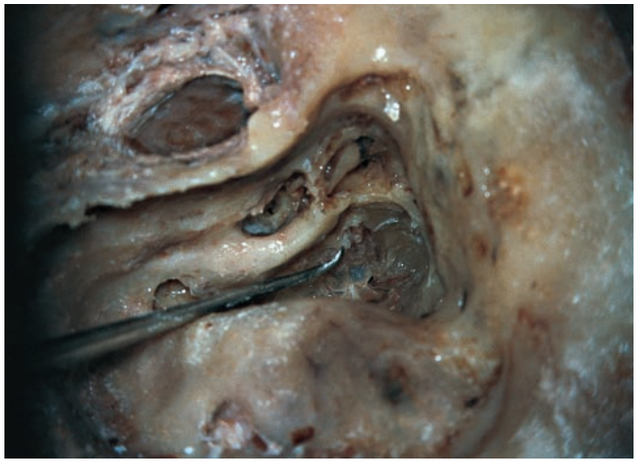
The continuation of drilling exposes the dural plates of the internal auditory canal and the posterior cranial fossa. The area where the internal auditory canal dura has just been exposed is displayed in the figure.

II: 2–3 mm diamond burr
MIL: Medial wall of vestibule

IAC: Internal auditory canal (dura)
PCF: Posterior cranial fossa (dural plate)



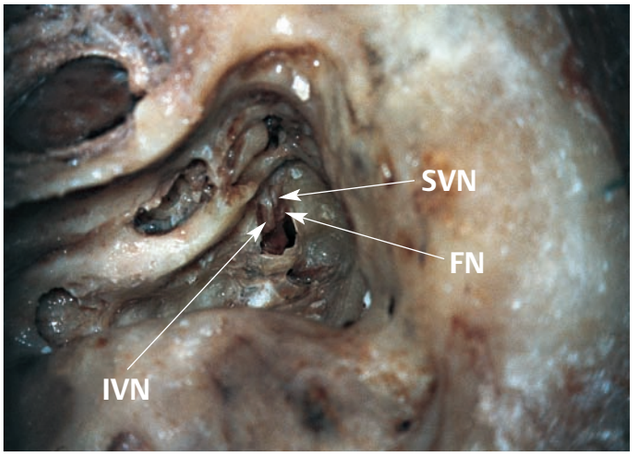
The internal auditory canal has been exposed completely. The curved micro dissector is pointing to the transverse crest, which is the critical landmark for the subsequent stages of the translabyrinthine approach.



Definitions and Tips

- **Spherical recess (recessus sphericus)**: *Definition:* The cavity in the anteroinferior part of the vestibule containing a little sac—the saccule (sacculus). *Tips:* Knowledge of the location of the spherical recess and saccule is essential for precise destruction of the labyrinth during a labyrinthectomy.
- **Elliptical recess (recessus ellipticus)**: *Definition:* The cavity in the posterosuperior part of the vestibule, containing a little sac—the utricle (utriculus). *Tips:* Knowledge of the location of the elliptical recess and the utricle is essential for precise destruction of the labyrinth during a labyrinthectomy.

The final stage is the opening of the dura and identification of the nerves running into the internal auditory canal. The superior and inferior vestibular nerves, which are located posteriorly in the canal, are separated by means of a curved micro dissector.



In addition to the superior and inferior vestibular nerves, the meatal segment of the facial nerve has also been exposed. The facial nerve lies anterior to the vertical crest.

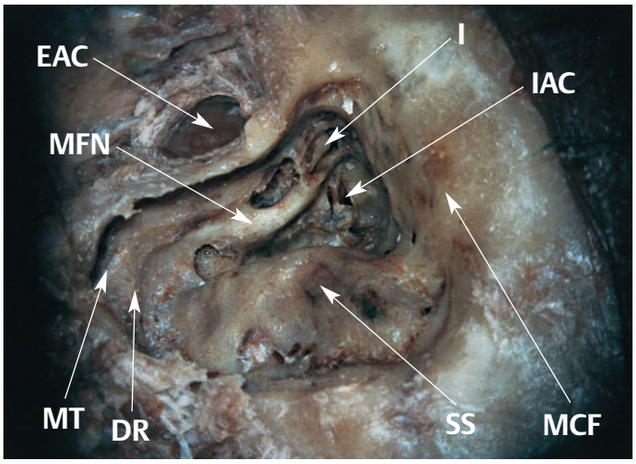
FN: Facial nerve
IVN: Inferior vestibular nerve
SVN: Superior vestibular nerve

Close-up view of the exposed internal auditory canal. The superior vestibular nerve, inferior vestibular nerve, and the facial nerve can all be seen in detail in this figure. Note the position of the incus and skeletonized facial canal laterally.

Definitions and Tips

- **Transverse crest (falciform crest, crista transversa)**: *Definition:* The horizontal spine that separates the fundus of the internal auditory canal into two parts. *Tips:* On the upper part of the fundus separated by the transverse crest are the facial nerve (anterosuperiorly) and the superior vestibular nerve (posterosuperiorly). On the lower part of the fundus are the cochlear nerve (anteroinferiorly) and the inferior vestibular nerve (posteroinferiorly). The transverse crest is an important reference point for all procedures involving the internal auditory canal.

In this way the translabyrinthine approach has been completed. During the operation, the dura of the posterior cranial fossa is also exposed and incised to work at the cerebellopontine angle. The critical structures encountered in this approach are indicated in the figure.



DR: Digastric ridge
EAC: External auditory canal
I: Incus
IAC: Internal auditory canal
MCF: Middle cranial fossa (dural plate)
MFN: Mastoid facial nerve
MT: Mastoid tip
SS: Sigmoid sinus (dural plate)

Definitions and Tips

- The purpose of the translabyrinthine approach is exposure of the internal auditory canal, posterior cranial fossa, and cerebellopontine angle, without disturbing the integrity of the external auditory canal and tympanic cavity.
- During the live operation, the dural plates of the middle cranial fossa and posterior cranial fossa are removed, which affords not only better exposure, but also sufficient working space.

21 Endolymphatic Sac Decompression

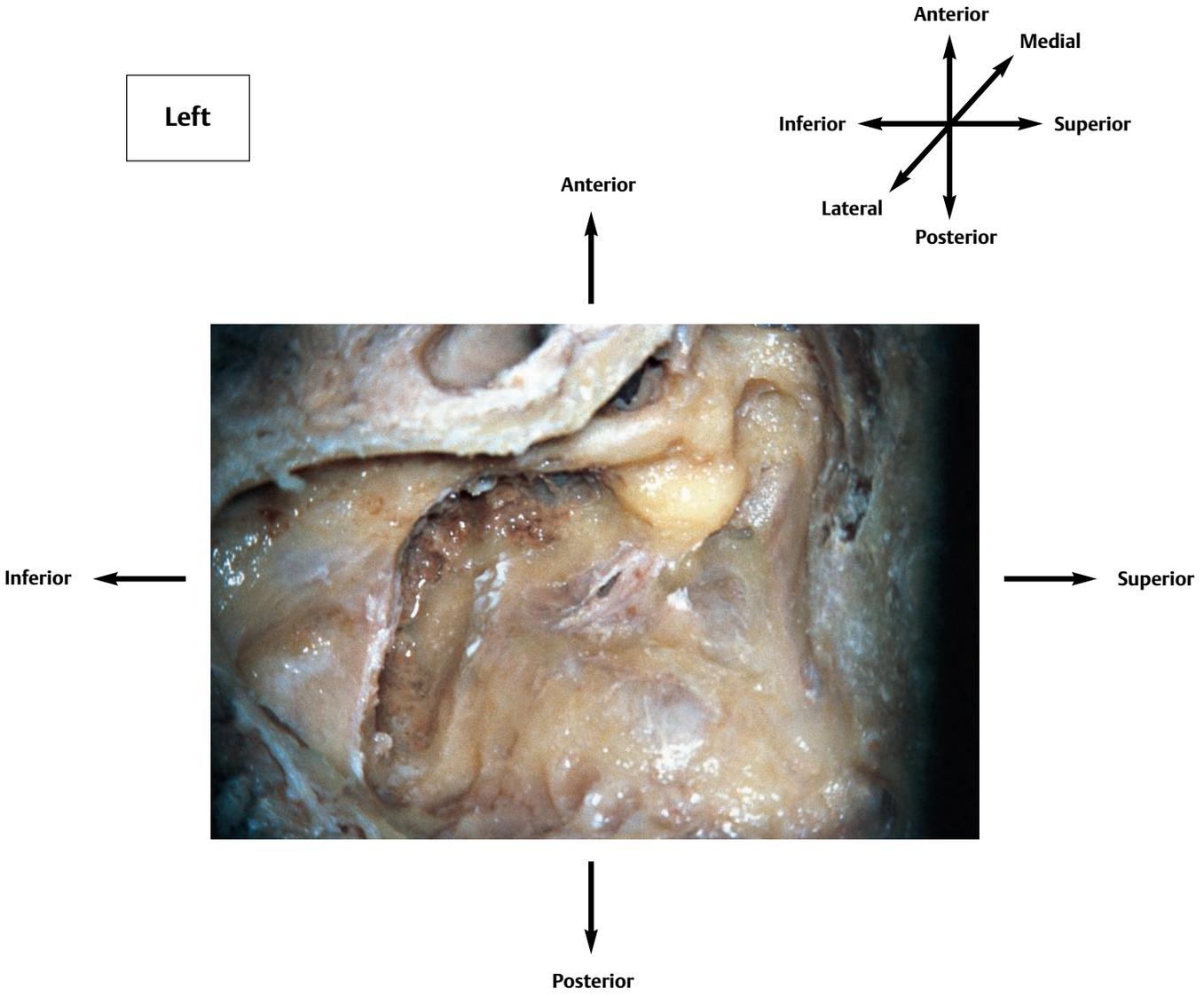
Definition

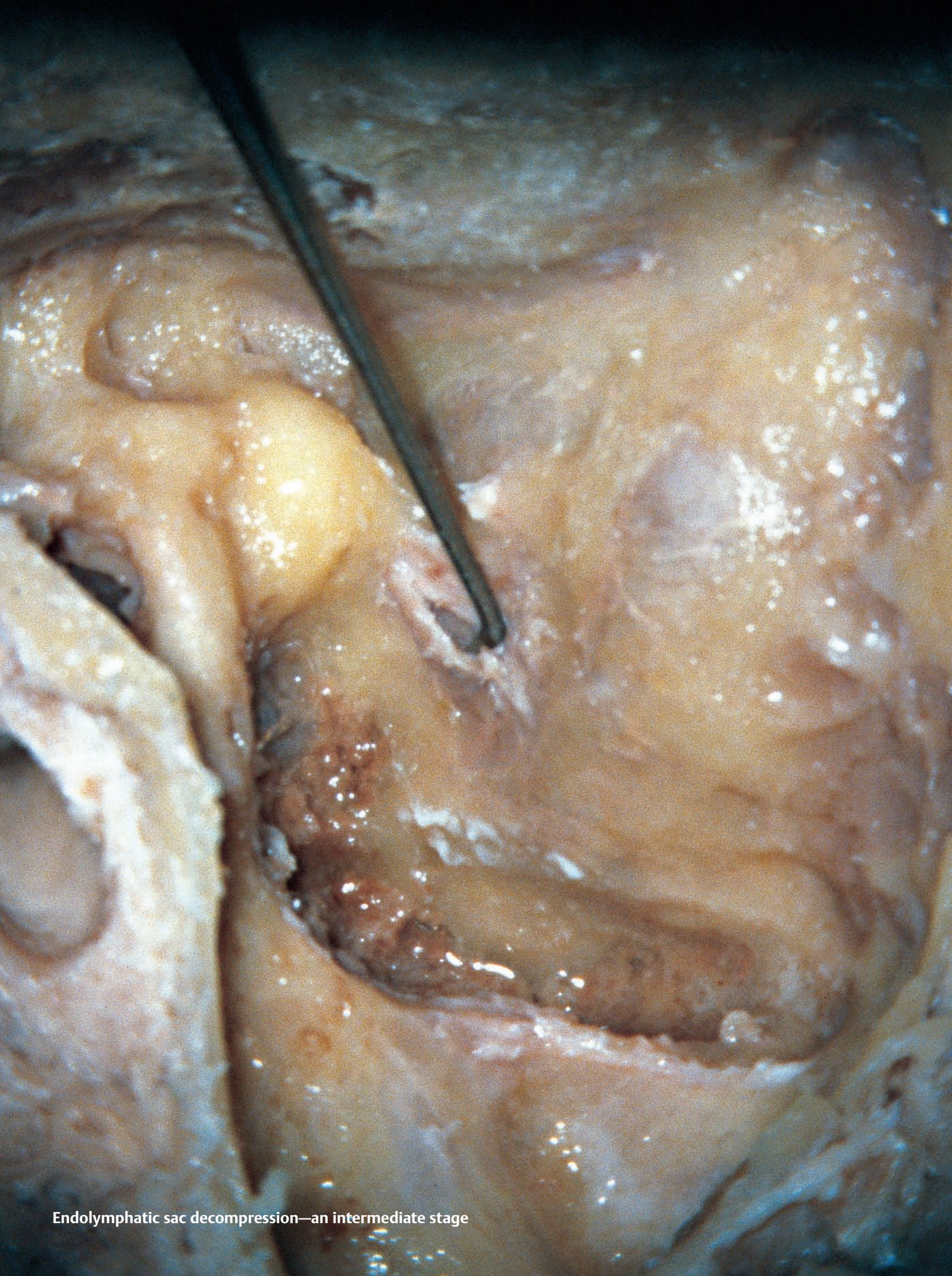
Following a cortical mastoidectomy, decompression of the endolymphatic sac by removal of bone between the posterior semicircular canal and sigmoid sinus, and placement of a shunt tube from the endolymphatic sac lumen toward the created mastoid cavity.

Indications

It is used as an alternative surgical technique to treat Ménière disease.

Anatomical Orientation



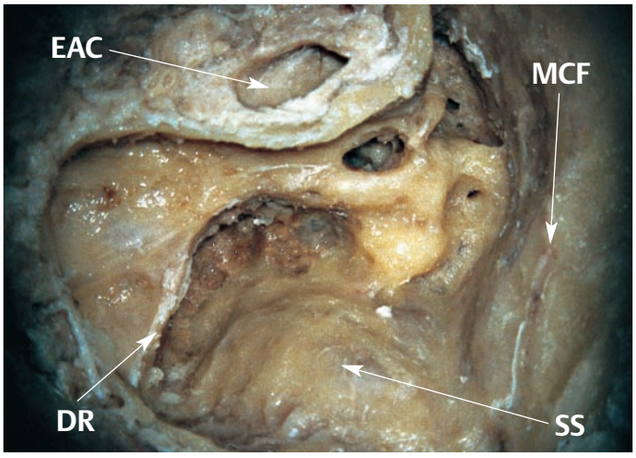


Endolymphatic sac decompression—an intermediate stage

Surgical Steps

Endolymphatic sac decompression will be demonstrated on the temporal bone in which an extended cortical mastoidectomy has been carried out. In the operation, there is no need to carry out a posterior tympanotomy or expose the epitympanum during this procedure.

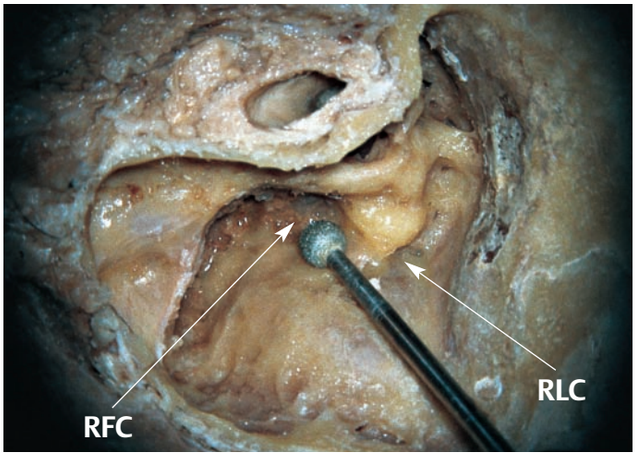
EAC: External auditory canal
DR: Digastric ridge
MCF: Middle cranial fossa (dural plate)
SS: Sigmoid sinus (dural plate)



The retrolabyrinthine cells have already been extirpated. In this stage, the retrolabyrinthine, i. e., the presigmoid area, is skeletonized using a medium-sized diamond burr. In addition, the retrofacial cells are removed.

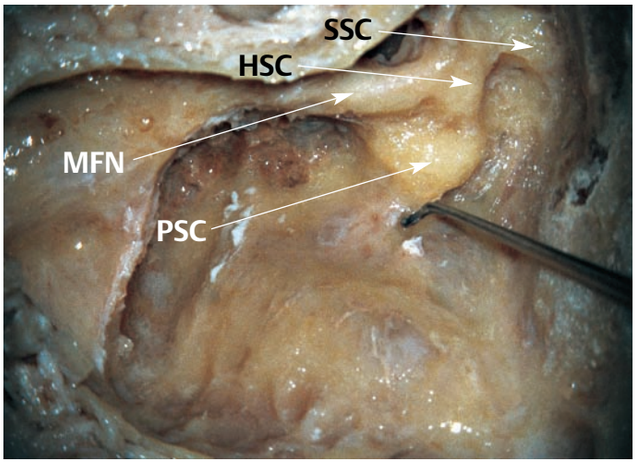
II: 3–4 mm diamond burr
MIL: Posterior semicircular canal

RFC: Retrofacial cells
RLC: Retrolabyrinthine cells (removed)



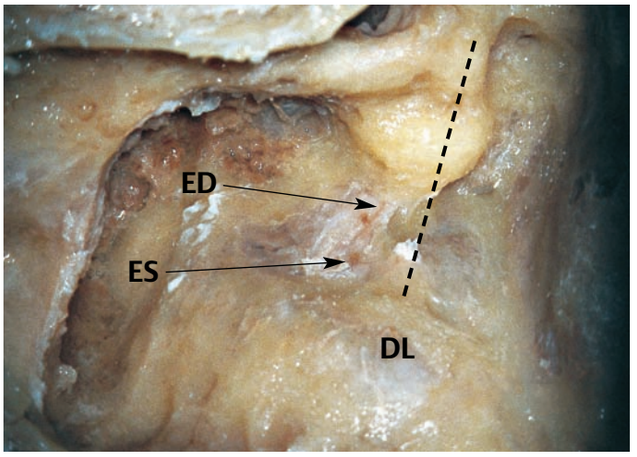
The bone close to the posterior semicircular canal is extirpated, revealing the endolymphatic duct. After this, the eggshell-thin bone covering the posterior cranial fossa dura is elevated using a curved micro dissector, thus exposing the dura and endolymphatic sac. The dissector is pointing to the endolymphatic duct in the figure.

HSC: Horizontal semicircular canal
MFN: Mastoid facial nerve
PSC: Posterior semicircular canal
SSC: Superior semicircular canal



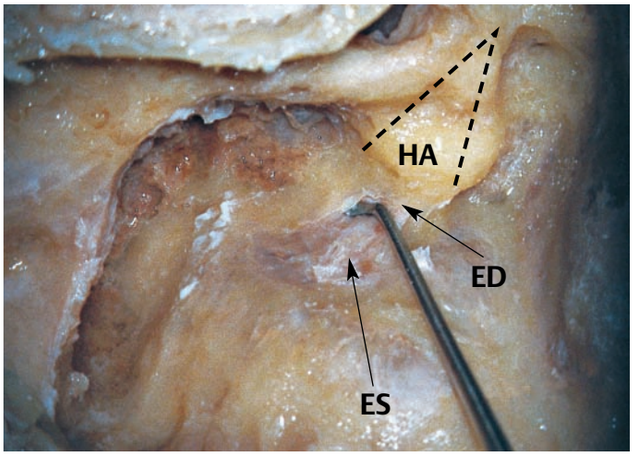
Definitions and Tips

- **Endolymphatic duct (ductus endolymphaticus)**: *Definition:* The membranous canal that connects the endolymphatic sac to the vestibule. The bony canal in which it runs is called the vestibular aqueduct (aquaeductus vestibuli). *Tips:* The endolymphatic duct begins anteromedial to the aperture of the common crus to the vestibule, runs medial to this crus posteriorly, and then appears posteroinferior to the posterior semicircular canal, leading to the endolymphatic sac in the posterior cranial fossa dura.
- **Endolymphatic sac (saccus endolymphaticus)**: *Definition:* The membranous sac containing endolymphatic fluid, located in, and posterior to, the indentation approximately 15 mm posterior to the internal auditory canal. *Tips:* It is important during execution of techniques such as endolymphatic sac decompression or translabyrinthine approach. The junction of the endolymphatic sac with the endolymphatic duct is embedded in the bone; because of this, this junctional area may be mistaken for damaged dura.



The endolymphatic duct and the endolymphatic sac have been found inferior to the Donaldson line and posteroinferior to the hard angle, as expected. The Donaldson line is shown in the figure. Note that the duct and sac are whiter than the surrounding dura.

DL: Donaldson line
ED: Endolymphatic duct
ES: Endolymphatic sac



A closer view of the surgical site where the hard angle is displayed. Note the position of the endolymphatic sac in relation to the hard angle. As the next step, the dura with the endolymphatic sac is separated from the adjacent bone using a curved micro dissector.

ED: Endolymphatic duct
ES: Endolymphatic sac
HA: Hard angle

The opening of the sac is the next step. While the dura close to the sac is retracted by means of a surgical hook, the lateral wall of the endolymphatic sac is incised with a No. 11 blade.

II: No. 11 blade or sickle knife
MIL: White discoloration of the dura

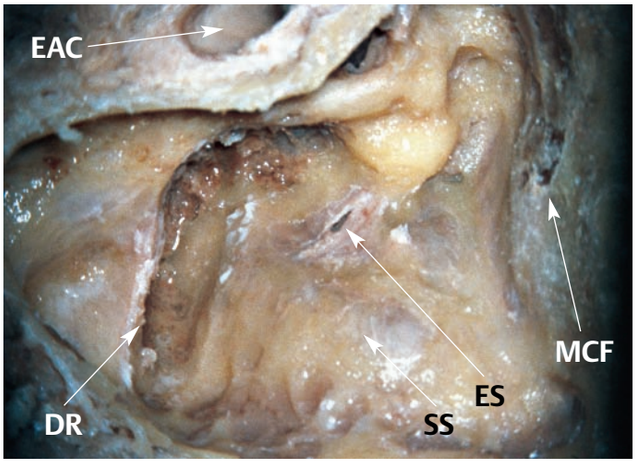
Definitions and Tips

- **Donaldson line**: *Definition:* The line that extends from the ampulla of the horizontal semicircular canal, along its arc, to the sigmoid sinus. *Tips:* The endolymphatic sac is located inferior to this line, that is, posteroinferior to the posterior semicircular canal in the presigmoid area. It is one of the clues used in endolymphatic sac decompression surgery.
- **Hard angle**: *Definition:* The angle between the superior line that extends 10 mm from the short process of the incus along the arc of the horizontal semicircular canal and the inferior line that extends 12 mm from the same point to the inferior margin of the posterior semicircular canal arc. *Tips:* This angle contains the posterior semicircular canal, and the endolymphatic sac is located posteroinferior to this angle.

Lastly, the lumen of the endolymphatic sac is entered with the curved micro dissector, and the medial and lateral walls are dissected. Following this, in the operation a shunt tube should be placed into the sac, extending into the mastoid cavity.

The endolymphatic sac decompression has been completed. The critical structures encountered during this procedure are indicated in the figure.

DR: Digastric ridge
EAC: External auditory canal
ES: Endolymphatic sac
MCF: Middle cranial fossa (dural plate)
SS: Sigmoid sinus (dural plate)



Definitions and Tips

- The endolymphatic sac is an intradural structure. Although the surrounding dura has a darker color, in the region of the endolymphatic sac, the dura is thicker and whiter; in the live operation it is also more vascular.
- In most instances, difficulty in finding the endolymphatic sac is because of the insufficient removal of the retrofacial and retrolabyrinthine cells.
- If difficulties arise during the exposure of the endolymphatic sac because of a prominent sigmoid sinus, decompression of the sigmoid sinus will result in adequate exposure.

22 Postauricular Facial Nerve Decompression

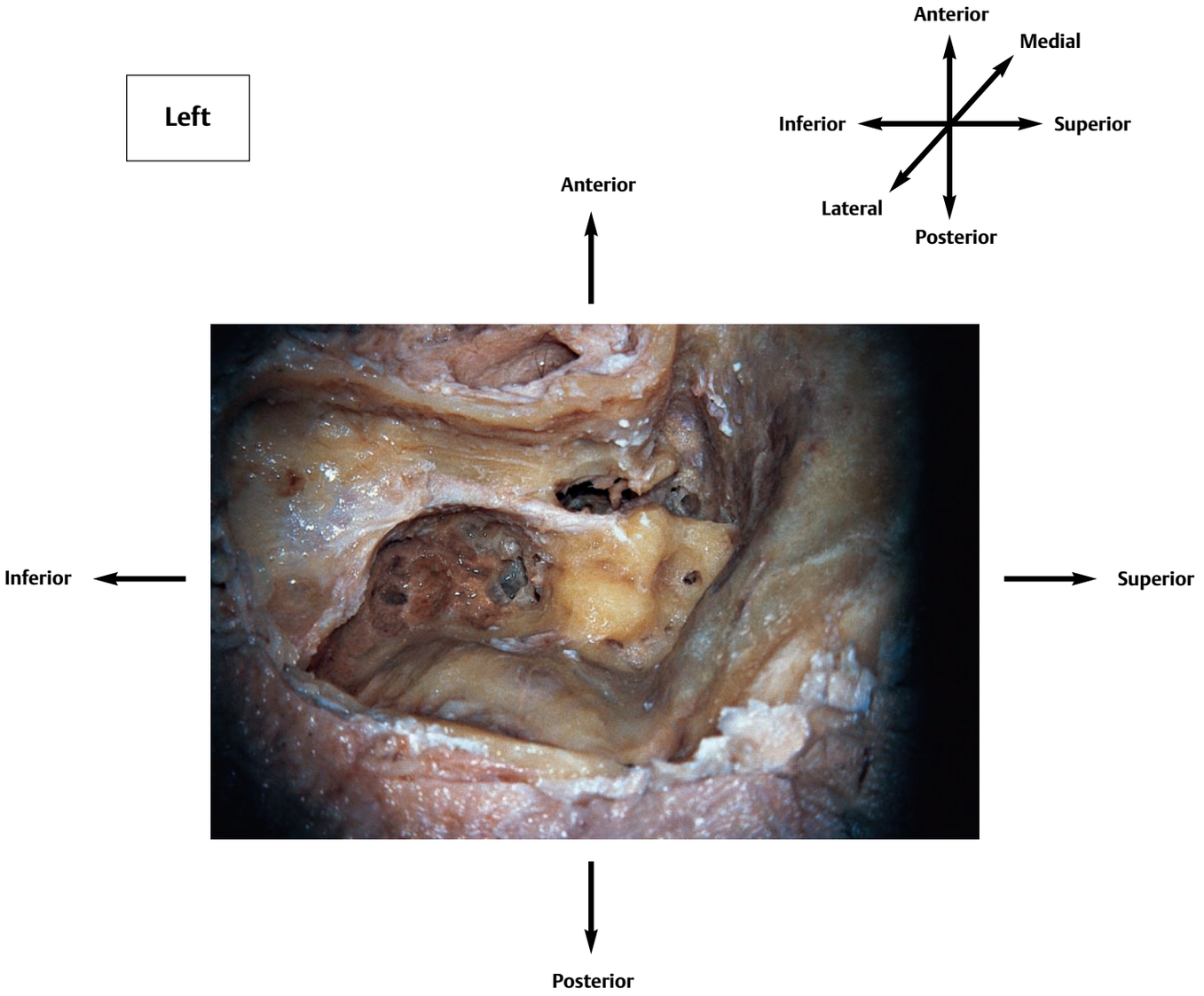
Definition

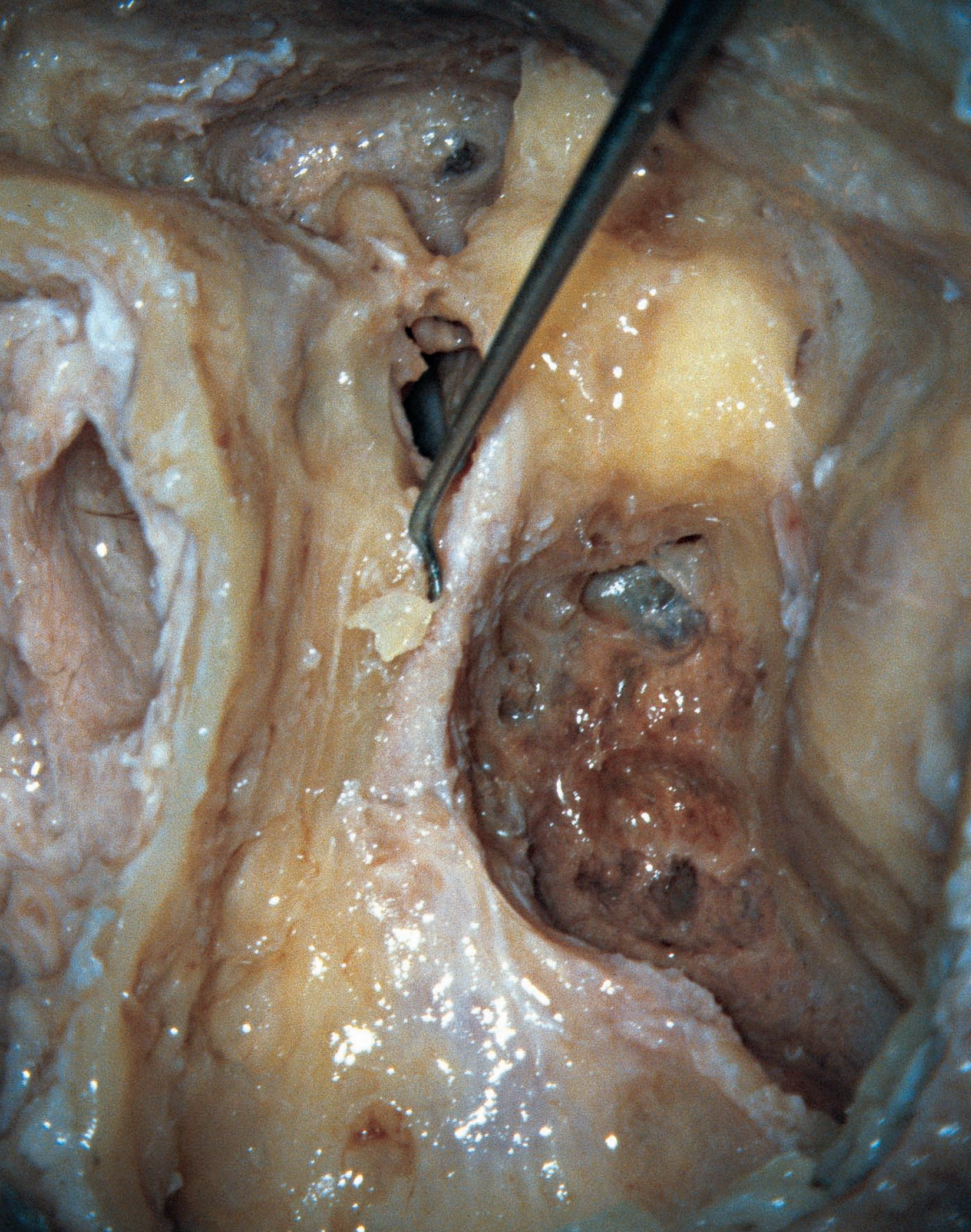
Following a cortical mastoidectomy, exposure and decompression of the tympanic and mastoid segments of the facial nerve. It is also called transmastoid facial nerve decompression.

Indications

Iatrogenic facial paralysis and facial paralysis due to cholesteatoma are the main indications. It is also undertaken for facial paralysis resulting from a transverse fracture, as part of a combined procedure.

Anatomical Orientation





Postauricular facial nerve decompression—an intermediate stage

Surgical Steps

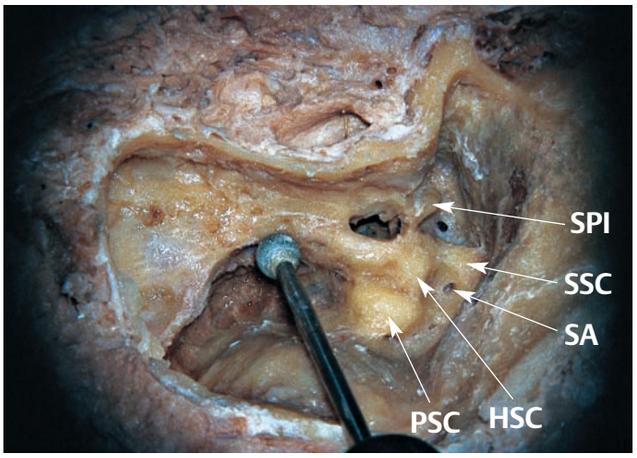
The cortical mastoidectomy including posterior tympanotomy has been completed. The facial canal and all three semicircular canals have also been skeletonized. The temporal bone is ready for the next steps of postauricular facial nerve decompression.

DR: Digastric ridge
EAC: External auditory canal
MCF: Middle cranial fossa (dural plate)
SS: Sigmoid sinus (dural plate)

Drilling with a medium-sized diamond burr, the digastric ridge is followed anterosuperiorly to expose the periosteum of the stylomastoid foramen, which is continuous with the mastoid facial canal. The critical structures are shown in the figure.

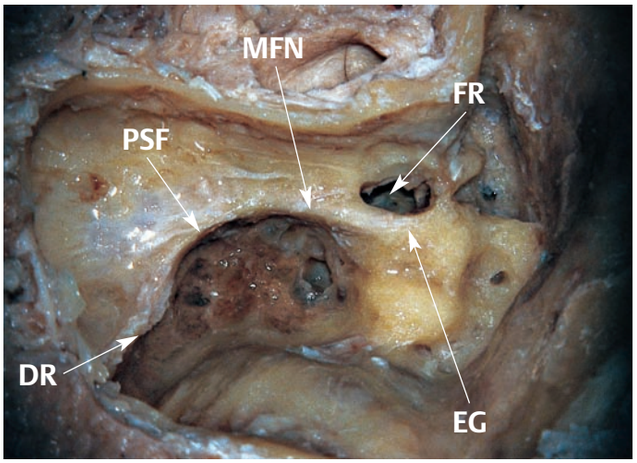
II: 3–4 mm diamond burr
MIL: Periosteum of stylomastoid foramen

HSC: Horizontal semicircular canal
PSC: Posterior semicircular canal
SA: Subarcuate artery
SPI: Short process of incus
SSC: Superior semicircular canal



Drilling is continued until the mastoid segment of the facial nerve remains covered only by an eggshell-thin layer of bone. Note the relationship of the mastoid segment of the facial nerve, the periosteum of the stylomastoid foramen, and the digastric ridge.

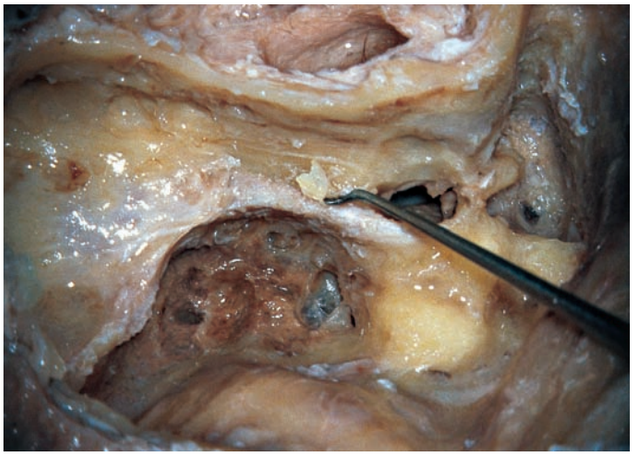
DR: Digastric ridge
EG: External genu
FR: Facial recess
MFN: Mastoid facial nerve
PSF: Periosteum of stylomastoid foramen



Definitions and Tips

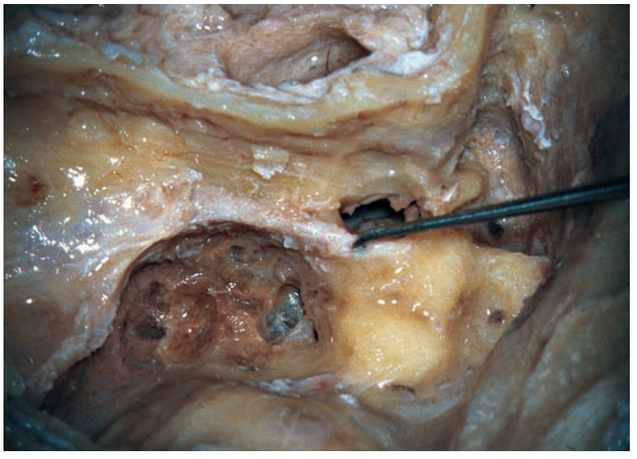
- **Periosteum of stylomastoid foramen**: *Definition:* The periosteum covering the stylomastoid foramen. *Tips:* It is found by following the digastric ridge while drilling in an anterosuperomedial direction. The periosteum of the stylomastoid foramen is the most defining landmark for the distal part of the mastoid segment of the facial nerve.
- The intratemporal facial nerve is generally described as having three parts—the labyrinthine, tympanic and mastoid segments. Although the bend between the last two segments is generally known as the external genu, it is also called the pyramidal segment because of its close proximity to the pyramidal process.

Following this, the bone covering the pyramidal segment of the facial nerve, i. e., external genu, is drilled with the same burr until an eggshell-thin layer of bone is left surrounding it anteriorly and laterally. Care should be taken not to drill posterosuperiorly in this segment, which may result in damage to the horizontal semicircular canal.



The next step is elevation of the eggshell-thin bone. Using a curved micro dissector, this thin bone is elevated from the mastoid segment of facial nerve and removed in pieces. The last shell of bone surrounding any segment of the facial nerve should always be removed with a surgical dissector instead of a burr.

II: Micro elevator or curved micro dissector
MIL: Epineurium of facial nerve



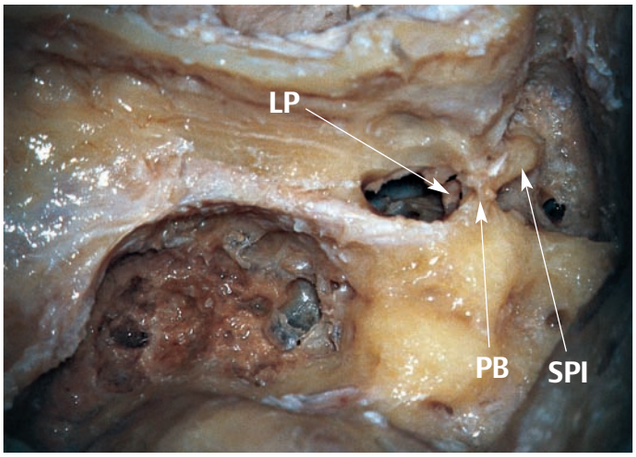
The same delicate technique is carried out on the pyramidal segment to prevent damage to the facial nerve. Care should be taken not to compress the facial nerve with the shoulder of the instrument tip during this maneuver.

Definitions and Tips

- **External genu (external genu of the facial nerve, pyramidal facial nerve, pyramidal turn)**: *Definition:* The bend of the facial nerve between its tympanic and mastoid segments, behind the pyramidal prominence. *Tips:* The external genu forms the most posterior point of the intratemporal facial nerve. Good knowledge of its location is important to prevent damage to the facial nerve when the mastoid bone is drilled too far anteriorly in this area.
- The curved micro dissector is an indispensable instrument for removing the last shell of bone around the facial nerve. During this process, the right and left curved instruments are needed alternately. The double-sided microsurgery instruments designed by the author provide both speed and convenience; only one maneuver of the fingers is required to rotate the instrument, thus enabling usage of the appropriate right or left curved tip. See page 185.

In this way, decompression of the mastoid and pyramidal segments of the facial nerve is completed. The important structures in the following step of the procedure are shown in the figure.

LP: Lenticular process
PB: Posterior buttress
SPI: Short process of incus

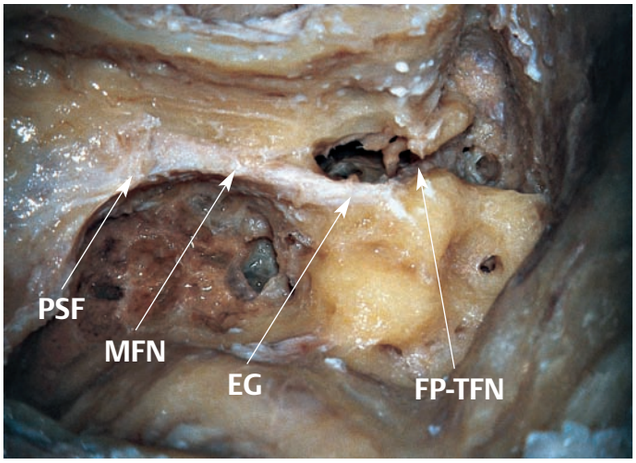


The last step is decompression of the tympanic segment of the facial nerve. With this intention, first the posterior buttress is drilled away using a small diamond burr, taking care not to come into contact with the surrounding structures.

II: 1–2 mm diamond burr
MIL: Facial prominence

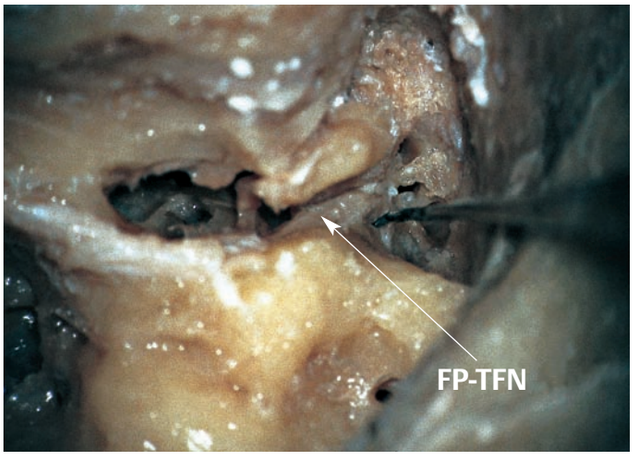
A close-up view of the surgical site. The segments of the facial nerve are displayed in the figure. Note the relation of the tympanic facial nerve to the incus.

EG: External genu
FP: Facial prominence
MFN: Mastoid facial nerve
PSF: Periosteum of stylomastoid foramen
TFN: Tympanic facial nerve



Definitions and Tips

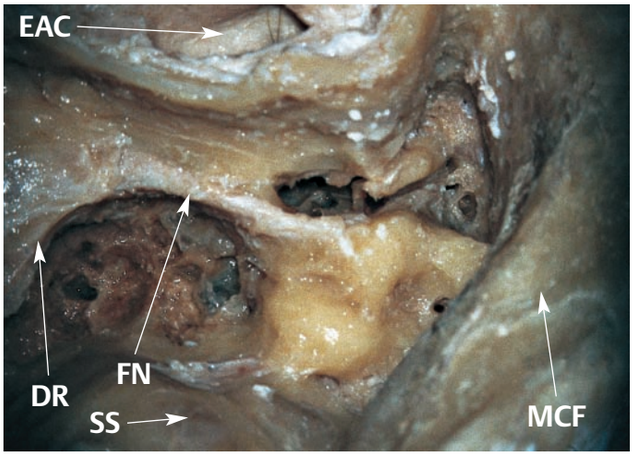
- The facial recess is the key area in the execution of postauricular facial decompression. When carrying out this procedure, a comprehensive posterior tympanotomy should be done. In addition, the drilling should continue superiorly and the posterior buttress should also be removed.
- The appropriate approach to the geniculate ganglion and labyrinthine facial nerve has long been disputed by the proponents of the middle cranial fossa approach and the proponents of the postauricular transmastoid extralabyrinthine approach. The zygomatic root approach described by the author offers an ideal compromise to this problem, combining the advantages of both procedures. See page 181.



The eggshell-thin layer of bone covering the anterior side of the tympanic segment of the facial nerve is removed using a micro needle. In this area, a surgical needle is preferable to the micro dissector because of the restricted working space.

II: Micro needle
MIL: Epineurium of the facial nerve

FP: Facial prominence
TFN: Tympanic facial nerve



The view of the entire surgical site. The postauricular facial nerve decompression has been completed. In the live operation, all the steps of the procedure are exactly the same as in the temporal bone. The structures surrounding the surgical access area are shown in the figure.

DR: Digastric ridge
EAC: External auditory canal
FN: Facial nerve
MCF: Middle cranial fossa (dural plate)
SS: Sigmoid sinus (dural plate)

Definitions and Tips

- There are two basic working techniques when performing postauricular facial nerve decompression in the mastoid segment:
  – superoinferior technique—drilling from the fossa incudis inferiorly
  – inferosuperior technique—drilling from the digastric ridge superiorly
  However, defining superiorly the facial prominence and inferiorly exposing the periosteum of the stylomastoid foramen combines both techniques, resulting in quick and safe drilling.
- The decompressed side of the facial nerve changes in accordance with the segment:
  – mastoid segment–the lateral side is decompressed
  – pyramidal segment–the anterolateral side is decompressed
  – tympanic segment–the anterior side is decompressed

23 Infratemporal Fossa “Type A” Approach

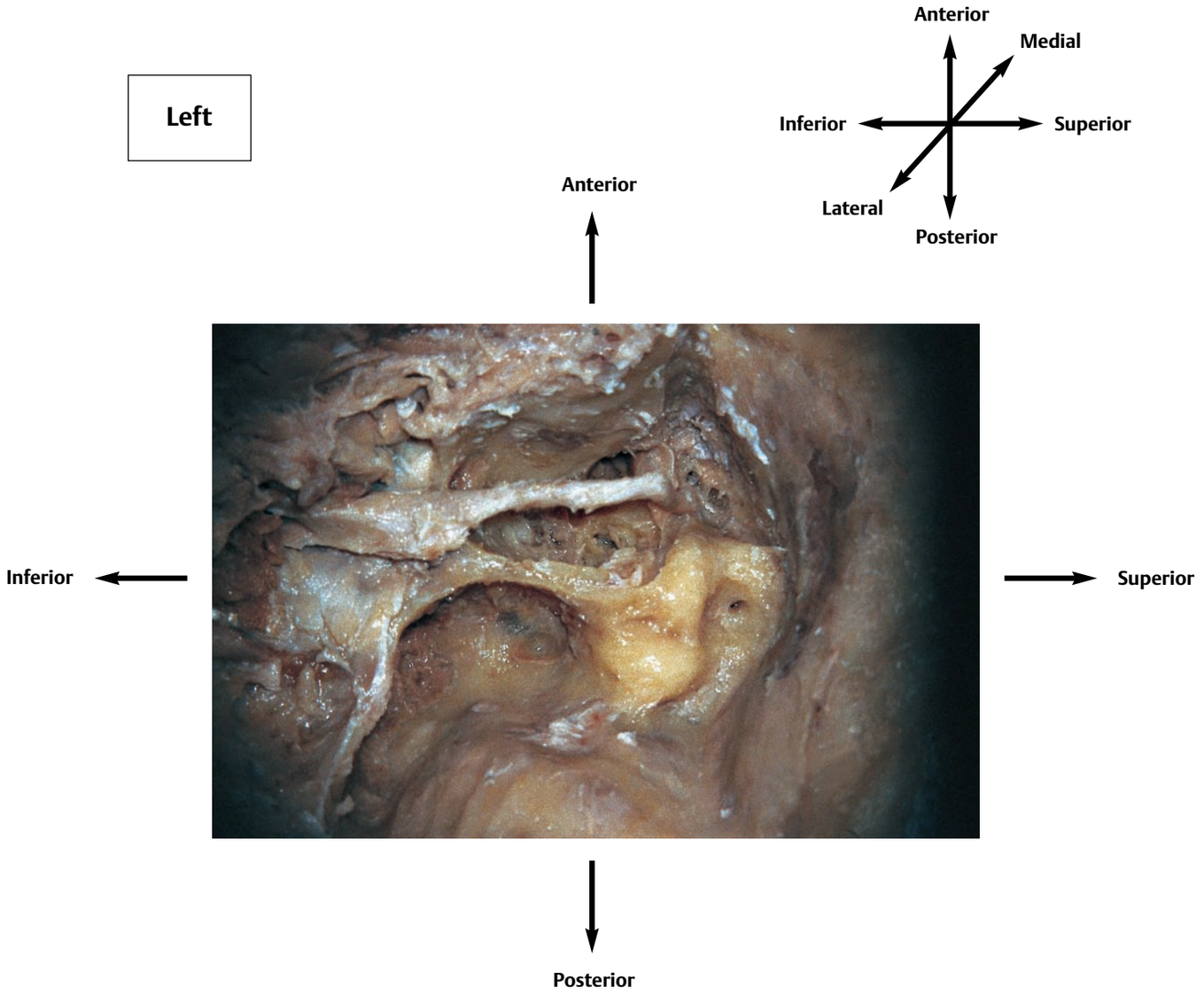
Definition

Following a subtotal petrosectomy, permanent anterior transposition of the facial nerve, and performing procedures on the structures located medial to the facial canal. At the end of this approach, abdominal fat is put into the cavity and a “blind sac” closure of the external auditory canal is carried out.

Indications

An infratemporal fossa “type A” approach is mainly carried out for removal of glomus jugulare tumors and neuromas of cranial nerves IX–XII.

Anatomical Orientation



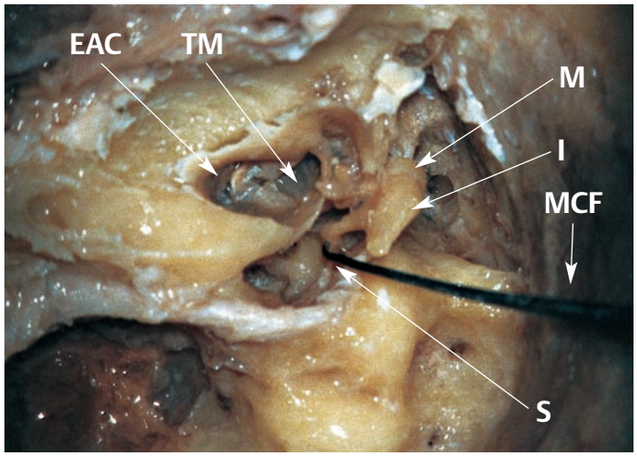
Infratemporal fossa “type A” approach—an intermediate stage

Surgical Steps

The procedure will be carried out on the temporal bone where a modified radical mastoidectomy and exposure of the facial nerve have already been performed. In the first stage, the incudostapedial joint is separated with a micro hook.

II: Micro hook
MIL: Stapes head

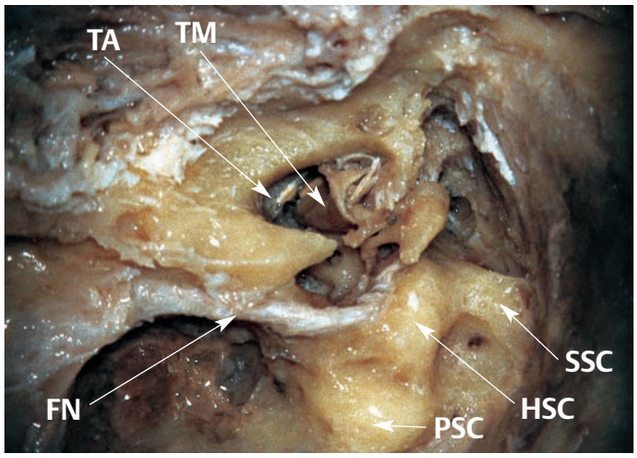
EAC: External auditory canal
I: Incus
M: Malleus
MCF: Middle cranial fossa (dural plate)
S: Stapes
TM: Tympanic membrane



The tympanic membrane is separated from the tympanic annulus by means of a micro elevator and positioned superiorly. The anatomical structures encountered during this stage are indicated in this and the previous figure.

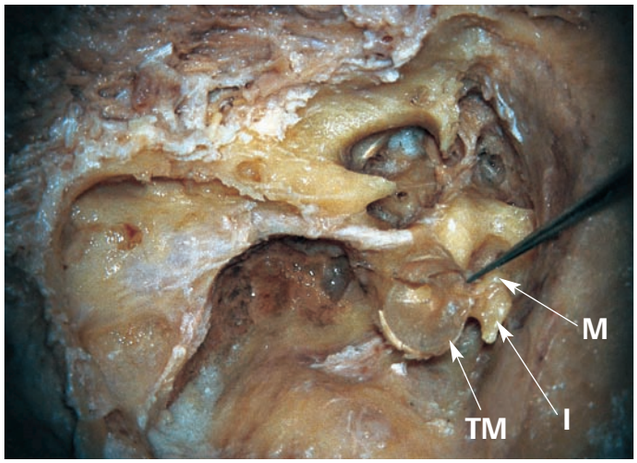
II: Micro elevator
MIL: Tympanic annulus

FN: Facial nerve
HSC: Horizontal semicircular canal
PSC: Posterior semicircular canal
SSC: Superior semicircular canal
TA: Tympanic annulus
TM: Tympanic membrane



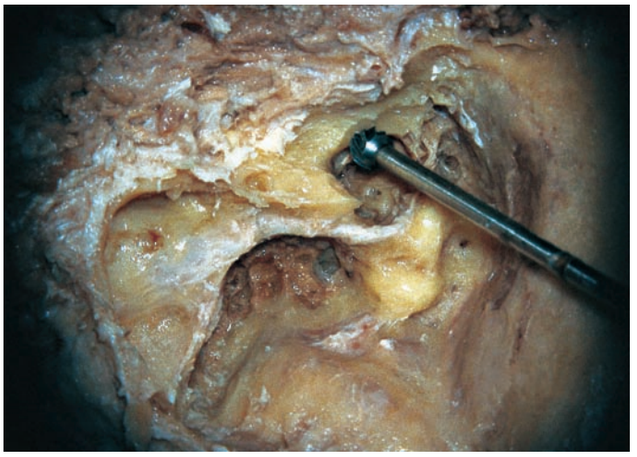
After separating the tympanic membrane from the tympanic annulus circumferentially, and making a cut to the tendon of the tensor tympani muscle, the tympanic membrane, including the malleus and incus, is removed as a whole unit.

I: Incus
M: Malleus
TM: Tympanic membrane



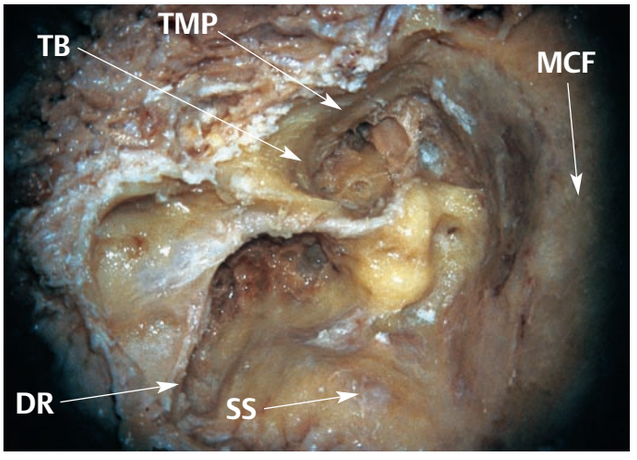
Definitions and Tips

- The infratemporal fossa “type A” approach affords the most extensive, most direct, and an unobscured exposure of the jugular foramen area, which is hidden medial to the facial nerve, without sacrificing the facial nerve itself.
- There are two principal approaches, where the facial nerve is transposed from the facial canal to gain unobstructed access to the medially located petrous parts and the cerebellopontine angle. The infratemporal fossa “type A” approach involves anterior transposition of the facial nerve and the transcochlear approach involves posterior transposition of the facial nerve.



The bony overhang anterior to the mastoid facial nerve is removed. The anterior and inferior walls of the tympanic bone are drilled by means of a medium-sized cutting burr. The direction of burr rotation should be away from the facial nerve.

II: 3–4 mm cutting burr
MIL: Facial nerve



Drilling of the anterior part of the temporal bone is continued and the anterior wall of the tympanic bone is thinned until a bluish-pink discoloration indicates the temporomandibular joint reflection. Alternatively, the periosteum of the temporomandibular joint can be directly exposed, depending on the needs of the individual procedure.

II: 3–4 mm cutting and diamond burrs
MIL: Temporomandibular joint periosteum

DR: Digastric ridge
MCF: Middle cranial fossa (dural plate)
SS: Sigmoid sinus (dural plate)
TB: Tympanic bone
TMP: Temporomandibular joint periosteum (plate)

Following this, the inferior part of the tympanic bone is drilled extensively. When working in this area, the blue-colored reflection of the jugular bulb should be sought, in both the laboratory and the operation.

II: 3–4 mm cutting and diamond burrs
MIL: Jugular bulb reflection

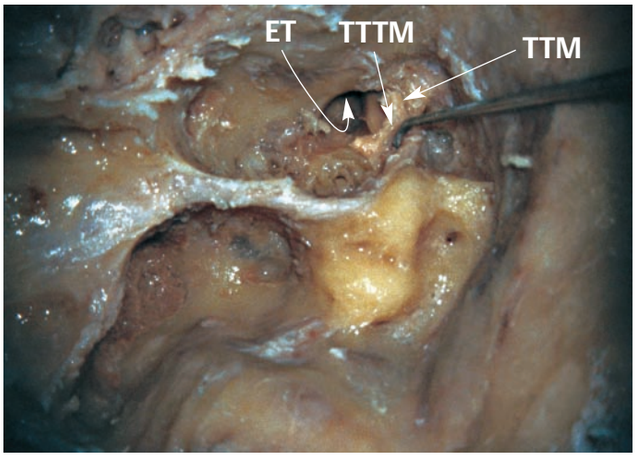
Definitions and Tips

- During the operation, the crura of the stapes may be cut and the stapes suprastructure removed, leaving only the stapes footplate in place. This maneuver reduces the risk of dislocation of the footplate during tumor removal or packing the middle ear with fat, and preserves the functions of the inner ear.
- The facial nerve should not be exposed until the final stages of the subtotal petrosectomy. The reason for this is to prevent inadvertent damage to the facial nerve during the extensive drilling process. Once the facial nerve is uncovered, it is immediately transposed anteriorly into its prepared groove.

In the next stage, the tensor tympani muscle and its tendon are separated from the cochleariform process and moved anteriorly using a curved micro dissector. Afterward, the proximal part of the tympanic facial nerve is exposed up to the geniculate ganglion.

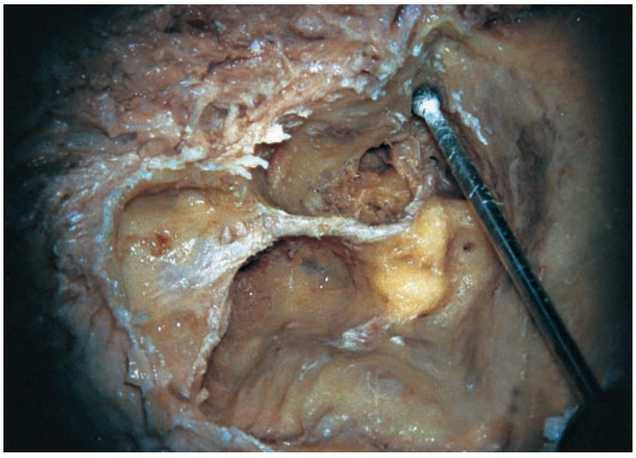
II: Curved micro dissector
MIL: Cochleariform process

ET: Eustachian tube
TTM: Tensor tympani muscle
TTTM: Tendon of tensor tympani muscle



At this point, using medium-sized cutting and diamond burrs, the bone at the zygomatic root is drilled and a groove is made, beginning at the geniculate ganglion and ending at the squamosa. The facial nerve will later be transposed and placed into this groove.

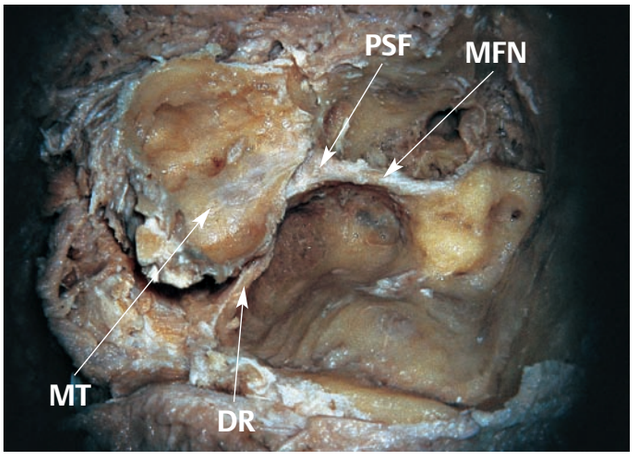
II: 2–3 mm cutting and diamond burrs
MIL: Geniculate ganglion



This completes the subtotal petrosectomy, the full exposure of the facial nerve, and the creation of the “groove.” The figure shows a wide-angle view of the surgical site. In the operation, the extratemporal facial nerve trunk should be found, and its two main branches exposed in the parotid gland, prior to the execution of the aforementioned procedures.

Definitions and Tips

- The facial nerve divides into two main branches, the temporozygomatic branch and the cervicofacial branch, 1–2 cm after emerging from the stylomastoid foramen.
- The transposition of the facial nerve to this extent generally results in some type of paralysis because of a deficiency in blood supply. However, if the procedure is carried out with a good surgical technique, the paralysis is temporary, and heals with an average House–Brackmann grade II.

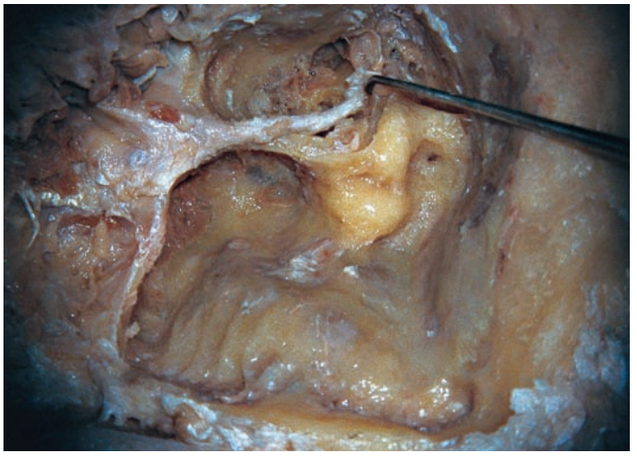


The next step is resection of the mastoid tip. The figure shows the dissected and prepared mastoid tip as well as the structures that are of importance during this dissection.

II: No. 15 blade or scissors
MIL: Digastric ridge

DR: Digastric ridge
MFN: Mastoid facial nerve
MT: Mastoid tip
PSF: Periosteum of stylomastoid foramen

The mastoid tip is grasped with strong forceps and it is separated from the digastric muscle and other attached tissues using scissors or a No. 15 blade. The incisions should be made adjacent to the bone of the mastoid tip, otherwise the facial nerve may be cut inadvertently at the stylomastoid foramen.



The exposed facial nerve is elevated from its canal by means of a curved micro dissector. The separation of first the mastoid segment, then the tympanic segment, and lastly the pyramidal segment, which has a rich blood supply and tissue attachments, facilitates this procedure.

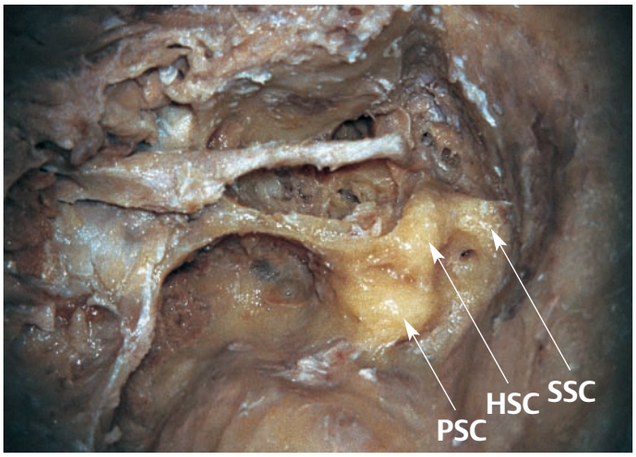
II: Curved micro dissector or curved needle
MIL: Facial nerve

Definitions and Tips

- For atraumatic transposition of the facial nerve, the following points must be considered:
  - The surrounding bone should be removed extensively (in the mastoid part, 270°; in the tympanic part, 180°).
  - While drilling, copious irrigation should be used.
  - The last shell of bone should be removed using a micro elevator, not the burr.
  - The micro elevator should not compress the facial nerve.
  - First the mastoid, then the tympanic, and finally the pyramidal segments should be elevated.

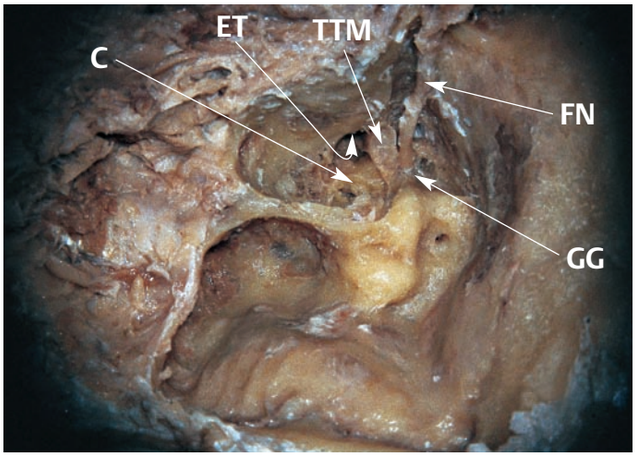
The elevated facial nerve, comprising the tympanic, mastoid, and extratemporal segments, is moved anteriorly to be positioned into the previously created groove. In the operation, extreme care is mandatory during this maneuver to prevent damage to the facial nerve.

HSC: Horizontal semicircular canal
PSC: Posterior semicircular canal
SSC: Superior semicircular canal



In this way, the facial nerve is placed into the groove, completing the transposition of the facial nerve. In the operation, additionally, the transposed extratemporal segment is enclosed by suturing parotid gland tissue over it.

C: Cochlea
ET: Eustachian tube
FN: Facial nerve
GG: Geniculate ganglion
TTM: Tensor tympani muscle

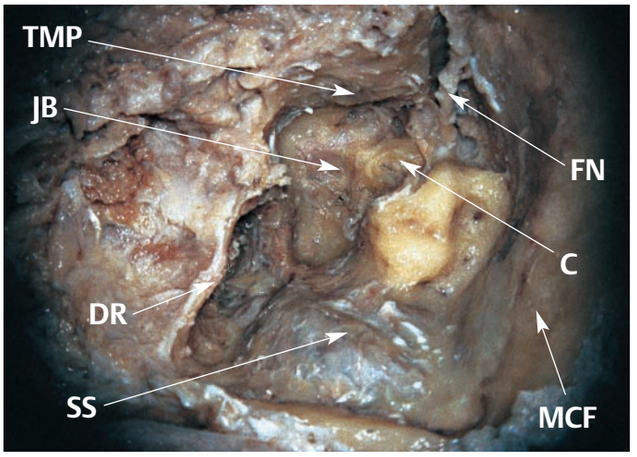


The structures medial to the facial canal can now be reached. The mastoid part of the facial canal and the bone medial to it are drilled at a high-speed setting. Anteriorly, the cochlear aqueduct may be encountered, which includes the perilymphatic duct. During the operation, cerebrospinal fluid seeps out through this area, allowing intracranial decompression.

II: 3–4 mm cutting burr
MIL: Labyrinth

Definitions and Tips

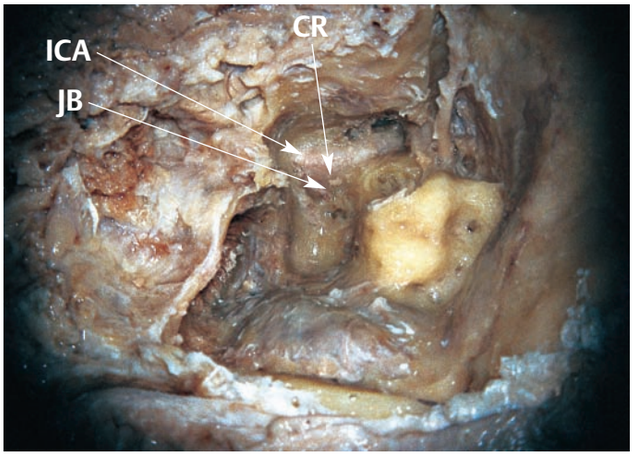
- **Perilymphatic duct (ductus perilymphaticus)**: *Definition:* The membranous canal that connects the perilymphatic space of the cochlea with the subarachnoid space. The bony canal in which it runs is called the cochlear aqueduct (aquaeductus cochlea). *Tips:* The perilymphatic duct begins at the entrance of the scala tympani and then runs inferiorly, ending inferior to the internal auditory canal and anterior to the jugular fossa in the triagonal depression known as the fossula petrosa, where it joins with the subarachnoid space of the posterior cranial fossa. During neurotologic procedures, the opening of this duct results in decompression of cerebrospinal fluid.



Drilling proceeds medially in this area using a diamond burr, and the junction of the sigmoid sinus and jugular bulb is identified. The critical structures exposed in this stage are shown in the figure.

II: 3–4 mm diamond burr
MIL: Jugular bulb

C: Cochlea
DR: Digastric ridge
FN: Facial nerve
JB: Jugular bulb
MCF: Middle cranial fossa (dural plate)
SS: Sigmoid sinus (dural plate)
TMP: Temporomandibular joint periosteum (plate)



Subsequently, the jugular bulb is exposed. In the same stage, the crotch and the vertical segment of the internal carotid artery are also revealed. Note at this point, how the anterior transposition of the facial nerve facilitates all of the procedures in this area.

II: 3–4 mm diamond burr
MIL: Vertical segment of internal carotid artery

CR: Crotch
ICA: Internal carotid artery
JB: Jugular bulb

The essential parts of the infratemporal fossa "type A" approach have been completed. In the operation, the subsequent steps of the specific procedure may differ according to the neurotologic pathology. However, in all cases, the last step involves the plugging of the eustachian tube, obliteration of the cavity with abdominal fat, and blind sac closure of the external auditory canal.

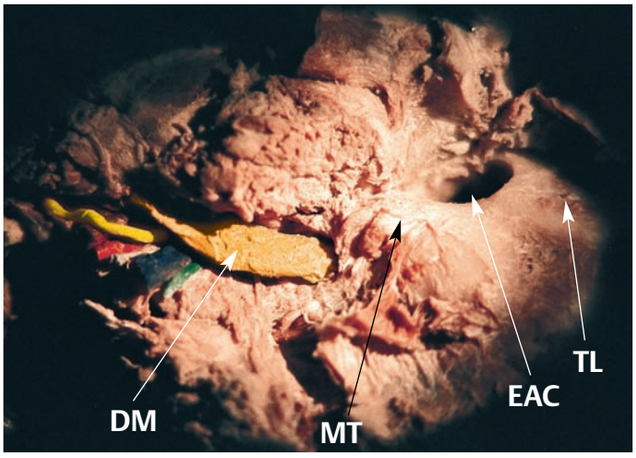
Definitions and Tips

- **Crotch (jugulocarotid septum)**: *Definition:* The bony septum separating the jugular bulb and petrosal internal carotid artery. Its superior edge is formed as a bony spine by drilling the bone between these two structures; this spine is called crotch. *Tips:* It is an important structure in glomus jugulare surgery.
- **Petrotympanic fissure (fissura petrotympanica, glasserian fissure)**: *Definition:* The fissure at the junction of the tympanic and petrous bones, located on the anterior wall of the tympanic cavity. *Tips:* The petrotympanic fissure transmits the chorda tympani, the anterior tympanic artery, and the anterior ligament of malleus.

Surgical Anatomy

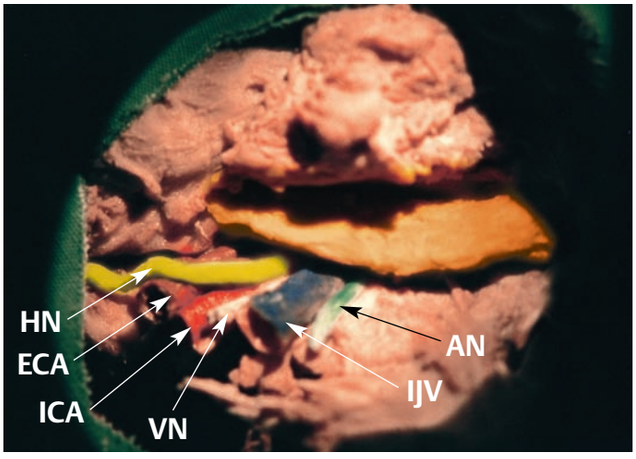
The left side of a cadaver has been dissected to present the infratemporal fossa “type A” approach comprehensively, including the neck and parotid gland areas. The important anatomical structures have been exposed and dyed for illustrative purposes. The figure shows a general view of the surgical site.

DM: Digastric muscle
EAC: External auditory canal
MT: Mastoid tip
TL: Temporal line



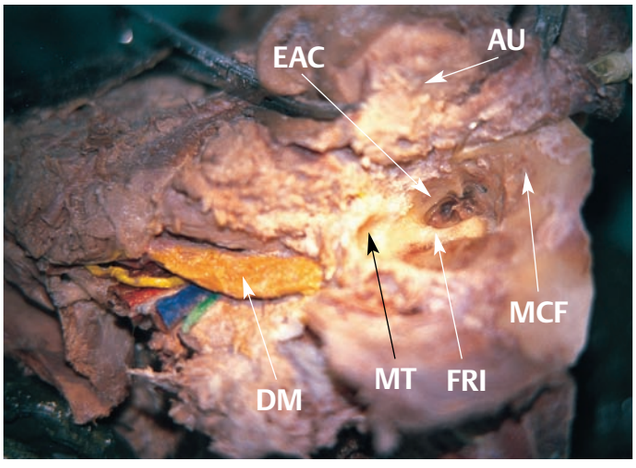
A close-up view of the surgical site in the neck region. The external and internal carotid arteries, the internal jugular vein, and the cranial nerves of the region have been exposed.

AN: Accessory nerve
ECA: External carotid artery
HN: Hypoglossal nerve
ICA: Internal carotid artery
IJV: Internal jugular vein
VN: Vagus nerve



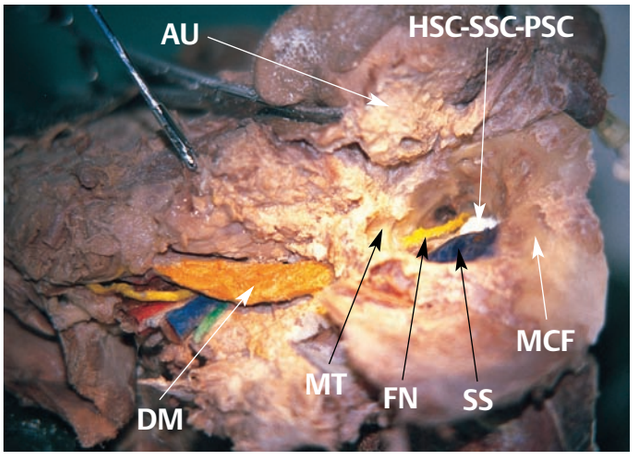
A subtotal petrosectomy has been carried out on the temporal bone. Note that the auricle has been moved anteriorly.

AU: Auricle
DM: Digastric muscle
EAC: External auditory canal
FRI: Facial ridge
MCF: Middle cranial fossa (dural plate)
MT: Mastoid tip



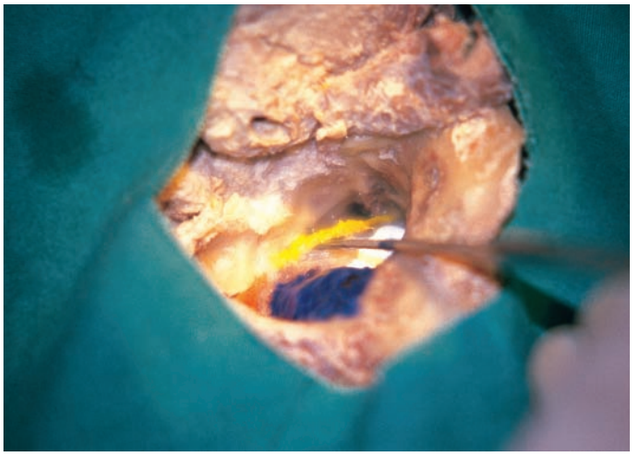
Definitions and Tips

- The infratemporal fossa “type A” approach consists of a combination of different surgical procedures:
  - exposure of the vessels and cranial nerves in the neck
  - exposure of the main branches of the facial nerve in the parotid
  - a subtotal petrosectomy
  - anterior transposition of the facial nerve
  - the procedures for pathology
  - occlusion of the eustachian tube
  - fat obliteration of the cavity
  - transposition of the temporal muscle
  - blind sac closure of the external auditory canal

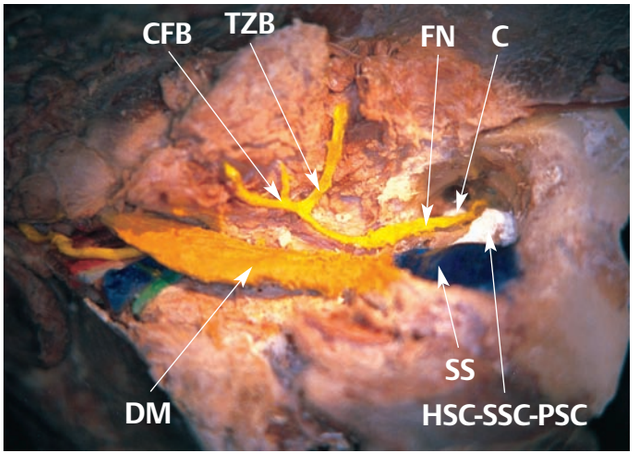


The figure shows the surgical site where the intratemporal segments of the facial nerve have been prepared for transposition.

AU: Auricle
DM: Digastric muscle
FN: Facial nerve
HSC: Horizontal semicircular canal
MCF: Middle cranial fossa (dural plate)
MT: Mastoid tip
PSC: Posterior semicircular canal
SS: Sigmoid sinus
SSC: Superior semicircular canal



The tympanic and mastoid segments of the facial nerve have been elevated from the facial canal. The close-up view displays this maneuver. The critical structures encountered at this stage are labeled in the previous figure.



The extratemporal trunk of the facial nerve has been mobilized, with its two branches, i. e., the cervicofacial and temporozygomatic branches. The figure presents a wide-angle view of the entire facial nerve, ready for transposition.

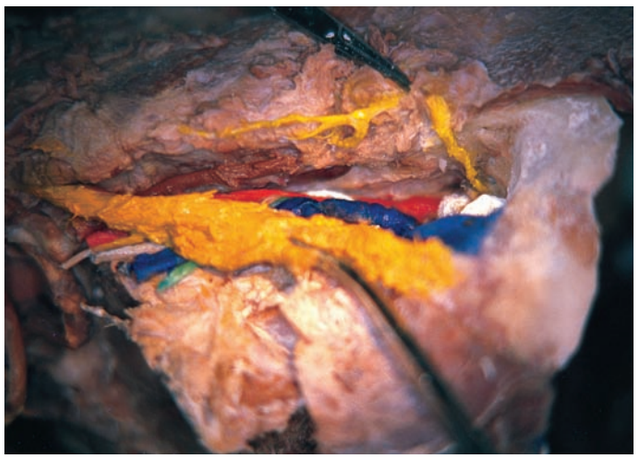
C: Cochlea
CFB: Cervicofacial branch
DM: Digastric muscle
FN: Facial nerve
HSC: Horizontal semicircular canal
PSC: Posterior semicircular canal
SS: Sigmoid sinus
SSC: Superior semicircular canal
TZB: Temporozygomatic branch

Definitions and Tips

- **Blind sac closure**: *Definition:* Permanent closure of the external auditory canal. *Tips:* It is executed with occlusion of the eustachian tube and fat obliteration of the cavity. It is the reconstruction technique of subtotal petrosectomy, infratemporal fossa “type A,” “type B,” “type C,” and transotic approaches.

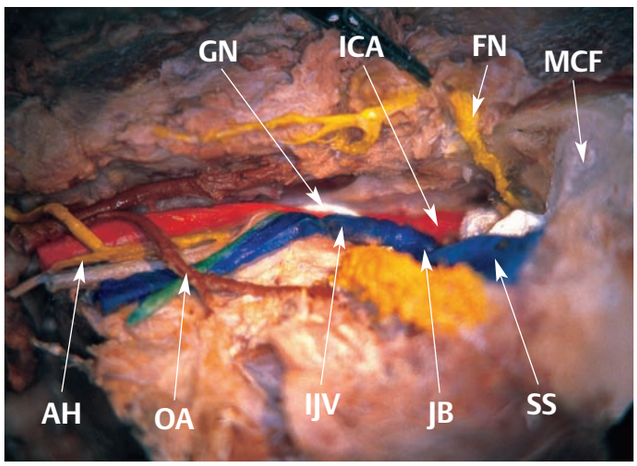
The facial nerve has been transposed anteriorly. The figure presents a wide-angle view of all three regions, i. e., the temporal bone, the neck, and the parotid gland areas, at this stage. It should be noted that the inferior wall of the tympanic bone and medial wall of the facial canal have been entirely exposed, which will allow extensive drilling of this region.

The bone medial and anterior to the facial canal has been drilled and the vital structures in this area, i. e., the internal carotid artery and the jugular bulb–internal jugular vein, are revealed. The view shows the surgical site with these exposed structures.



The digastric muscle has been cut and removed. This is the completed stage of the infratemporal fossa “type A” approach. The wide-angle view gives a comprehensive illustration of the exposed critical structures in continuity from the brainstem to the neck.

AH: Ansa hypoglossi
FN: Facial nerve
GN: Glossopharyngeal nerve
ICA: Internal carotid artery
IJV: Internal jugular vein
JB: Jugular bulb
MCF: Middle cranial fossa (dural plate)
OA: Occipital artery
SS: Sigmoid sinus



Definitions and Tips

- To avoid damaging the facial nerve after transposition, the following points must be considered:
  - The transposition should be executed at a later stage of the procedure to lower the duration of risk.
  - Maximum care should be taken to prevent the burr coming into contact with the transposed facial nerve.

24 Infratemporal Fossa “Type B” Approach

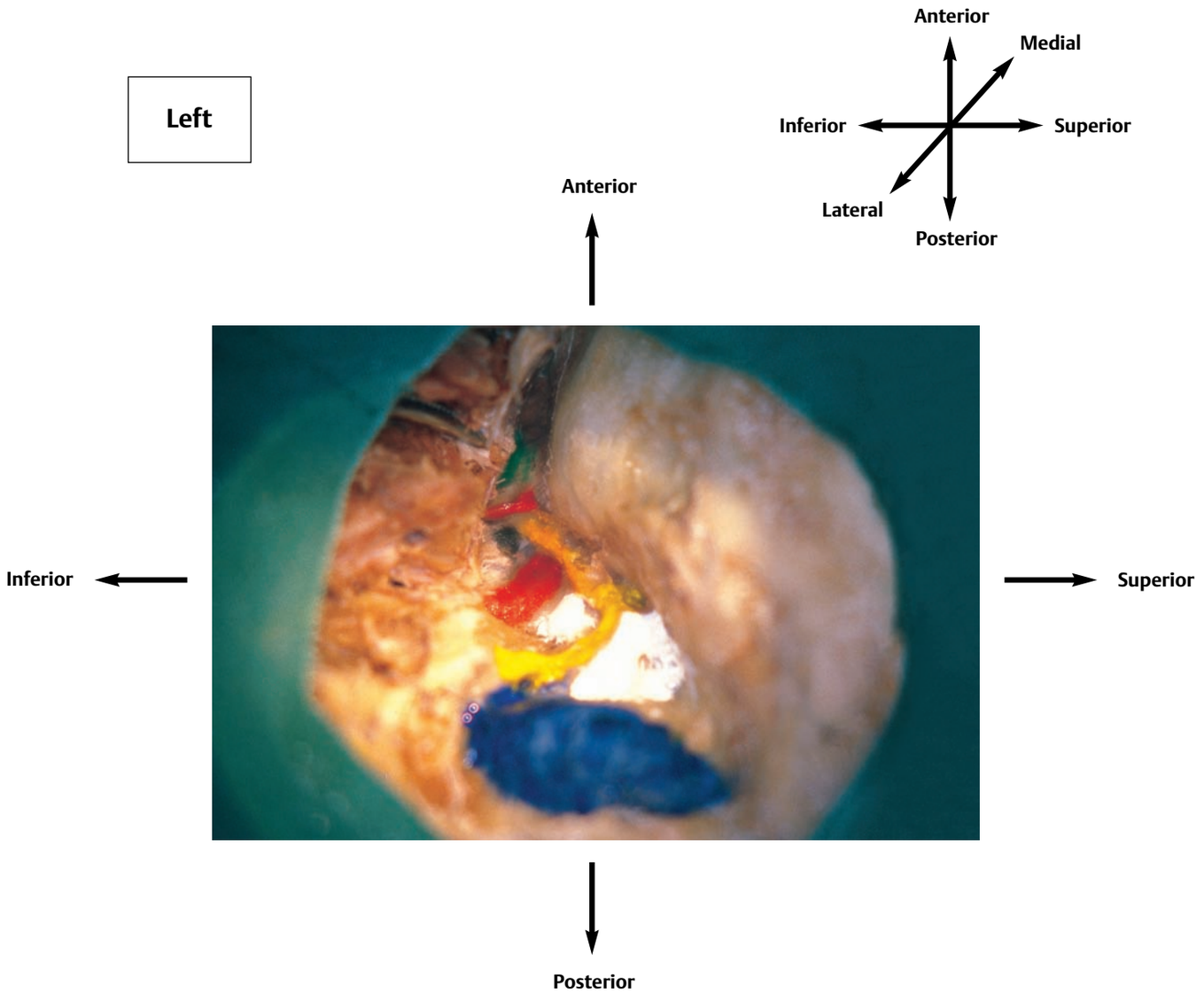
Definition

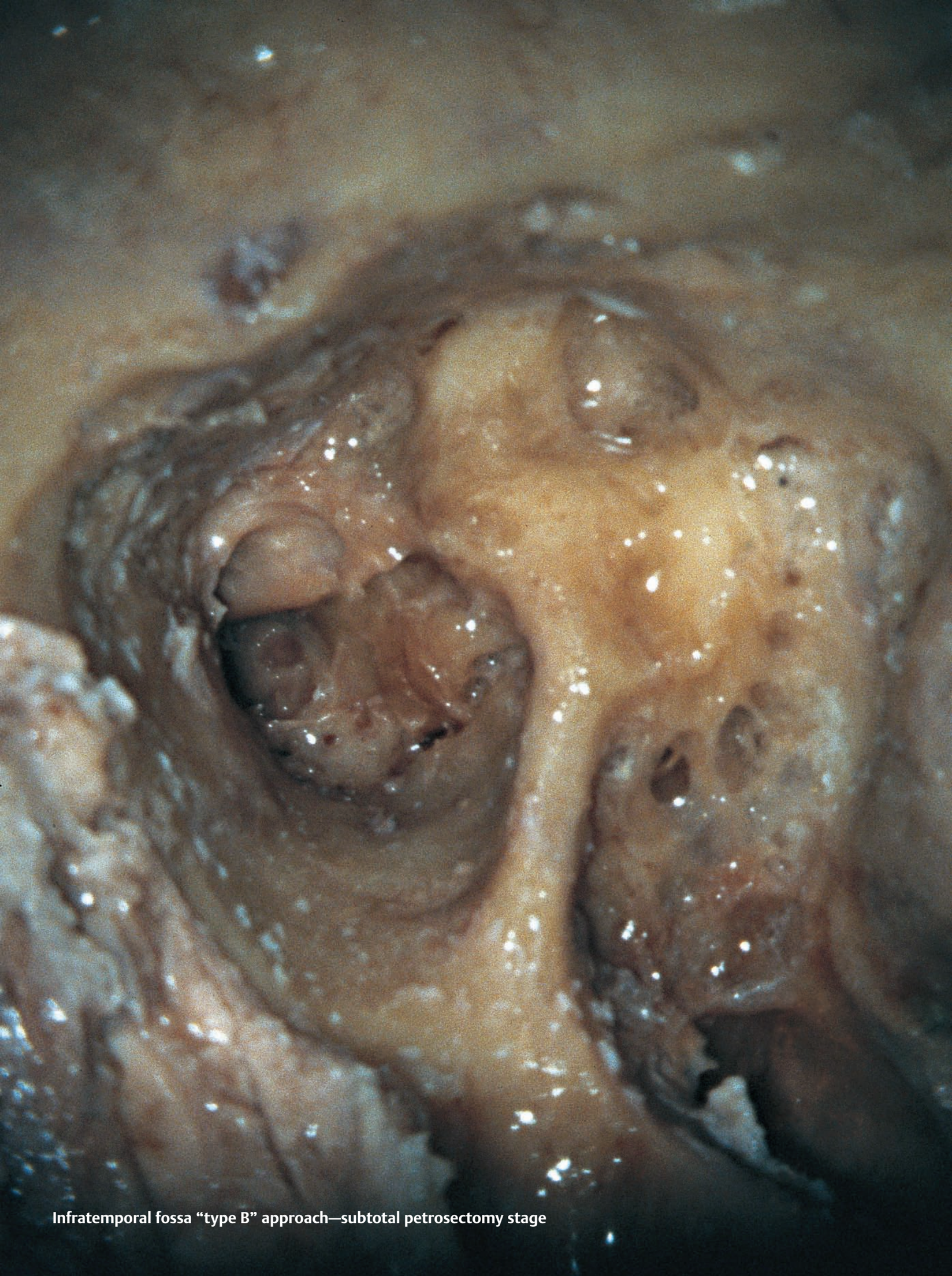
Following a subtotal petrosectomy, proceeding with drilling along the glenoid fossa and exposure of the petrous tip and clivus. At the end of this approach, abdominal fat is put into the cavity if it is not communicating with the nasopharynx, and a “blind sac” closure of the external auditory canal is carried out.

Indications

An infratemporal fossa “type B” approach is mainly carried out for pathologies on the petrous or clivus, such as epidermoid cysts or chordoma.

Anatomical Orientation

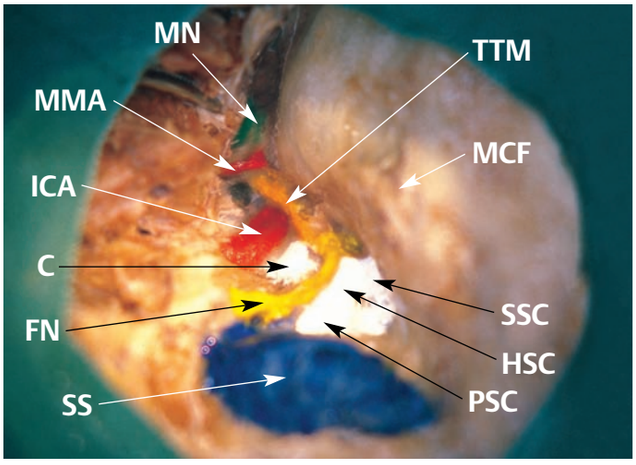




Infratemporal fossa “type B” approach—subtotal petrosectomy stage

Surgical Anatomy

The left side of a cadaver, including the base of the skull, has been dissected to present the infratemporal fossa “type B” approach comprehensively. The important anatomical structures have been exposed and dyed for illustrative purposes. The figure displays a general view of the surgical site in the completed infratemporal fossa “type B” approach.



C: Cochlea
FN: Facial nerve
HSC: Horizontal semicircular canal
ICA: Internal carotid artery
MCF: Middle cranial fossa (dural plate)
MMA: Middle meningeal artery
MN: Mandibular nerve
PSC: Posterior semicircular canal
SS: Sigmoid sinus
SSC: Superior semicircular canal
TTM: Tensor tympani muscle

Definitions and Tips

- The infratemporal fossa “type B” approach consists of a combination of different surgical procedures:
  - exposure of the extratemporal trunk and temporozygomatic branch of the facial nerve
  - reflection of the temporal muscle and zygomatic arc inferiorly
  - displacement of the mandible inferiorly
  - subtotal petrosectomy
  - procedures for pathology
  - fat obliteration of the cavity if it is not communicating with the nasopharynx
  - transposition of the temporal muscle
  - blind sac closure of the external auditory canal
- There are also alternative approaches to access the petrous tip and clivus, such as the subtemporal-preauricular infratemporal fossa approach, in which the region is exposed without a tympanomastoid procedure.

25 Infratemporal Fossa “Type C” Approach

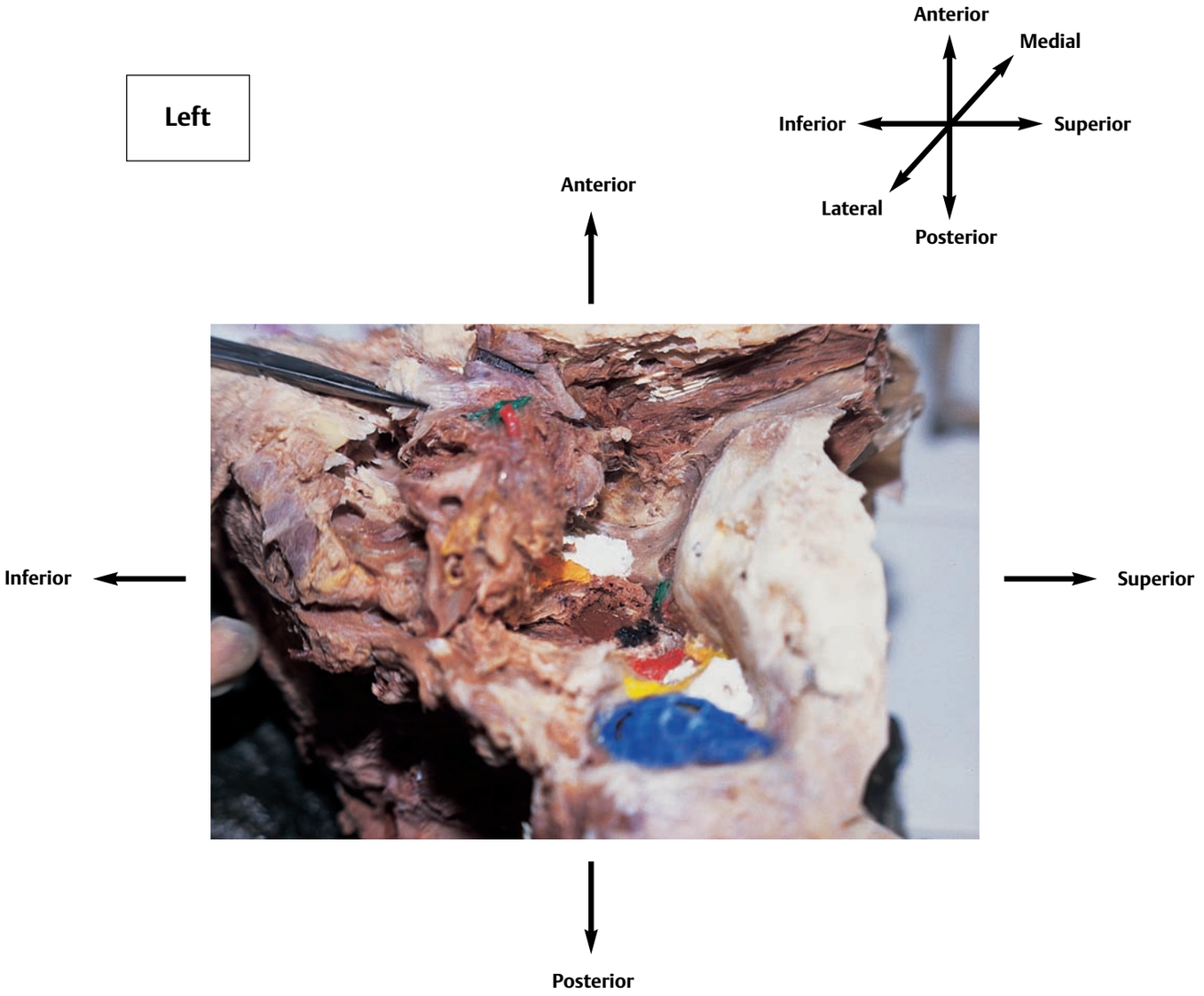
Definition

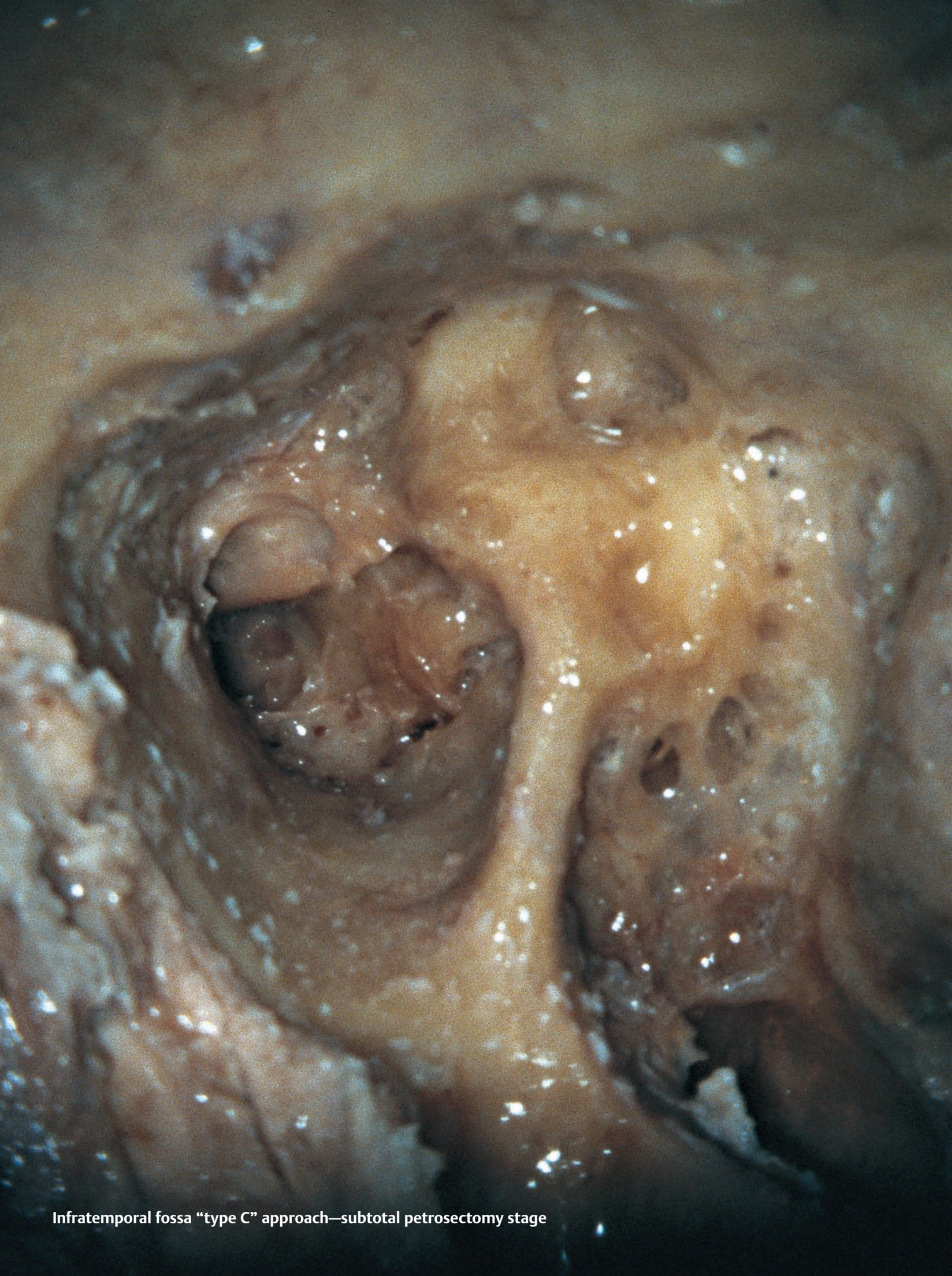
Following a subtotal petrosectomy, proceeding with drilling more anteromedially along the glenoid fossa and exposure of the pterygopalatine fossa, parasellar region, and nasopharynx. At the end of this approach, temporal muscle is transposed in the cavity rather than fat obliteration and a “blind sac” closure of the external auditory canal is carried out.

Indications

An infratemporal fossa “type C” approach is mainly carried out for pathologies on the neighboring regions surrounding the nasopharynx, such as advanced nasopharyngeal angiofibroma or radiotherapy-failed nasopharyngeal carcinoma.

Anatomical Orientation

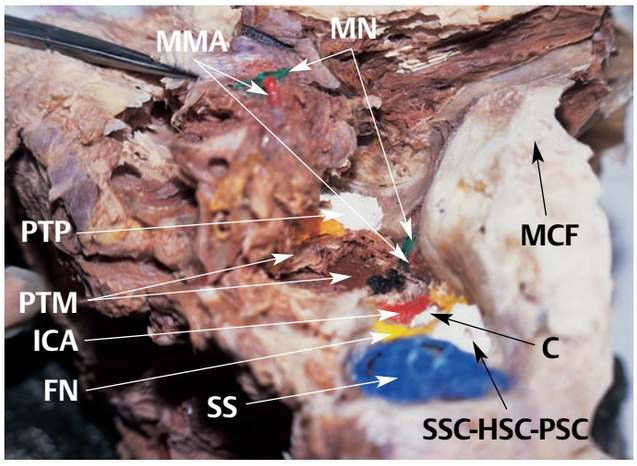




Infratemporal fossa “type C” approach—subtotal petrosectomy stage

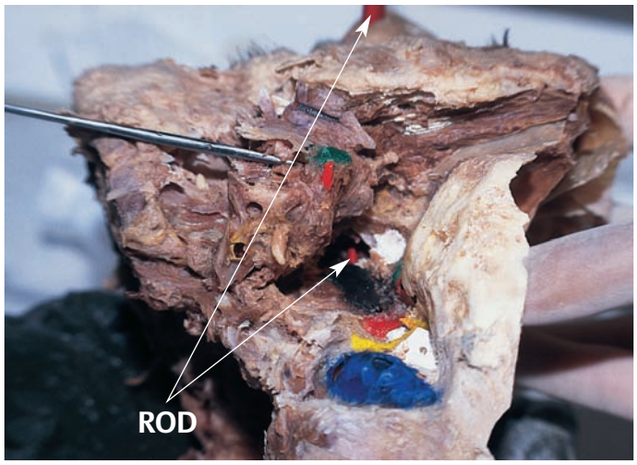
Surgical Anatomy

The left side of a cadaver, including the base of the skull, has been dissected to present the infratemporal fossa “type C” approach comprehensively. The important anatomical structures have been exposed and dyed for illustrative purposes. The figure displays a general view of the surgical site at a stage where the pterygoid processes are intact.



C: Cochlea
FN: Facial nerve
HSC: Horizontal semicircular canal
ICA: Internal carotid artery
MCF: Middle cranial fossa (dural plate)
MMA: Middle meningeal artery
MN: Mandibular nerve
PSC: Posterior semicircular canal
PTM: Pterygoid muscles
PTP: Pterygoid process
SS: Sigmoid sinus
SSC: Superior semicircular canal

The completed stage of the infratemporal fossa “type C” approach where the pterygoid processes have been removed. A red rod has been inserted through the nose into the nasopharynx for demonstration purposes. Note the tip of the rod in the exposed nasopharynx. In addition, note that in both figures, the middle meningeal artery, the mandibular nerve, and the pterygoid muscles have been divided, resulting in the proximal and distal parts of these structures being seen as two separate elements.



Definitions and Tips

- The infratemporal fossa “type C” approach consists of a combination of different surgical procedures:
  - exposure of the extratemporal trunk and temporozygomatic branch of the facial nerve
  - reflection of the temporal muscle and zygomatic arc inferiorly
  - displacement of the mandible inferiorly
  - subtotal petrosectomy
  - division of the middle meningeal artery and branches of the trigeminal nerve
  - removal of the pterygoid processes
  - procedures for pathology
  - obliteration of the cavity with temporal muscle rather than fat
  - blind sac closure of the external auditory canal
- There are also alternative approaches to access the pterygopalatine fossa and nasopharynx such as the facial translocation approach or transmandibular-transcervical approach, in which the region is exposed without a tympanomastoid procedure.

26 Radical Mastoidectomy

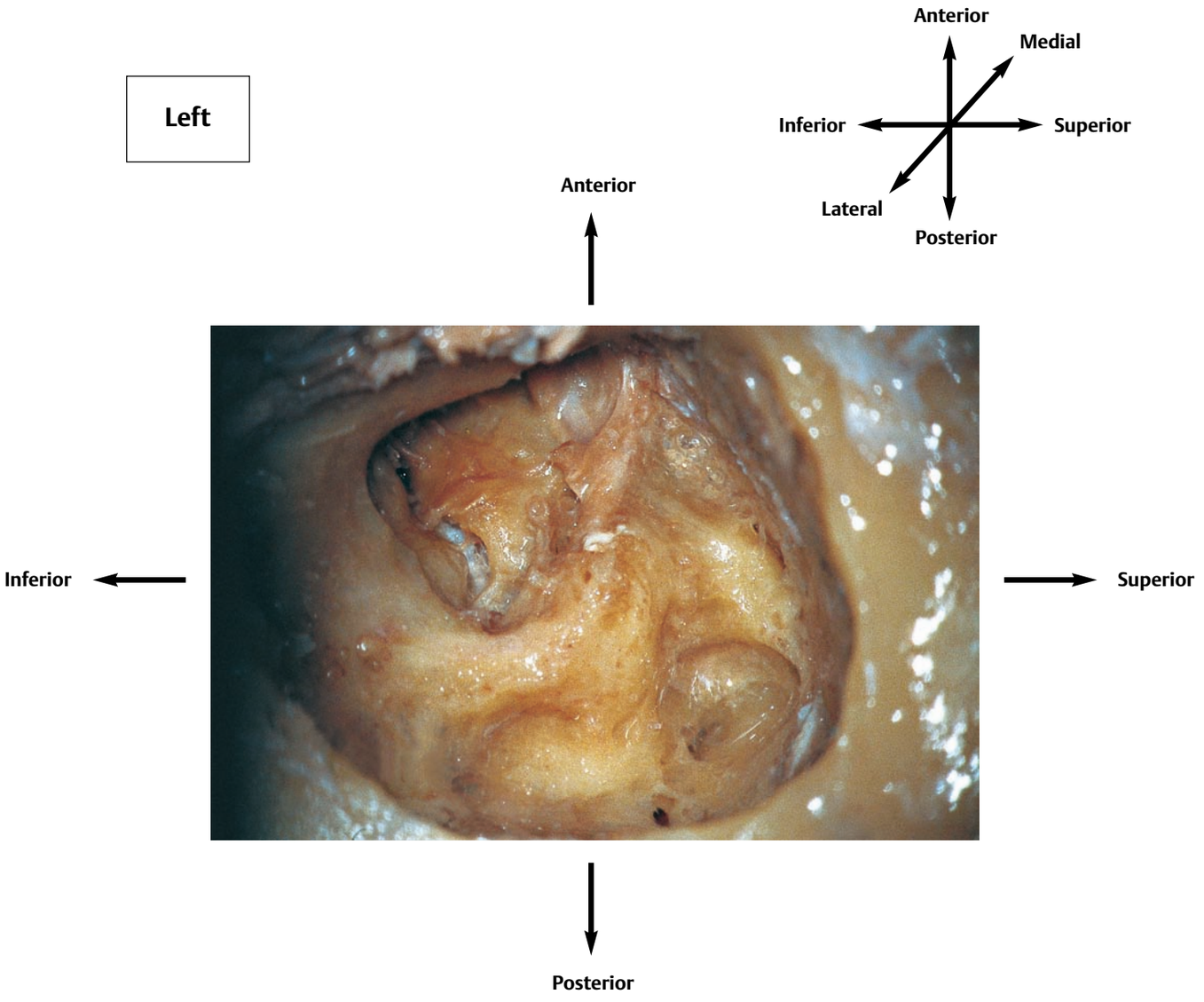
Definition

Following exenteration of the mastoid cells and removal of the posterior wall of the external auditory canal, creation of a large open tympanomastoid cavity. The malleus and incus are removed, the eustachian tube is obliterated, and a meatoplasty is carried out. In the modified radical mastoidectomy technique, the tympanic membrane and the ossicular chain are reconstructed, preserving the aeration of the tympanic cavity.

Indications

A radical mastoidectomy is mainly carried out in chronic otitis media with cholesteatoma. However, it has been replaced by modified radical mastoidectomy in present-day otology, with some exceptions.

Anatomical Orientation



Completed radical mastoidectomy

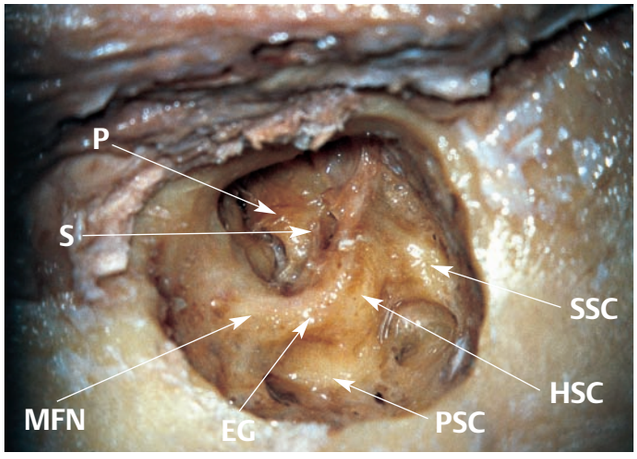
Surgical Steps

On this temporal bone, a limited radical mastoidectomy has already been accomplished. The posterior and superior walls of the external auditory canal have been removed and the mastoid cortex and cells have been extirpated. In addition, the malleus and incus have been removed. The critical structures, including subiculum and sinus tympani, encountered during this procedure are shown in the following figures.

MT: Mastoid tip
TL: Temporal line
ZR: Zygomatic root

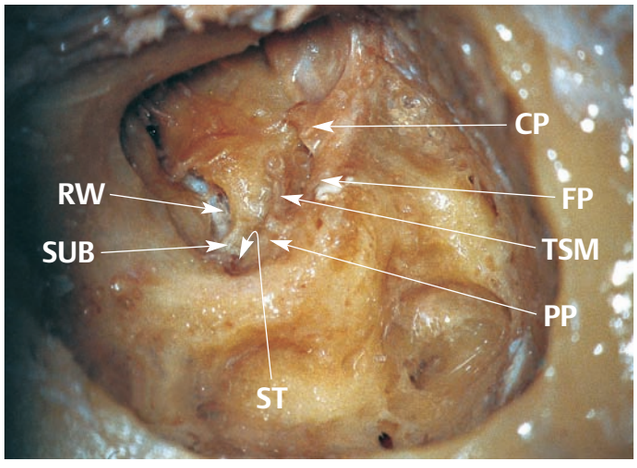
The cavity has not been enlarged extensively. Note that the bone covering the facial canal has been lowered. The hard bone of the semicircular canals can be seen in part through the surrounding cells.

EG: External genu
HSC: Horizontal semicircular canal
MFN: Mastoid facial nerve
P: Promontory
PSC: Posterior semicircular canal
S: Stapes
SSC: Superior semicircular canal



A close-up view of the surgical site showing the completed, conservative radical mastoidectomy cavity. This procedure is mainly carried out in sclerotic or contracted mastoids in which it is not always necessary to enlarge the cavity up to the surrounding structures.

CP: Cochleariform process
FP: Facial prominence
PP: Pyramidal process
ST: Sinus tympani
SUB: Subiculum
TSM: Tendon of stapedius muscle
RW: Round window



Definitions and Tips

- **Modified radical mastoidectomy**: *Definition:* Canal wall down tympanomastoidectomy with reconstruction of the tympanic membrane and ossicular chain, preserving the aeration of the tympanic cavity. *Tips:* This technique is the contemporary modification of classical radical mastoidectomy. It includes all the steps of the basic technique, except for the procedures on the middle ear.
- **Bondy technique**: *Definition:* Canal wall down tympanomastoidectomy with preservation of the tympanic membrane and ossicular chain. *Tips:* This procedure includes all the steps of classical radical mastoidectomy, except for the procedures on the middle ear. In the original Bondy technique, the rest of the tympanic membrane and ossicular chain are preserved and left as they are, and not reconstructed.

27 Extended Radical Mastoidectomy

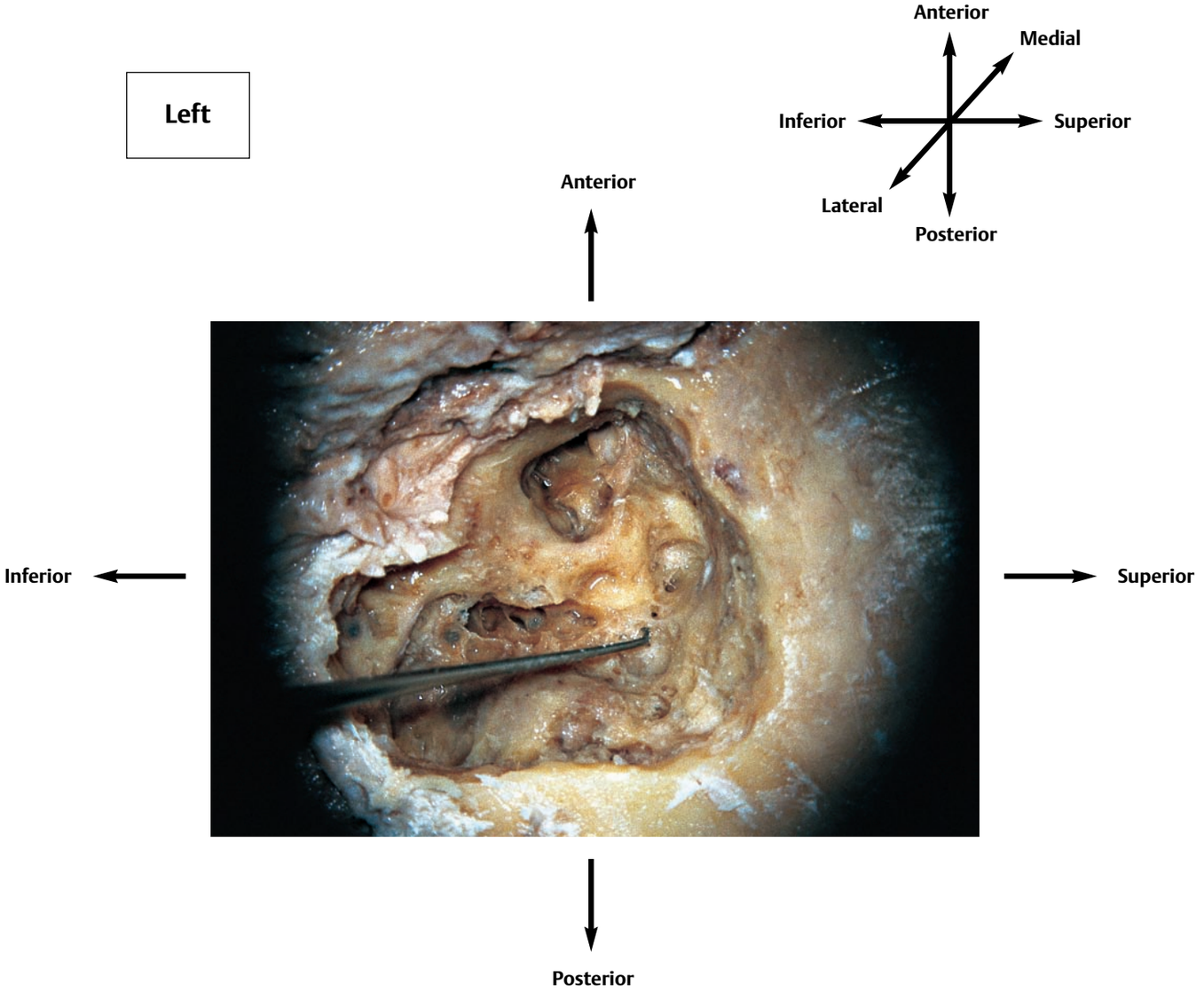
Definition

Enlargement of the radical mastoidectomy with complete skeletonization of all of the neighboring structures and the semicircular canals. There is no specific classification for this procedure in surgical literature. It could be called the extended radical mastoidectomy. It is performed in the classical manner or as a modified form, with reconstruction of the tympanic membrane and the ossicular chain and preservation of the aeration of the tympanic cavity.

Indications

It is mainly carried out in chronic otitis media with cholesteatoma. It is also an intermediate stage in neurotologic procedures such as subtotal petrosectomy, infratemporal fossa "types A, B, and C" approaches or the transotic approach.

Anatomical Orientation

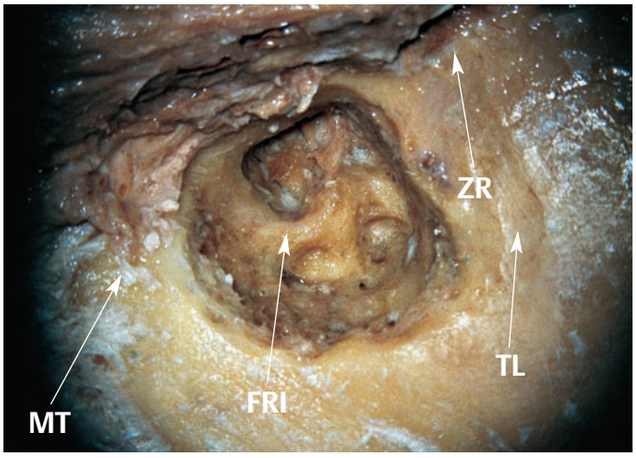


Extended radical mastoidectomy—an intermediate stage

Surgical Steps

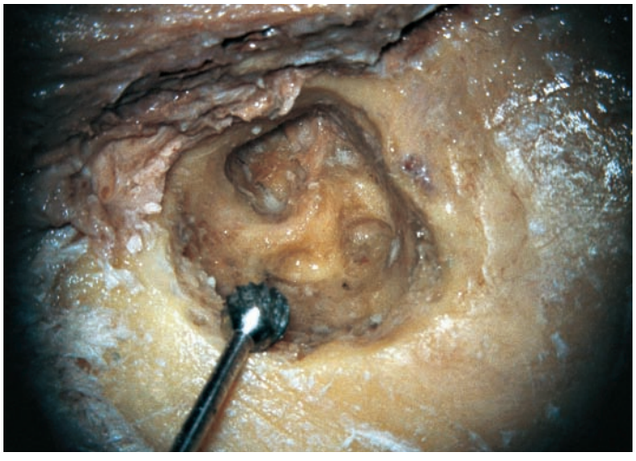
The procedure will be carried out on the temporal bone in which a limited radical mastoidectomy has already been performed. The critical structures are indicated in the figure.

FRI: Facial ridge
MT: Mastoid tip
TL: Temporal line
ZR: Zygomatic root



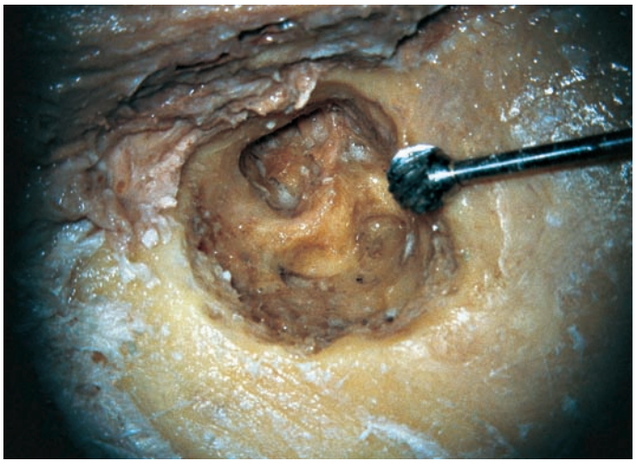
In the first stage, using a large cutting burr, the cortical bone is drilled and the cavity is enlarged posteriorly toward the sigmoid sinus, and inferiorly toward the mastoid tip. Posteriorly, the drilling direction is from superior to inferior, parallel to the removed posterior wall of the external auditory canal; it is, at the same time, parallel to the sigmoid sinus.

II: 7 mm cutting burr
MIL: Sigmoid sinus dural plate



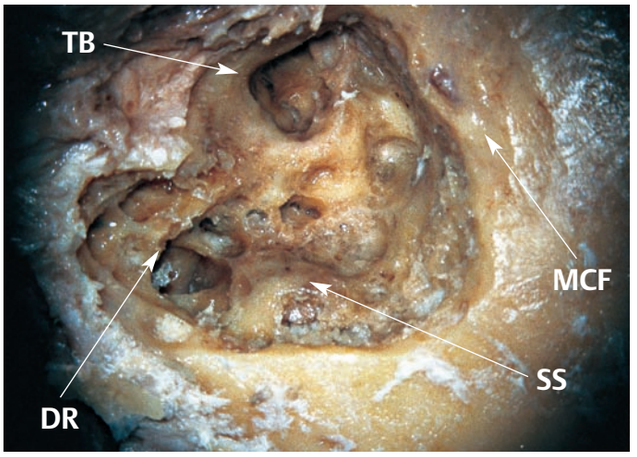
Using the same large cutting burr, the temporal line area is drilled in an antero-posterior direction, thus enlarging the cavity toward the dural plate of the middle cranial fossa. During this extensive drilling process, copious irrigation is necessary to prevent overheating of the burr.

II: 7 mm cutting burr
MIL: Middle cranial fossa dural plate



Definitions and Tips

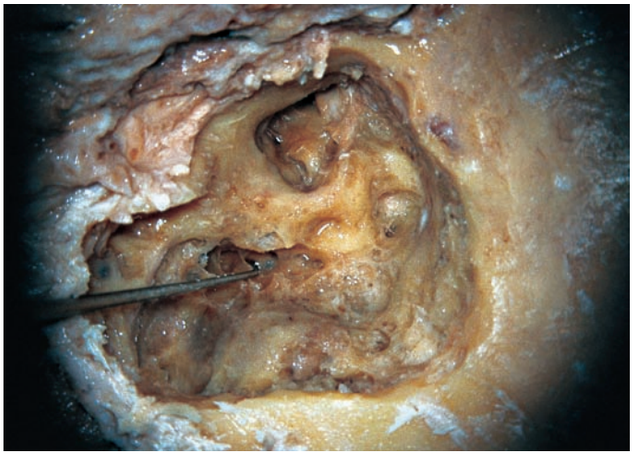
- **Facial ridge:** *Definition:* The bony ridge covering the mastoid segment of the facial nerve. *Tips:* Anatomically, there is no such natural structure, rather it is created during drilling in a mastoidectomy by leaving a little of the bone close to the mastoid segment of the facial nerve.
- In a radical mastoidectomy, as with a cortical mastoidectomy, the sequence of bone removal and exposure of the anatomical structures may be changed. It is possible first to find the antrum, and then to drill from the center to the periphery. However, the identification of the vital structures, i. e., the dura of the middle cranial fossa, the sigmoid sinus, and the digastric ridge, through the technique of skeletonization, and then drilling from the periphery to the center, is faster and safer.



The cavity has been enlarged extensively, with exposure of the dural plate of the middle cranial fossa superiorly, the dural plate of the sigmoid sinus posteriorly, and the digastric ridge inferiorly. Care has been taken not to break through the thinned bone, into the middle or posterior cranial fossa.

DR: Digastric ridge
MCF: Middle cranial fossa (dural plate)
TB: Tympanic bone
SS: Sigmoid sinus (dural plate)

The next stage is skeletonization of the semicircular canals. The presigmoid, retrofacial, retrolabyrinthine, and interlabyrinthine cells are removed carefully using different sized cutting and diamond burrs. The microsurgical instrument in the figure is pointing to the sigmoid sinus.



Another view of the cavity. The microsurgical instrument is pointing to the remaining retrofacial cells. While removing these cells, the direction of drilling should be parallel to the expected position of the facial nerve, i. e., supero-inferior. Note also that the mastoid tip cells have been exenterated and the tip has been delineated.

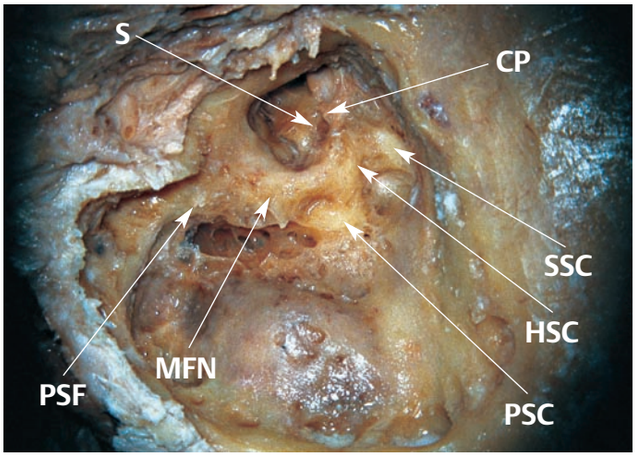
Definitions and Tips

- **Exteriorization (saucerization)**: *Definition:* Removal of the sharp edges of bone, resulting in a saucerized cavity. *Tips:* This is a technique which enables self-cleaning of cavities due to the wide opening toward the exterior. In addition, with regard to the main mastoid cavity, it allows the soft tissues to fall into the cavity, resulting in a reduction of the cavity size.
- In canal wall down procedures, the creation of large cavities might cause problems by leading to retention of debris. The transposed canal wall tympanomastoidectomy described by the author prevents problems related to the size of the cavity by affording a small anterior tympanomastoidectomy cavity, twice the size of a normal external auditory canal. See page 183.

The same surgical view. This time, the surgical instrument is pointing to the last remaining retrolabyrinthine cells. While operating around the semicircular canals, the drilling should be directed along the expected position of each structure to safely preserve them.

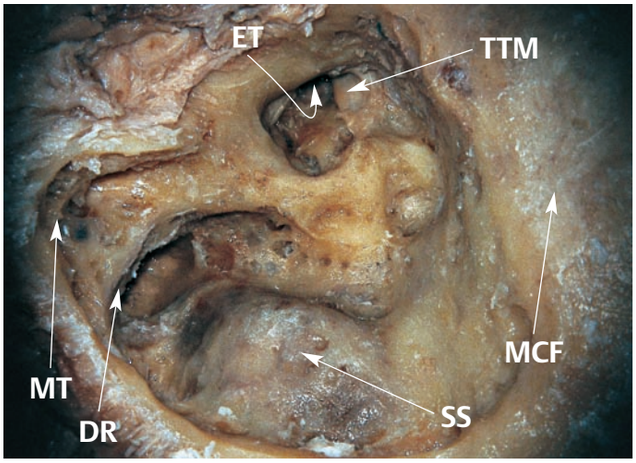
The view of the surgical site at this stage of the procedure, with the critical structures indicated. The neighboring structures have been delineated circumferentially and the mastoid segment of the facial nerve and the semicircular canals have been skeletonized.

CP: Cochleariform process
HSC: Horizontal semicircular canal
MFN: Mastoid facial nerve
PSC: Posterior semicircular canal
PSF: Periosteum of stylomastoid foramen
S: Stapes
SSC: Superior semicircular canal



The surgical site following the completed procedure. The last remaining retrofacial and retrolabyrinthine cells have been removed and the compact bone of the facial canal and semicircular canals has been completely exposed. Note the digastric ridge, the periosteum of the stylomastoid foramen, and the facial canal running in continuity.

DR: Digastric ridge
ET: Eustachian tube
MCF: Middle cranial fossa (dural plate)
MT: Mastoid tip
SS: Sigmoid sinus (dural plate)
TTM: Tensor tympani muscle

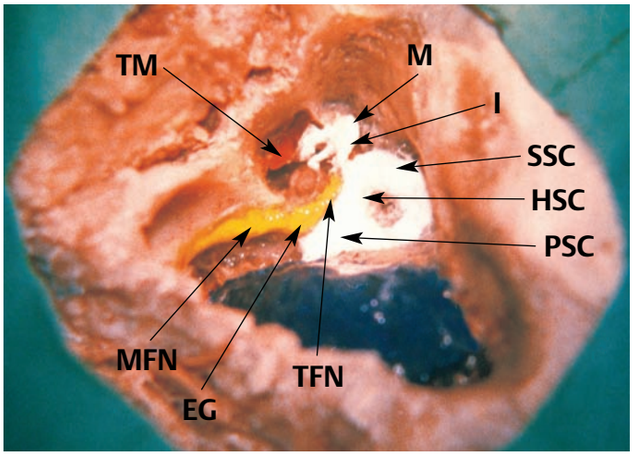


Definitions and Tips

- **Exenteration:** *Definition:* Removal of bone, especially the bony cells, to eradicate the pathologic tissues or to gain sufficient exposure of the surgical site. *Tips:* This is one of the main techniques in temporal bone surgery. Insufficient exenteration results in incomplete removal of the pathologic tissues or inadequate surgical exposure.
- Reasons for failure following a radical or modified radical mastoidectomy are:
  - insufficient exenteration
  - insufficient exteriorization
  - insufficient lowering of the facial ridge
  - insufficient meatoplasty
  - insufficient obliteration, if it is a large cavity

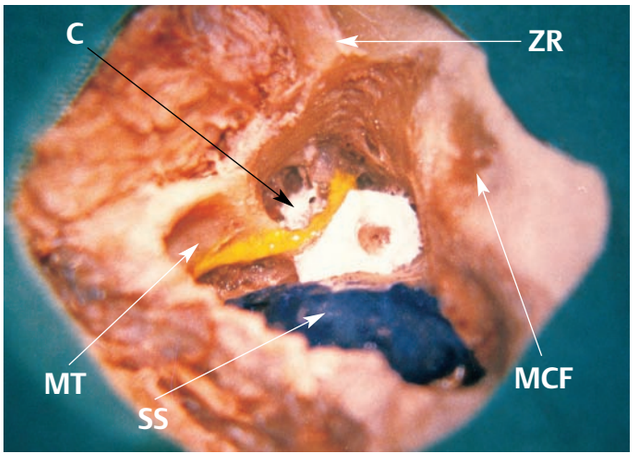
  In other words, a small, smooth, well exteriorized cavity should be created to prevent the failure of a radical or modified radical mastoidectomy.

Surgical Anatomy



A dissected temporal bone in a cadaver. A modified radical mastoidectomy has been carried out, and the important anatomical structures have been exposed and dyed for illustrative purposes.

EG: External genu
HSC: Horizontal semicircular canal
I: Incus
M: Malleus
MFN: Mastoid facial nerve
PSC: Posterior semicircular canal
SSC: Superior semicircular canal
TFN: Tympanic facial nerve
TM: Tympanic membrane



On the same cadaveric temporal bone, following the removal of the tympanic membrane and malleus and incus, an extended radical mastoidectomy has been carried out. The neighboring skeletonized structures are indicated in the figure.

C: Cochlea
MCF: Middle cranial fossa (dural plate)
MT: Mastoid tip
SS: Sigmoid sinus
ZR: Zygomatic root

Definitions and Tips

- In sclerotic, i. e., acellular, or contracted mastoids, i. e., with inferiorly located middle cranial fossa dura and anteriorly located sigmoid sinus, a conservative radical mastoidectomy may be the procedure of choice.
  In a well-pneumatized mastoid, an intact canal wall or an extended modified radical mastoidectomy with obliteration or canal wall reconstruction may be the procedure of choice.
- **Mastoid emissary vein:** *Definition:* The vein that appears through the bone 3–4 cm posteriorly to the spine of Henle on the mastoid cortex. *Tips:* The mastoid emissary vein extends from the sigmoid sinus and passes through the mastoid foramen to drain into the posterior auricular or occipital veins. It is used as a surface landmark for topographic orientation and for locating the sigmoid sinus.

28 Subtotal Petrosectomy

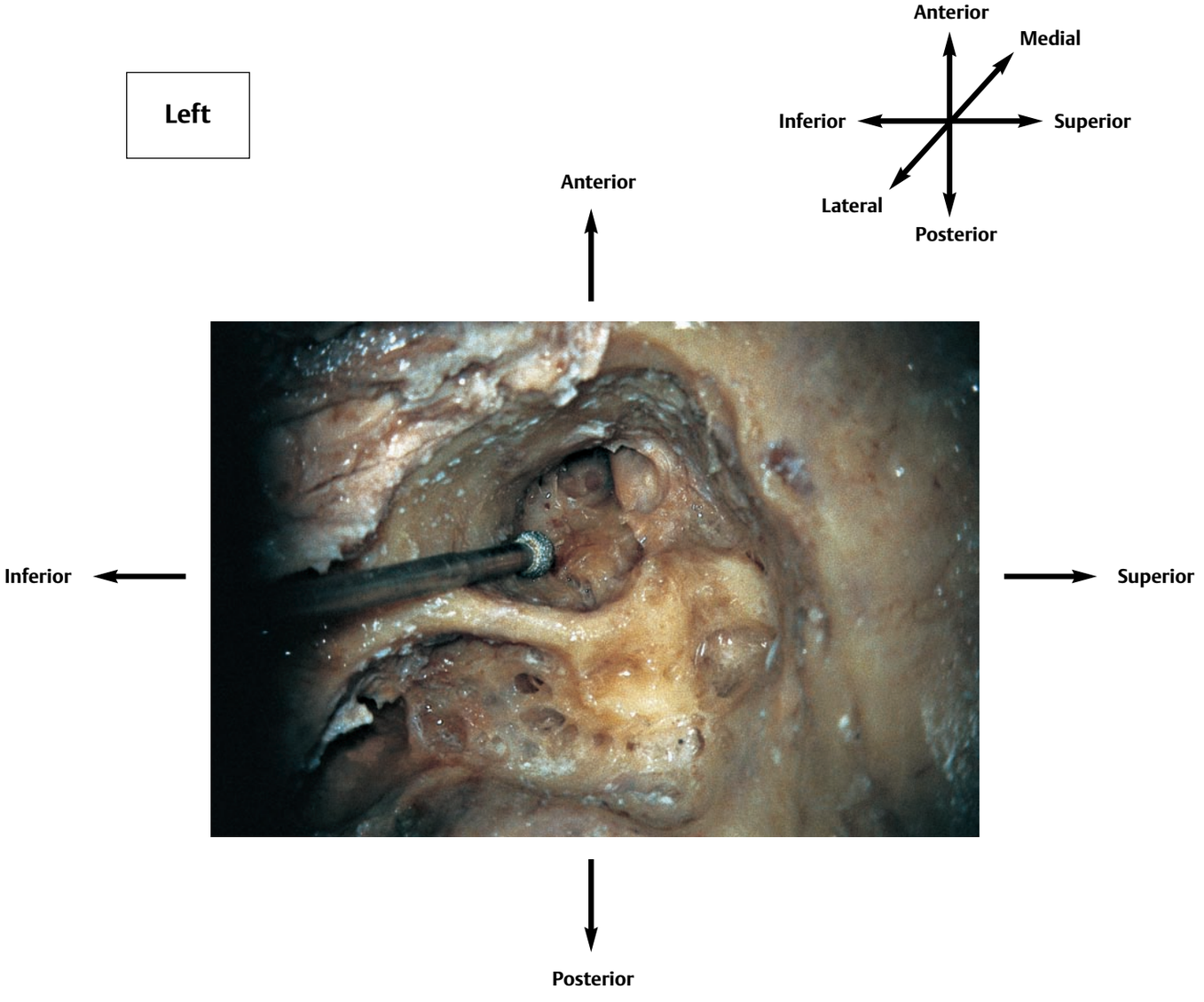
Definition

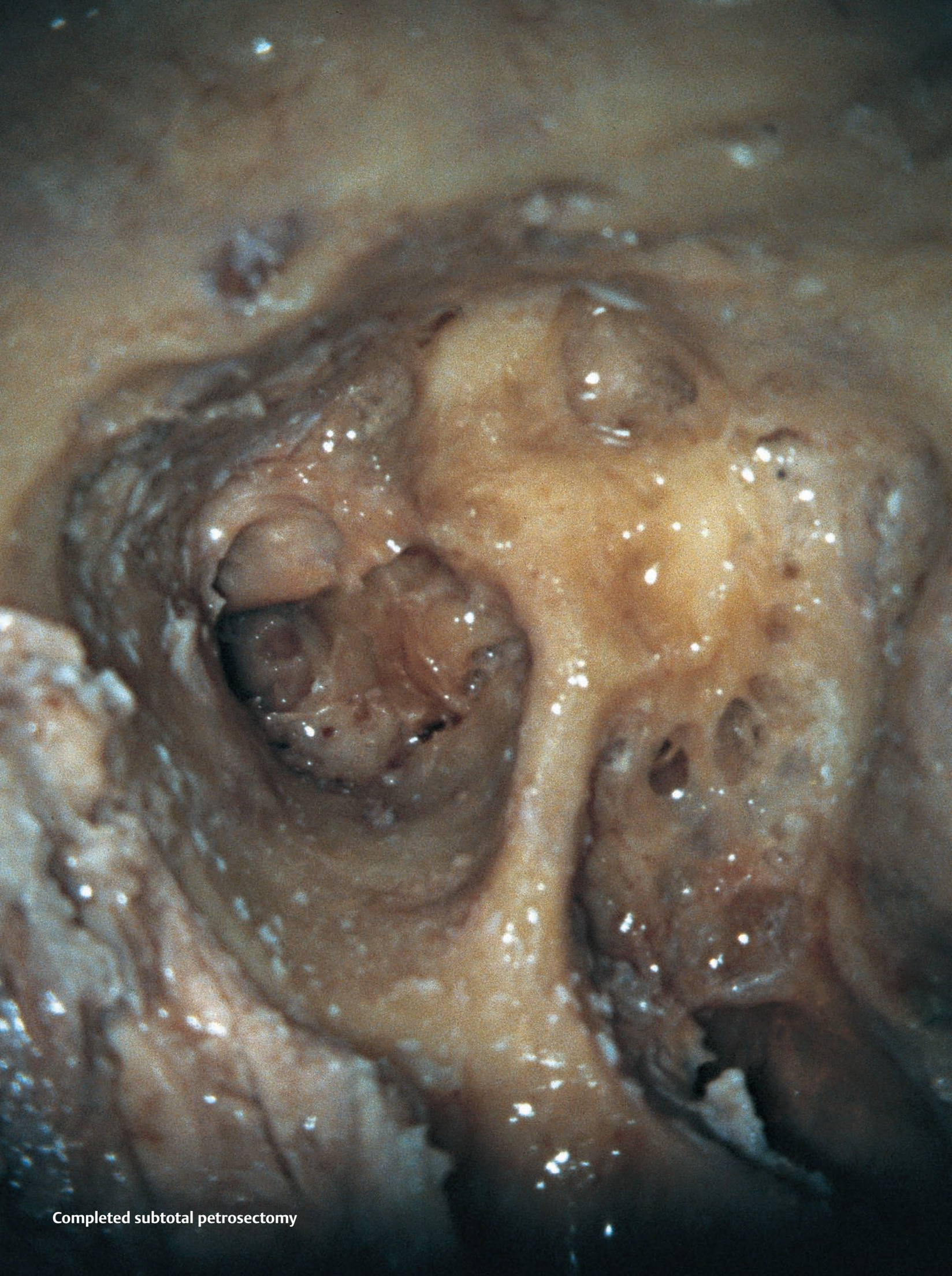
Following an extended radical mastoidectomy, exenteration of the inferior wall of the tympanic bone and the hypotympanic cells. Generally, at the end of this approach, abdominal fat is put into the cavity and a “blind sac” closure of the external auditory canal is carried out; however, it is also possible to leave the cavity open by performing a large meatoplasty.

Indications

It is mainly performed in cases of extensive cholesteatoma, such as petrous cholesteatoma and in cases with posttraumatic or postoperative cerebrospinal fluid leakage. The other indication is cochlear implantation or active middle ear device implantation where an open cavity procedure has previously been carried out. It is also an intermediate stage in neurotologic procedures such as infratemporal fossa “types A, B, or C” approaches or the transotic approach.

Anatomical Orientation





Completed subtotal petrosectomy

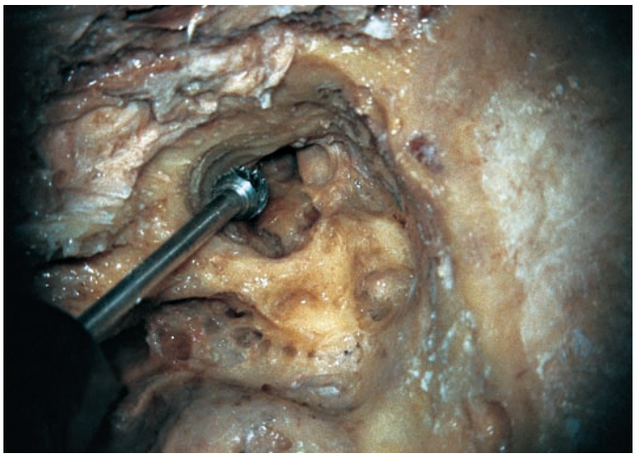
Surgical Steps

Dissection continues on the same bone on which an extended radical mastoidectomy has already been carried out. Superiorly the dural plate of the middle cranial fossa, posteriorly the dural plate of the sigmoid sinus, and inferiorly the digastric ridge have been exposed. The solid bone of the facial canal and of the three semicircular canals has also been revealed.

DR: Digastric ridge
MCF: Middle cranial fossa (dural plate)
SS: Sigmoid sinus (dural plate)
TB: Tympanic bone

The subsequent stages are specific to the subtotal petrosectomy procedure. Using a medium-sized cutting burr, the anterior and inferior walls of the tympanic bone, indicated in the previous illustration, are drilled. The burr should be revolving away from the facial nerve.

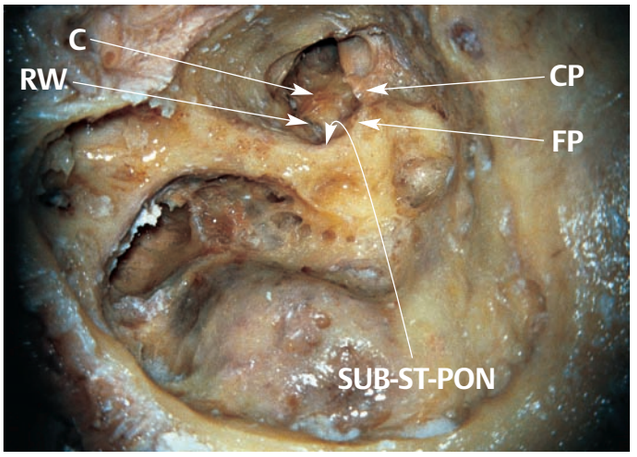
II: 3–4 mm cutting and diamond burrs
MIL: Mastoid facial nerve



The tympanic bone has been drilled; the inferior wall lowered and the anterior wall thinned. Care should be taken not to enter the temporomandibular joint during this stage. A white discoloration on the temporal bone and a bluish-pink discoloration in the operation indicates the temporomandibular joint.

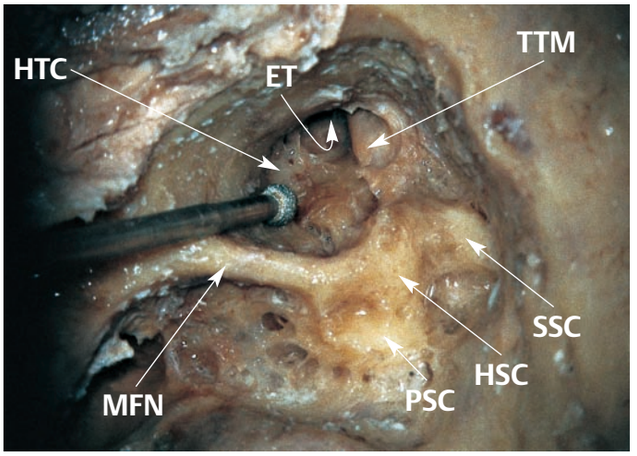
Definitions and Tips

- The structures located on the posteromedial wall of the tympanic cavity, superior to inferior, are as follows:
  - inferior edge of the horizontal semicircular canal
  - facial prominence and facial recess
  - oval window and pyramidal process
  - ponticulus
  - sinus tympani
  - subiculum
  - round window niche
  - posterior hypotympanic cells



A wide-angle view of the surgical site at this stage. The anatomical structures encountered at the anterior part of the cavity are shown in the figure.

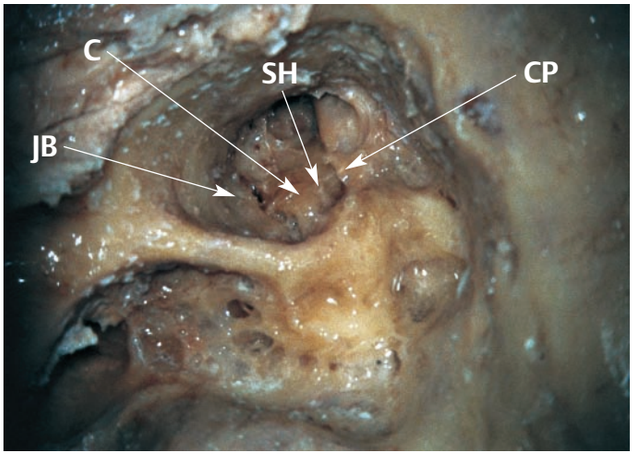
C: Cochlea
CP: Cochleariform process
FP: Facial prominence
PON: Ponticulus
RW: Round window
ST: Sinus tympani
SUB: Subiculum



The next stage is exenteration of the hypotympanic cells, using a small diamond burr. In this way, the inferior part of the cochlea is skeletonized, similar to the drilling method used for the semicircular canals.

II: 1–2 mm diamond burr
MIL: Cochlea

ET: Eustachian tube
HSC: Horizontal semicircular canal
HTC: Hypotympanic cells
MFN: Mastoid facial nerve
PSC: Posterior semicircular canal
SSC: Superior semicircular canal
TTM: Tensor tympani muscle



Following this, more bone is drilled inferiorly while looking for the reflection of the jugular bulb. The figure displays the situation in which all of the hypotympanic cells have been exenterated and only a thin plate of bone remains over the jugular bulb. The anatomical structures encountered at this stage are indicated in this and the previous figure.

C: Cochlea
CP: Cochleariform process
JB: Jugular bulb (plate)
SH: Stapes head

Definitions and Tips

- **Sinus tympani (infrapyramidal recess)**: *Definition:* The anatomical cavity beginning between the ponticulus and subiculum, and continuing posteriorly, inferior to the facial nerve and pyramidal process. *Tips:* The sinus tympani, which may vary in size, is a recess of the tympanic cavity posteriorly, and is one of the areas where a cholesteatoma may be concealed.
- The beginning of the facial recess is superior to the pyramidal process and it extends lateroinferiorly; because of this, it is also called the suprapyramidal recess. The beginning of the sinus tympani is inferior to the pyramidal process and it extends posteromedially; because of this, it is also called the infrapyramidal recess.

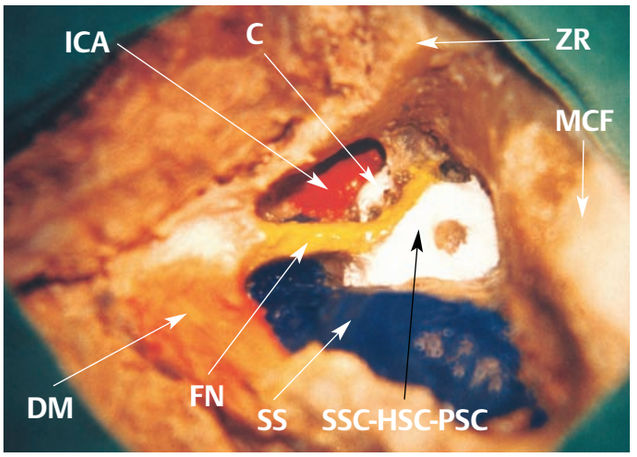
The subtotal petrosectomy approach has been completed. Note the skeletonized structures surrounding the cavity, the lowered inferior wall of tympanic bone, the skeletonized facial canal as well as the entire skeletonized labyrinth, i. e., the semicircular canals and the cochlea.

DR: Digastric ridge
MCF: Middle cranial fossa (dural plate)
SS: Sigmoid sinus (dural plate)
TMP: Temporomandibular joint periosteum (plate)

Definitions and Tips

- **Ponticulus (ponticulus promontorii)**: *Definition:* The small bony spine extending from the promontory to the pyramidal process, posteroinferior to the oval window, parallel to the stapedial tendon. *Tips:* Ponticulus is an important reference point in cholesteatoma surgery. The sinus tympani is located inferior to this spine.
- **Subiculum (subiculum promontorii)**: *Definition:* The small bony spine extending from the promontory posteriorly, posterosuperior to the round window. *Tips:* The subiculum is an important reference point in cholesteatoma surgery. The sinus tympani is located superior to this spine.

Surgical Anatomy



A dissected temporal bone in a cadaver. A subtotal petrosectomy has been carried out and the important anatomical structures have been exposed and dyed for illustrative purposes.

C: Cochlea
DM: Digastric muscle
FN: Facial nerve
HSC: Horizontal semicircular canal
ICA: Internal carotid artery
MCF: Middle cranial fossa (dural plate)
PSC: Posterior semicircular canal
SS: Sigmoid sinus
SSC: Superior semicircular canal
ZR: Zygomatic root

Definitions and Tips

- The comprehensive exenteration during a subtotal petrosectomy means skeletonization of the middle cranial fossa dura, sigmoid sinus, digastric ridge, jugular bulb, internal carotid artery, facial nerve, and labyrinth.
- In a subtotal petrosectomy, only some petrosal cells are left intact, the removal of which is not possible without carrying out a labyrinthectomy.
- In all the classical lateral approaches, such as the subtotal petrosectomy, the angle between the tympanic and labyrinthine segments of the facial nerve seems to be 15–20° from the surgeon's view.

29 Transotic Approach

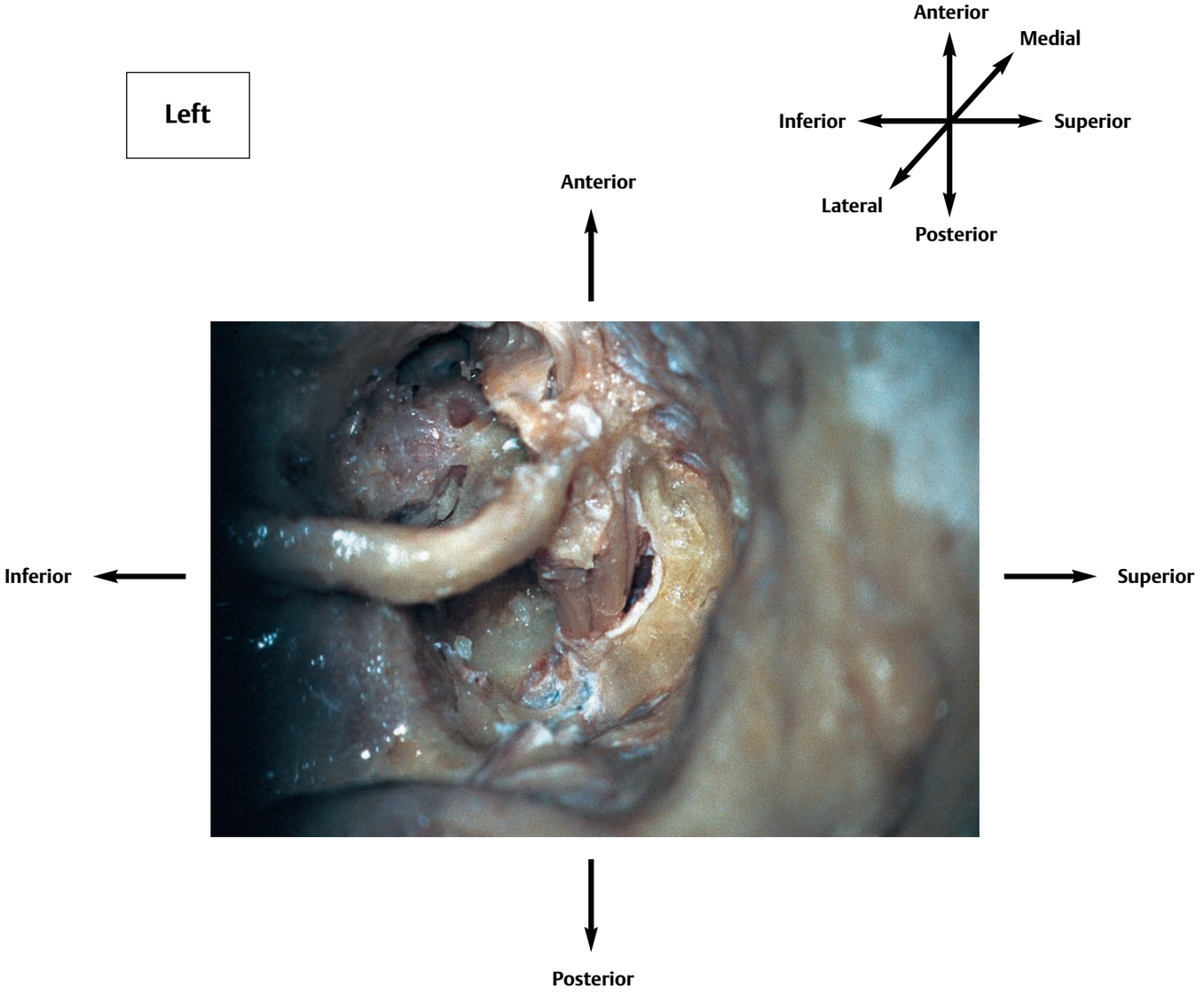
Definition

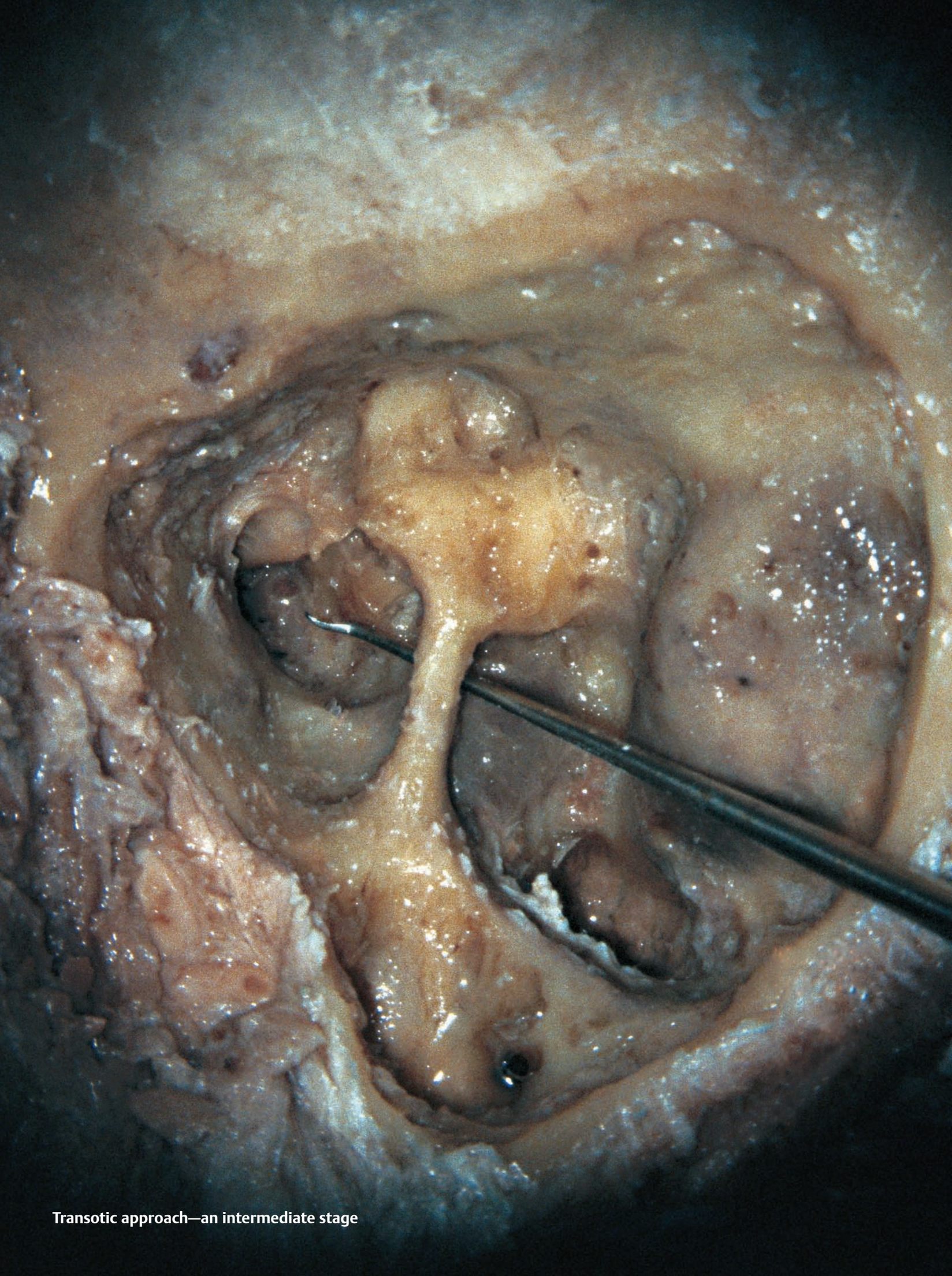
Following a subtotal petrosectomy, extirpation of the entire labyrinth, including the cochlea, leaving the tympanic and mastoid segments of the facial nerve covered with a thin shell of bone as a bridge in the cavity. This allows extensive exposure of the internal auditory canal, and the cerebellopontine angle through the posterior cranial fossa. At the end of this approach, abdominal fat is put into the cavity and a "blind sac" closure of the external auditory canal is carried out.

Indications

The main indication of this technique is in acoustic neuroma surgery where the hearing is not of concern. However, it may also be carried out for different neurotologic procedures.

Anatomical Orientation



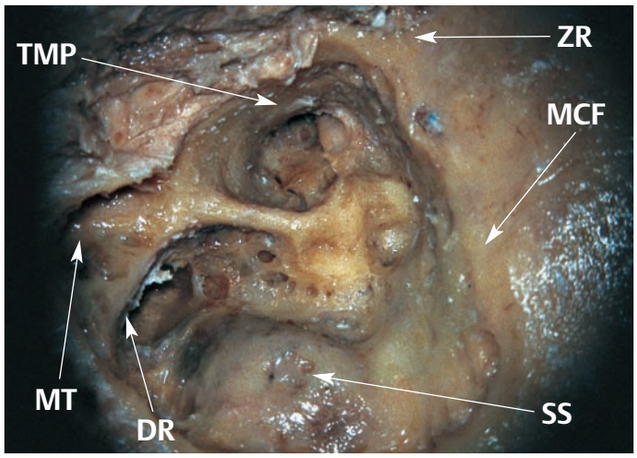


Transotic approach—an intermediate stage

Surgical Steps

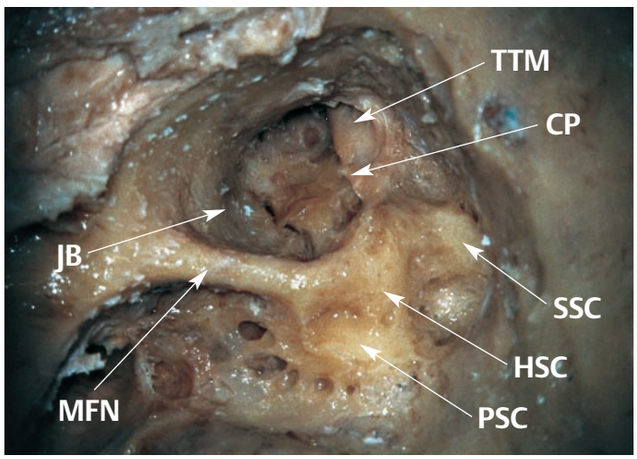
The procedure will be performed on the temporal bone where a subtotal petrosectomy has already been carried out. Superiorly the middle cranial fossa dural plate; posteriorly the sigmoid sinus dural plate; inferiorly the digastic ridge and mastoid tip, have all been exposed. Anteriorly, the reflection of the temporomandibular joint can be observed.

DR: Digastric ridge
MCF: Middle cranial fossa (dural plate)
MT: Mastoid tip
SS: Sigmoid sinus (dural plate)
TMP: Temporomandibular joint periosteum (plate)
ZR: Zygomatic root



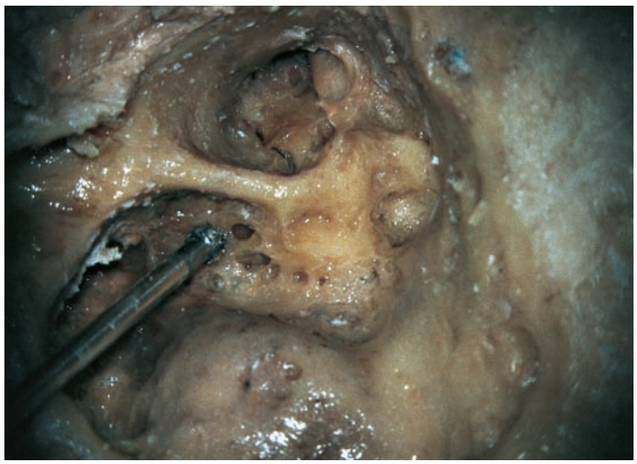
Additionally, the inferior wall of the tympanic bone has been extensively drilled where only a thin bone covering the jugular bulb remained. In the center of the cavity, the solid bone of the facial canal and of the labyrinth is observed. The forthcoming stages are specific to the transotic approach.

CP: Cochleariform process
HSC: Horizontal semicircular canal
JB: Jugular bulb (plate)
MFN: Mastoid facial nerve
PSC: Posterior semicircular canal
SSC: Superior semicircular canal
TTM: Tensor tympani muscle



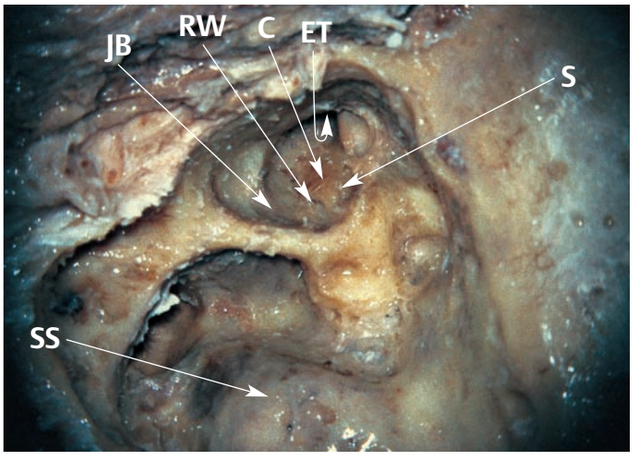
First, the area posteromedial to the facial canal is drilled by means of a small burr. This area comprises of the junction of the sigmoid sinus and jugular bulb. The sigmoid sinus makes an "S" form here. The surgeon should be aware of this anatomy and of its bearing; thus preventing damage to the sigmoid sinus.

II: 2–3 mm cutting and diamond burrs
MIL: Blue discoloration of bone (Junction)



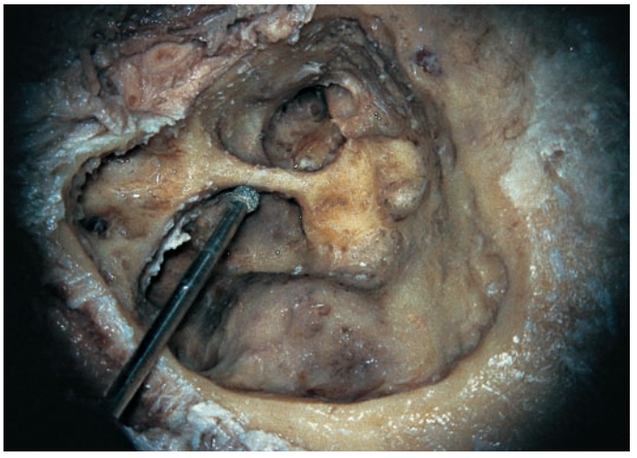
Definitions and Tips

- The objective of the transotic approach is to expose the medial deep parts of the temporal bone, from the middle cranial fossa dura to the mastoid tip, and from the anterior wall of the tympanic bone to the perisigmoid area. In other words, the aim is to expose the cerebellopontine angle from the superior petrosal sinus to the jugular bulb, and from the petrosal internal carotid artery to the sigmoid sinus.
- The zygomatic arch continues posteriorly as the temporal line, which is the inferior limit of the insertion of the temporal muscle.



The junction area of the sigmoid sinus and jugular bulb has been skeletonized leaving an eggshell-thin layer of bone. Note the blue discoloration of this area. Both on the temporal bone and in the operation, the discoloration is blue, differing only in color tone.

C: Cochlea
ET: Eustachian tube
JB: Jugular bulb (plate)
RW: Round window
S: Stapes
SS: Sigmoid sinus (dural plate)



In the next stage, the bone covering the mastoid segment of the facial canal is thinned by drilling with a small diamond burr. Care is taken not to expose any part of the facial nerve.

II: 2–3 mm diamond burr
MIL: Reflection of the facial nerve

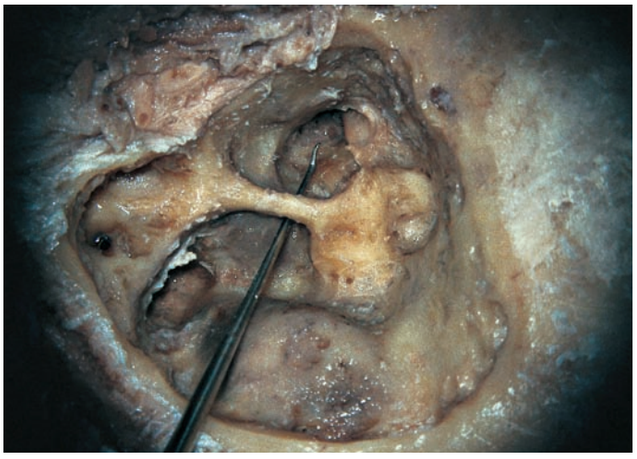
Using the same diamond burr, the bone covering the region medial to the facial canal, i. e., lateral to the junction of the sigmoid sinus and jugular bulb, is drilled away. In this way, a tunnel is created in this area medial to the mastoid segment of the facial nerve.

II: 2–3 mm diamond burr
MIL: Jugular bulb and facial nerve

Definitions and Tips

- The skeletonized facial nerve has a white discoloration on the cadaver, but a slightly pink discoloration during the live operation, because of blood supply.
- The horizontal semicircular canal is situated at a thirty degree angle to the axial plane. The posterior and superior semicircular canals are located vertically to the horizontal semicircular canal.

To highlight this tunnel, a curved micro dissector has been inserted through this tunnel from the mastoid cavity toward the tympanic cavity. The size of this tunnel differs between temporal bones or cases, depending on either the superior or inferior position of the jugular bulb.

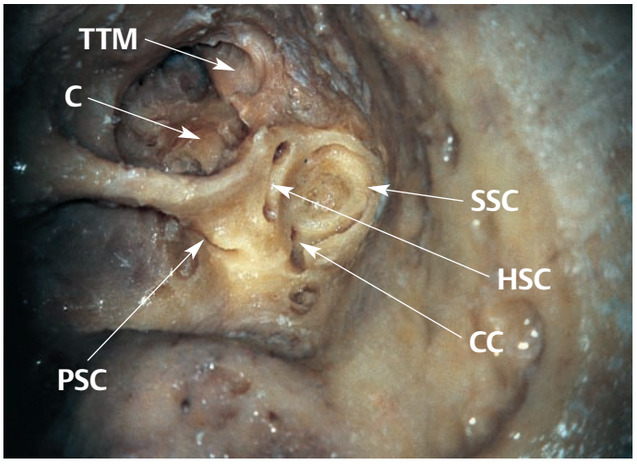


The next stage is extirpation of the semicircular canals. According to the main principle of temporal bone surgery, they should not be drilled away in haste. Therefore; each semicircular canal is drilled separately, in search of its own lumen.

II: 3–4 mm cutting burr
MIL: Solid bone of semicircular canals

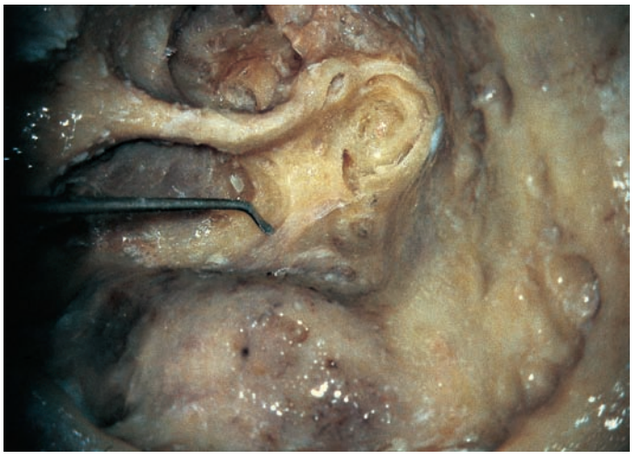
In this way, the lumens of the semicircular canals have been entirely exposed. It is extremely important to drill carefully, to prevent damage to the facial nerve during this and the following steps. The exposed semicircular canal lumens have been indicated in the figure.

C: Cochlea
CC: Common crus
HSC: Horizontal semicircular canal
PSC: Posterior semicircular canal
SSC: Superior semicircular canal
TTM: Tensor tympani muscle



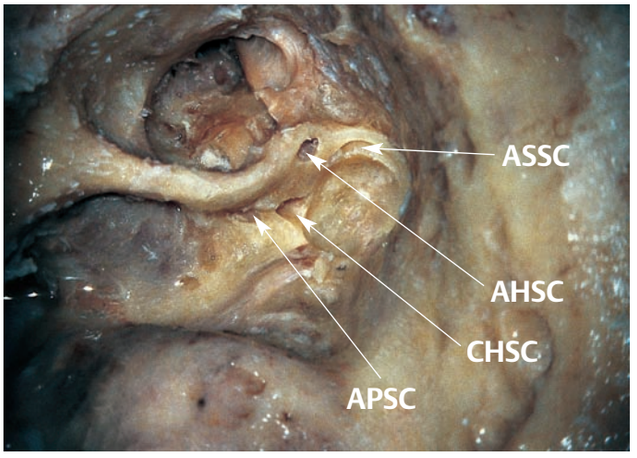
Definitions and Tips

- The removal of tympanic bone extensively, and the skeletonization of the jugular bulb and petrosal internal carotid artery are the essential steps of the transotic approach, because anterior and inferior exposure to the internal auditory canal and to the cerebellopontine angle is achieved through the space created between the jugular bulb, internal carotid artery, and the internal auditory canal.
- **Jacobson nerve (tympanic nerve)**: *Definition:* The thin branch of the glossopharyngeal nerve which runs along the promontory inferosuperiorly. *Tips:* It supplies sensory innervation to the middle ear and parasymphathetic innervation to the parotid gland. This is the area where the glomus tympanicum develops.



Following this, the solid bone containing the semicircular canals is removed step by step. Initially, the posterior semicircular canal area is drilled by means of a medium-sized cutting burr. The curved micro dissector in this figure indicates the endolymphatic duct, which is anatomically located medial to the posterior semicircular canal.

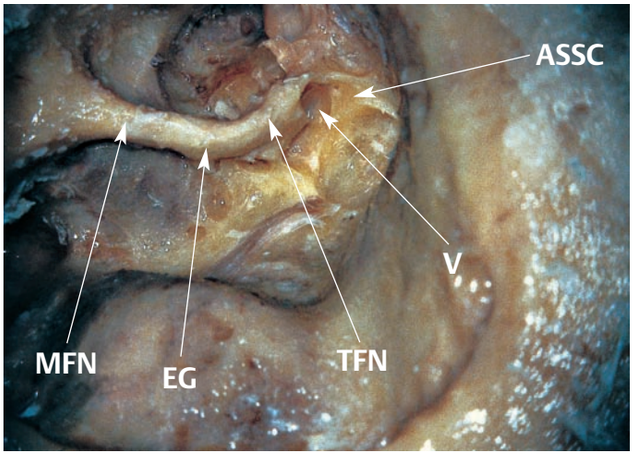
II: 3–4 mm cutting burr
MIL: Facial nerve



Drilling of the bone at the center of the posterior labyrinth continues by following the posterior and horizontal semicircular canal lumens toward the vestibule. The ampulla of the superior semicircular canal is preserved for use as a landmark in the subsequent steps of the procedure.

II: 3–4 mm cutting burr
MIL: Semicircular canal ampullae

AHSC: Ampulla of horizontal semicircular canal
APSC: Ampulla of posterior semicircular canal
ASSC: Ampulla of superior semicircular canal
CHSC: Crus of horizontal semicircular canal



At this point, the posterior labyrinth has almost been completely extirpated and the vestibule has been exposed. Consequently, the internal auditory canal is covered only by a thin layer of bone posteriorly.

II: 3–4 mm diamond burr
MIL: Medial wall of the vestibule

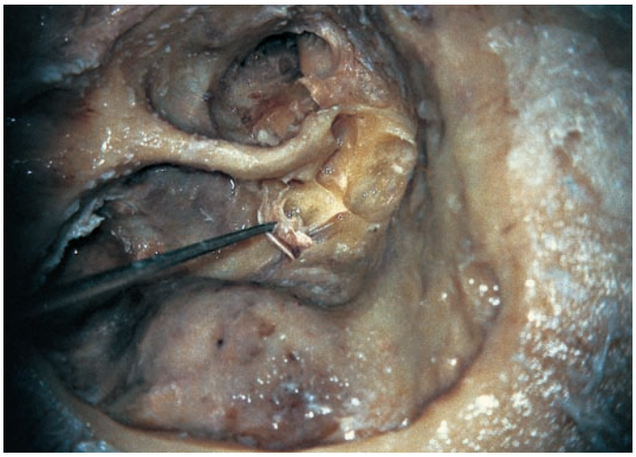
ASSC: Ampulla of superior semicircular canal
EG: External genu
MFN: Mastoid facial nerve
TFN: Tympanic facial nerve
V: Vestibule

Definitions and Tips

- The labyrinthine segment of the facial nerve can be found approximately 2 mm anterosuperior to the vestibule during a transotic or translabyrinthine procedure.
- It should be kept in mind that the medial wall of the vestibule is at the same time the lateral wall of the internal auditory canal fundus, meaning it is an exact reference to define the location of the internal auditory canal.

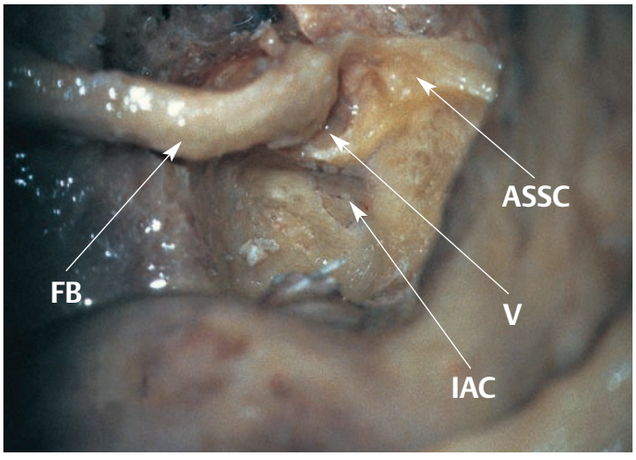
This last eggshell-thin bone covering the posterior wall of the internal auditory canal is elevated and removed piecemeal by means of a curved micro dissector. The exposed vestibule and its relation to other structures can also be observed in this figure and the previous one.

II: Micro elevator or curved micro dissector
MIL: Dura of the internal auditory canal



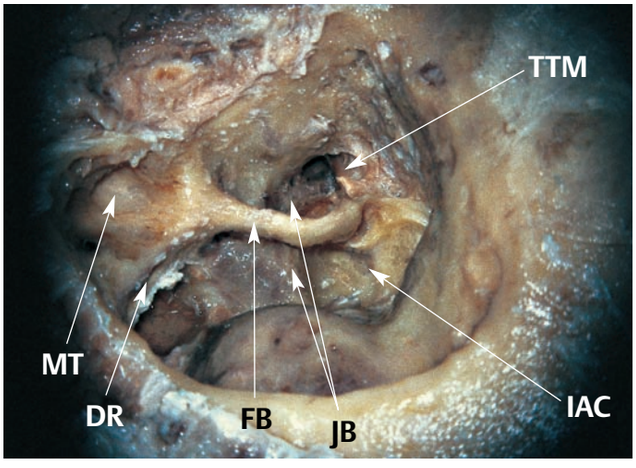
The dura of the internal auditory canal has been exposed partially. A close-up view shows the surgical site at this step. Note also the relation between the internal auditory canal and the vestibule.

ASSC: Ampulla of superior semicircular canal
FB: Facial bridge
IAC: Internal auditory canal (dura)
V: Vestibule



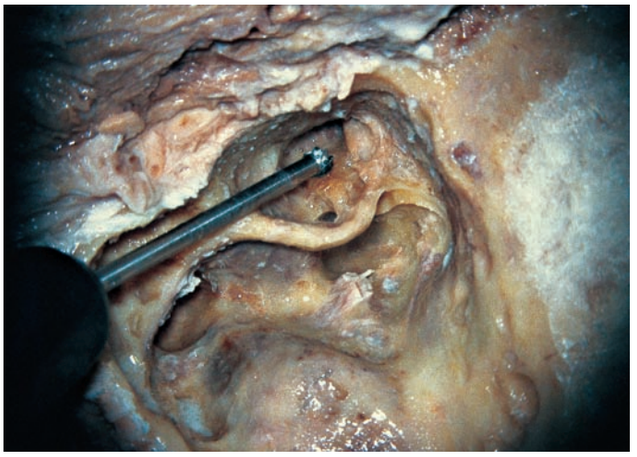
The drilling process posterior to the facial canal has almost been completed. The wide angle view outlines details of the surgical site where the exposed anatomical structures have been indicated.

DR: Digastric ridge
FB: Facial bridge
IAC: Internal auditory canal (dura)
JB: Jugular bulb (plate)
MT: Mastoid tip
TTM: Tensor tympani muscle



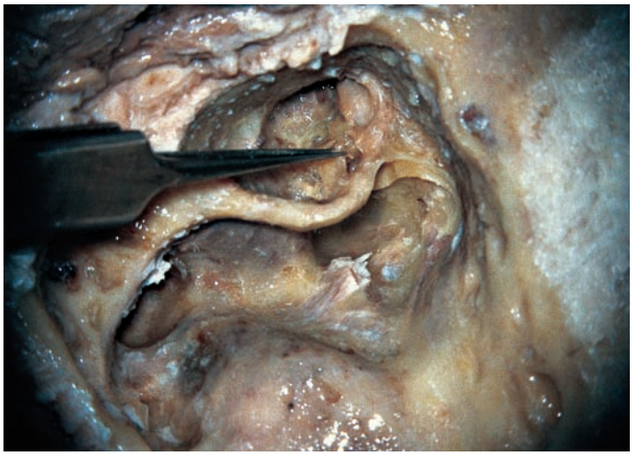
Definitions and Tips

- The skeletonized internal auditory canal dura has a blue discoloration on the cadaver as well as during the live operation. However, if the internal auditory canal is occupied by a tumor, it has a pink discoloration, because of the blood supply.

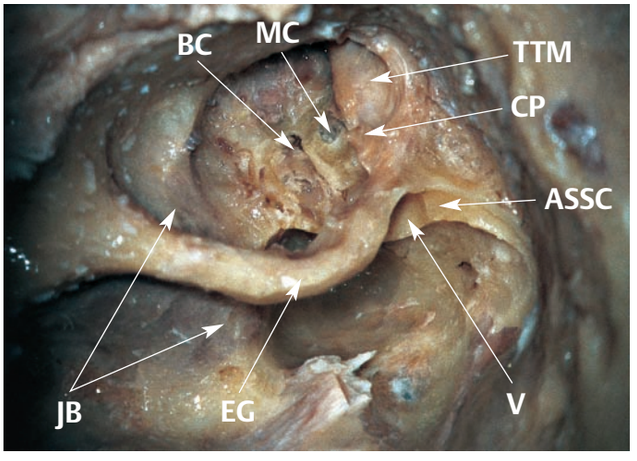


The drilling process now continues anterior to the facial canal. Using a small cutting burr, the inferior wall of the tympanic bone is further drilled and lowered, skeletonizing the jugular bulb completely. The cochlea is the next structure in line to be extirpated.

II: 2–3 mm cutting burr
MIL: Cochlea



The cochlea is drilled step by step, exposing its turns, with the same cutting burr. The direction of drilling is along the basal and middle turns of the cochlea. At the same stage, the stapes is also removed by means of forceps, as can be observed in the figure.



The inferior halves of the basal and middle turns of the cochlea have been exposed. The apical turn is hidden medial to the tensor tympani muscle. The critical structures encountered at this stage have been indicated in the figure.

ASSC: Ampulla of superior semicircular canal
BC: Basal turn of cochlea
CP: Cochleariform process
EG: External genu
JB: Jugular bulb (plate)
MC: Middle turn of cochlea
TTM: Tensor tympani muscle
V: Vestibule

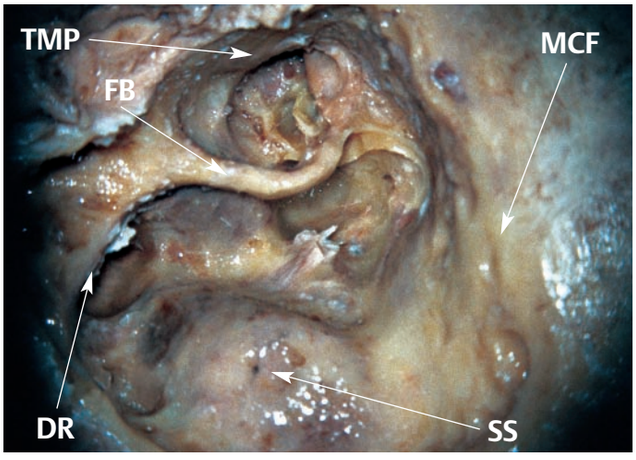
Definitions and Tips

- When performing a transotic approach, a prolonged operative time should be taken into account when scheduling the case in a patient. This is because of the oblique posterolateral–anteromedial axis of the petrous bone, requiring extensive drilling in the area anterior to the facial nerve.

A further step of this process is observed in the close-up view of the area anterior to the facial canal. Note the location of the middle and basal turns of the cochlea in relation to the tensor tympani muscle, the round window and the facial canal.

The wide-angle view of the surgical site at this stage. The skeletonized neighboring structures limiting the cavity have been indicated in the figure, as well as the facial canal running through the middle of the cavity.

DR: Digastric ridge
FB: Facial bridge
MCF: Middle cranial fossa (dural plate)
SS: Sigmoid sinus (dural plate)
TMP: Temporomandibular joint periosteum (plate)

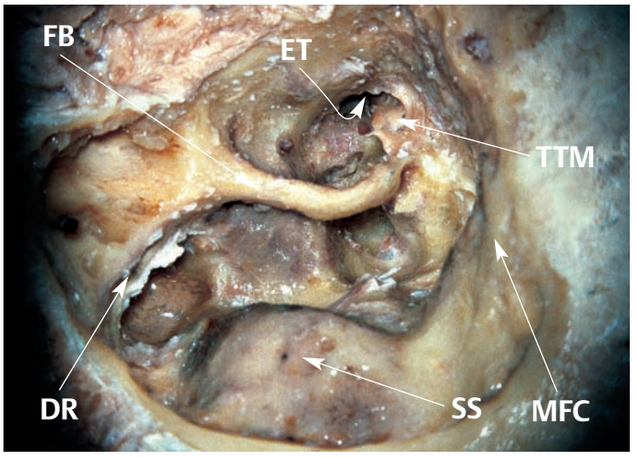


In this way, working with a medium-sized cutting burr, the entire cochlea is removed. Care should be taken to stay away from the facial nerve posteriorly and from the internal carotid artery anteriorly.

II: 3–4 mm cutting burr
MIL: Tympanic facial nerve

Definitions and Tips

- The apical turn of the cochlea is superior to the promontory, hidden medial to the tensor tympani muscle, facing anterolaterally. The inferior half of the middle turn is located in the superior part of the promontory, inferior to the tensor tympani muscle. The inferior half of the basal turn is located in the inferior part of the promontory, extending from the round window anteriorly, being in close proximity with the internal carotid artery.

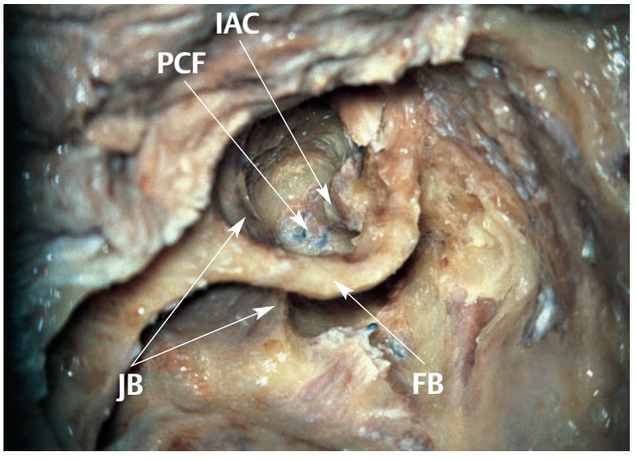


At this point, the cutting burr is replaced with a diamond one. The bone of the petrous is drilled away carefully, keeping in mind that the drilling area is limited by the vital structures; the internal auditory canal, internal carotid artery and jugular bulb.

II: 2–3 mm diamond burr
MIL: Reflection of the internal auditory canal

DR: Digastric ridge
ET: Eustachian tube
FB: Facial bridge
MCF: Middle cranial fossa (dural plate)
SS: Sigmoid sinus (dural plate)
TTM: Tensor tympani muscle

The next step is dissection and anterior transposition of the tensor tympani muscle by means of a micro dissector, as can be observed in the figure. Following this, the apical turn of the cochlea and the bone anterior to it are drilled away with a small diamond burr.



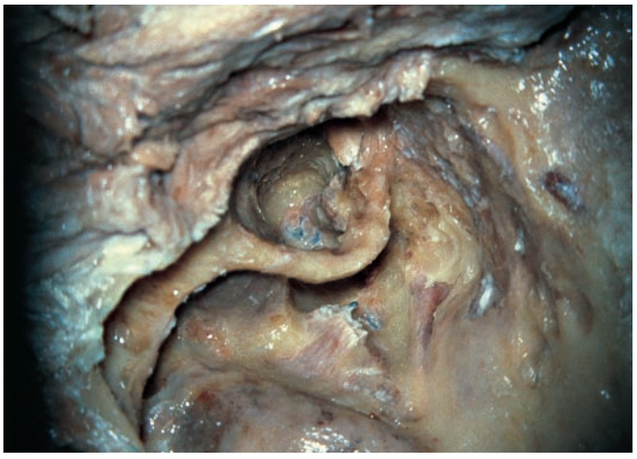
The anterior part of the internal auditory canal dura, and the posterior cranial fossa dura in close proximity, have both been exposed, anterior to the facial bridge. Note these exposed structures in relation to the jugular bulb in the figure.

FB: Facial bridge
IAC: Internal auditory canal (dura)
JB: Jugular bulb (plate)
PCF: Posterior cranial fossa (dura)

Definitions and Tips

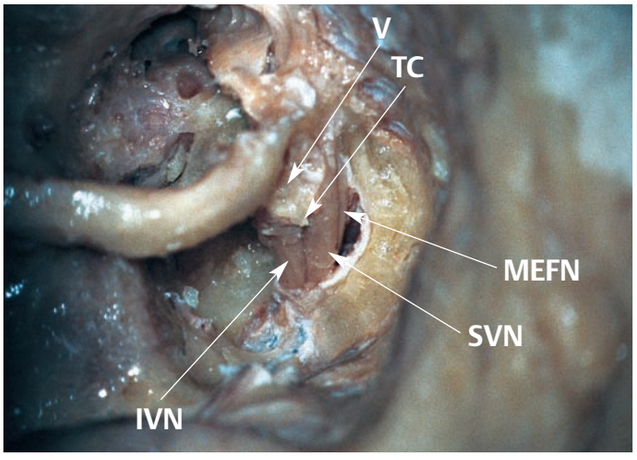
- The terminology with respect to the cochlea is defined regarding the modiolus, which is the central column in the cochlea, beginning at the fundus of the internal auditory canal and extending in an anterolateral direction. Accordingly, the terms such as “apical” and “basal” refer to the apical region of the modiolus and the basal region of the modiolus, respectively.

A wide-angle view of the surgical site at this stage. Nearly all of the bone surrounding the internal auditory canal has been drilled away. Only the area superior to the internal auditory canal has been left untouched. This area contains the geniculate ganglion and the labyrinthine segment of the facial nerve.



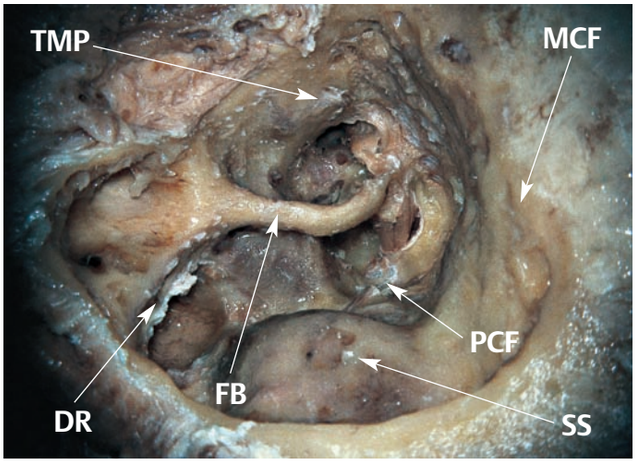
As the final stage, the dura of the internal auditory canal is incised. The nerves within the internal auditory canal are exposed, as observed in the figure. Note the proximity of the vestibule medial wall to the transverse crest; and also note the specific anatomical arrangement of the nerves in relation to each other.

IVN: Inferior vestibular nerve
MEFN: Meatal facial nerve
SVN: Superior vestibular nerve
TC: Transverse crest
V: Vestibule



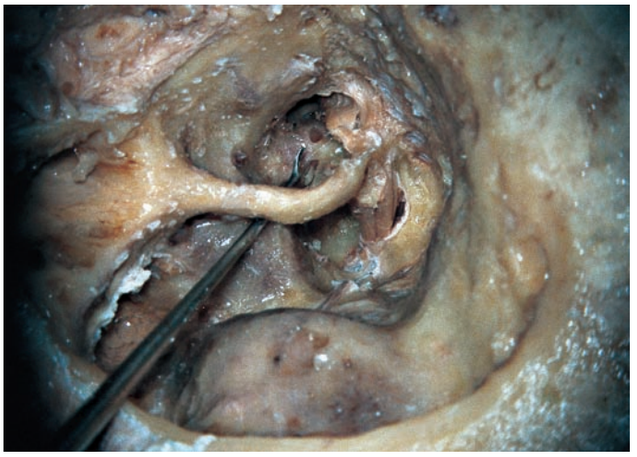
In this way, the transotic approach has been completed. During the operation, the dura of the posterior cranial fossa is also exposed and incised to work at the cerebellopontine angle. The surrounding structures encountered in this approach are indicated in the figure.

DR: Digastric ridge
FB: Facial bridge
MCF: Middle cranial fossa (dural plate)
PCF: Posterior cranial fossa (dural plate)
SS: Sigmoid sinus (dural plate)
TMP: Temporomandibular joint periosteum (plate)



Definitions and Tips

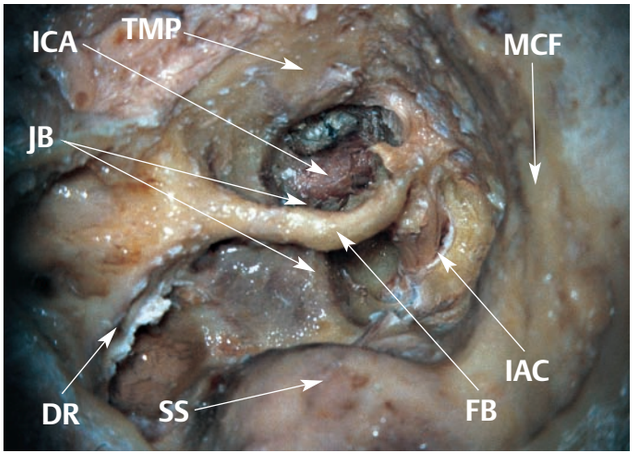
- **Internal auditory canal (meatus acusticus internus)**: *Definition:* The inner ear canal, located on the posterior face of the petrous, opening to the posterior cranial fossa. *Tips:* The internal auditory canal transmits the facial nerve as well as the three divisions of the vestibulocochlear nerve, namely the cochlear, superior vestibular, and inferior vestibular nerves.



The main feature of the transotic approach is leaving the bony facial canal intact as a bridge inside the created cavity. To outline this feature, a curved micro dissector has been inserted under the facial bridge, extending from the posterior part of the cavity to the anterior.

For illustrative purposes, one further step has been executed beyond the classical steps of the transotic approach; the bone covering the internal carotid artery has been drilled away, and the vertical segment and genu of the petrosal internal carotid artery have been exposed. This shows the need to work carefully when close to the eustachian tube during temporal bone surgery.

FB: Facial bridge
ICA: Internal carotid artery



A close-up view of the same step. All the critical structures encountered during the transotic approach are indicated in the figure. Note the relationship of each structure to one another.

DR: Digastric ridge
FB: Facial bridge
IAC: Internal auditory canal
ICA: Internal carotid artery
JB: Jugular bulb (plate)
MCF: Middle cranial fossa (dural plate)
SS: Sigmoid sinus (dural plate)
TMP: Temporomandibular joint periosteum (plate)

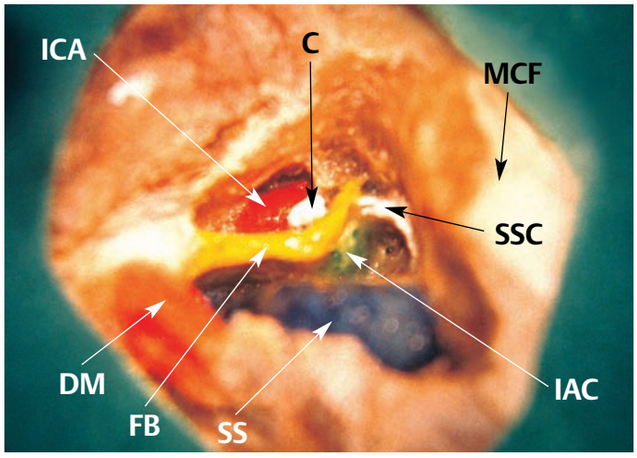
Definitions and Tips

- **Intratemporal internal carotid artery (intratemporal arteria carotis interna, petrosal internal carotid artery)**: *Definition:* The intratemporal part of the internal carotid artery which runs in a canal called canalis caroticus. *Tips:* The internal carotid artery enters medial to the processus styloideus, the carotid canal, and exits at the foramen lacerum from the carotid canal leading into the intracranial space. It has three segments; the vertical segment is located anterior to the jugular bulb, the genu is located anterior to the cochlea, and the horizontal segment is located medial to the eustachian tube.

Surgical Anatomy

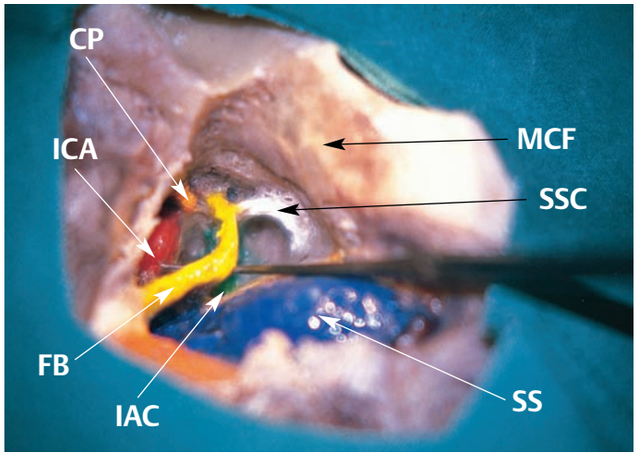
A dissected temporal bone in a cadaver. A transotic approach has been performed, the important anatomical structures have been exposed and dyed in different colors for illustrative purposes. The figure displays a view of the surgical site at the stage where the internal auditory canal dura has not yet been opened.

C: Cochlea
DM: Digastric muscle
FB: Facial bridge
IAC: Internal auditory canal (dura)
ICA: Internal carotid artery
MCF: Middle cranial fossa (dural plate)
SS: Sigmoid sinus
SSC: Superior semicircular canal

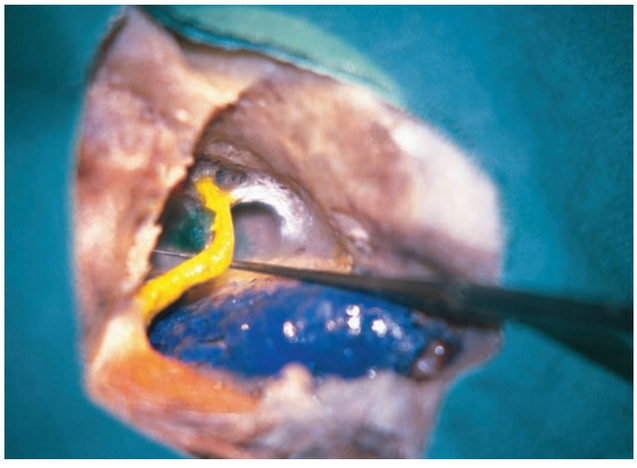


A microsurgical instrument has been inserted under the facial bridge. Note the tip of the instrument in the anterior part of the cavity. The critical structures are also indicated in this figure.

CP: Cochleariform process
FB: Facial bridge
IAC: Internal auditory canal (dura)
ICA: Internal carotid artery
MCF: Middle cranial fossa (dural plate)
SS: Sigmoid sinus
SSC: Superior semicircular canal

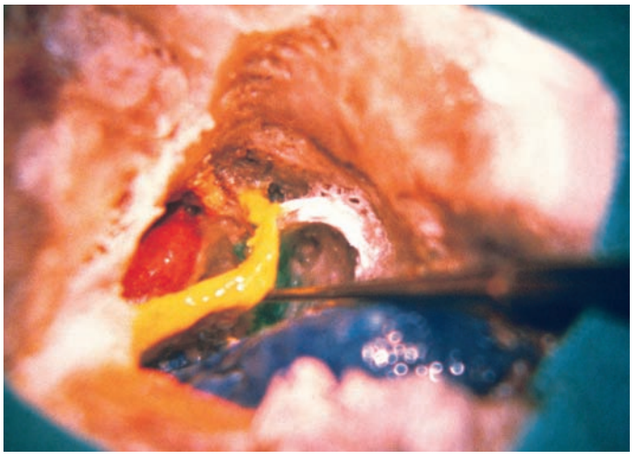


A close-up view of the surgical site during the same maneuver. Note the relationships of the facial bridge, internal auditory canal and superior semicircular canal ampulla to one another. In this figure and the previous one, the view is from the posteroinferior angle.

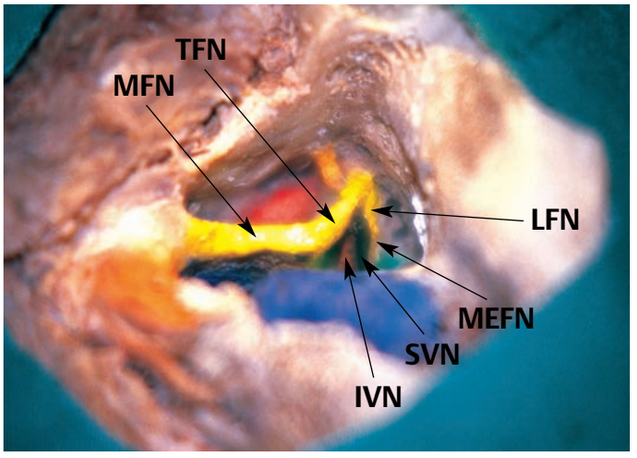


Definitions and Tips

- The transotic approach affords one of the largest exposures to the cerebellopontine angle through the lateral neurotologic passageway. This approach has the advantage of allowing exposure of the internal auditory canal and cerebellopontine angle, both anterior and posterior to the facial nerve, without putting the nerve at risk.



Another view of the surgical site during this maneuver. Note the relationship of the internal carotid artery to the internal auditory canal.



The final figure shows the completed transotic approach, where the internal auditory canal dura has been removed and the nerves exposed.

IVN: Inferior vestibular nerve
LFN: Labyrinthine facial nerve
MEFN: Meatal facial nerve
MFN: Mastoid facial nerve
SVN: Superior vestibular nerve
TFN: Tympanic facial nerve

Definitions and Tips

- The four nerves, entering the temporal bone, are specifically located in the internal auditory canal as follows:
  - facial nerve, anterosuperiorly
  - cochlear nerve, anteroinferiorly
  - superior vestibular nerve, posterosuperiorly
  - inferior vestibular nerve, posteroinferiorly

30 Other Approaches

Retrolabyrinthine Approach

Following a cortical mastoidectomy, exposure and incision of the posterior cranial fossa dura behind the semicircular canals, thus revealing the cerebellopontine angle.

Retrosigmoid Approach

After the exposure of the posterior part of the sigmoid sinus; carrying out a limited craniotomy by drilling the retrosigmoid area, and exposure and incision of the posterior cranial fossa dura, thus revealing the cerebellopontine angle.

Suboccipital Approach (with IAC Exposure)

Carrying out a direct suboccipital craniotomy and incising the dura, thus revealing the cerebellopontine angle; followed by drilling away the posterior wall of the internal auditory canal.

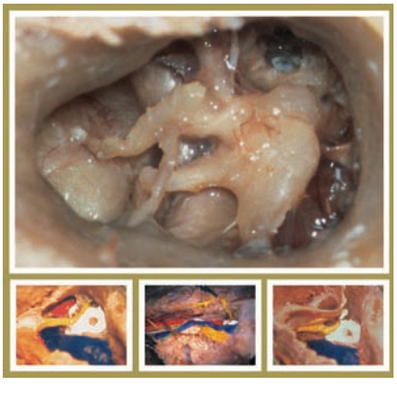
Transcochlear Approach (Modified)

Following a procedure similar to the transotic approach, uncovering the facial nerve, cutting the greater superficial petrosal nerve and transposing the facial nerve, i.e., labyrinthine, tympanic, and mastoid segments, posteriorly; thus allowing the exposure of all the medial structures, including the cerebellopontine angle.

Comment

- The surgical steps of these four important neurotologic approaches are not presented either because they are not carried out directly on the temporal bone or because only a limited, additional step is required to complete these procedures following the approaches described within this surgical atlas.

III Techniques and Designs Developed by the Author



31 Zygomatic Root Approach

Definition

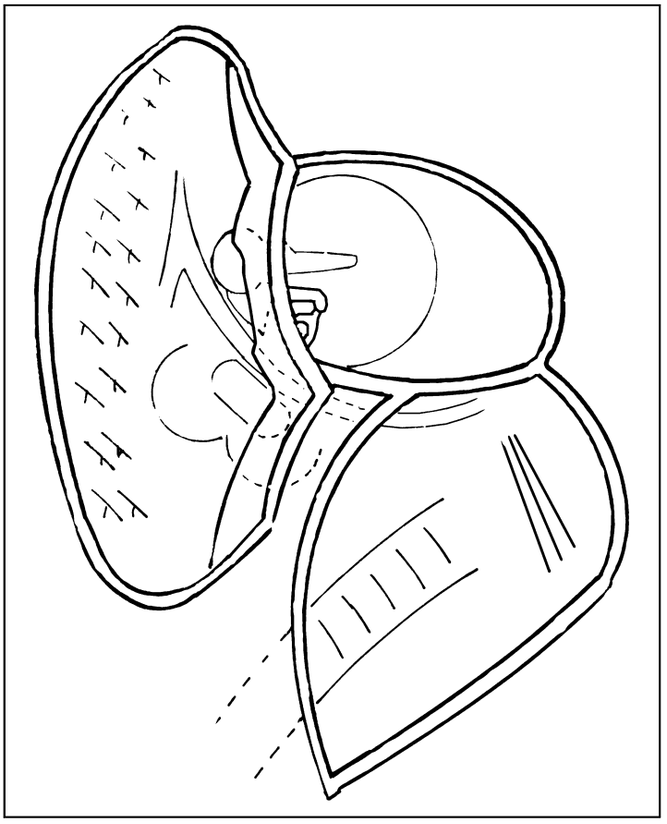
Drilling of the zygomatic root (ZR) area extensively, and exposure of the superior surface of the petrous bone including the perigeniculate area through the space created between the basal dura of the middle cranial fossa superiorly and the skeletonized external auditory canal inferiorly, without carrying out a craniotomy. The ZR approach can be carried out as an isolated technique, i.e., ZR isolated approach, or it can be combined with an inferior mastoidectomy, protecting the bony bridge in between, i.e., ZR combined approach.

Indications

The ZR approach is used in cases of facial paralysis due to temporal bone fractures, Bell palsy and Ramsay Hunt syndrome. This approach may also be useful in cases of iatrogenic facial palsy, superior semicircular canal dehiscence, and limited petrous cholesteatoma or cholesterol granuloma.

Surgical Technique

A retroauricular incision is made, with only a 2 cm anterosuperior temporal extension at the zygomatic root; for the combined approach approximately 7 cm in length, and only 4 cm in length for the isolated approach. A classical Palva flap is prepared, followed by slight elevation of the inferior part of the temporal muscle, which is temporarily sutured to the temporal skin. The initial step is the drilling of the zygomatic root area, taking the zygomatic root as the center. During this step, instead of extirpating the bone, a 2 × 1 cm cortical bone graft and bone dust are obtained to use for reconstruction at the end of the operation. Then extensive outside-in drilling is carried out, which consists of exenteration of the anterosuperior part of the mastoid and superior part of the petrous bone. In this way, the basal dura of the temporal lobe is completely exposed as in a middle cranial fossa approach. Following this, the superior wall of the external auditory canal is skeletonized, the tegmen tympani is opened, the dural attachment of the greater superficial petrosal nerve is located, and the superior semicircular canal is skeletonized or blue-lined according to the needs of the case. In cases of a combined approach, inferior mastoidectomy is added at this step, completely protecting the 0.5 cm thick bony bridge which extends from the mastoid cortex laterally close to the semicircular canals medially. The bridge avoids the creation of a large mastoidopetrosal cavity requiring adipose tissue obliteration.



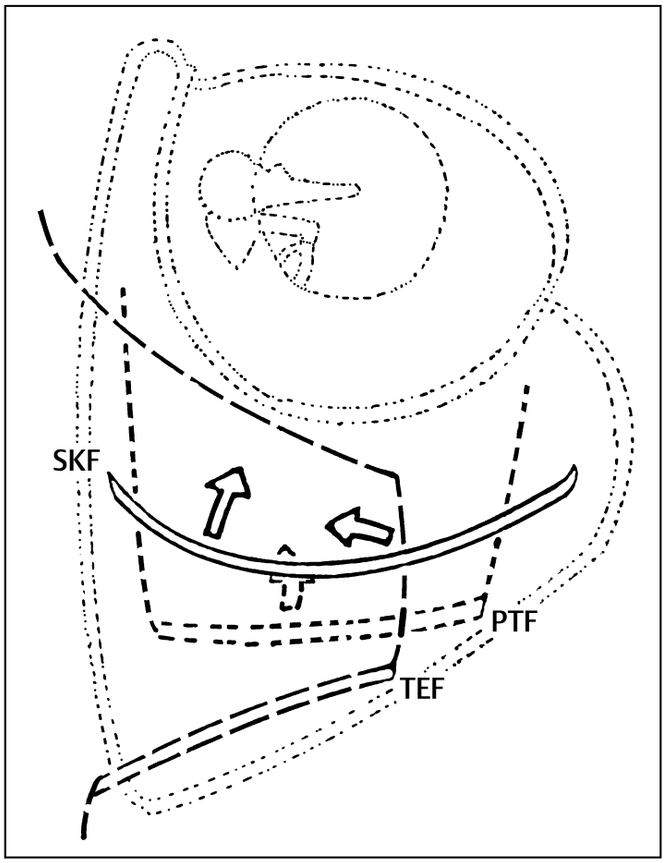
Zygomatic root approach.

If the procedure is undertaken for facial nerve pathology, exposure, diagnosis, and repair of the geniculate ganglion, the greater superficial petrosal nerve, and the labyrinthine and tympanic segments of the facial nerve are carried out via the ZR main approach, using hiatus facialis, cochleariform process, blue line of the superior semicircular canal, and other superficial petrosal landmarks as a reference. In cases of low-hanging dura, cerebrospinal fluid may be drained after making a small dural puncture. When additional procedures are required on the rest of the intratemporal facial nerve segments, these are carried out via the inferior mastoidectomy route, i.e., accomplishing a combined approach. For other indications of the approach, the appropriate special surgical steps are to be undertaken.

Definitions and Tips

- Ulug T. Zygomatic root approach. *Acta Otolaryngol* 2009:129:793–800.
- Presented at the 11th International Facial Nerve Symposium, April 25–28, 2009, Rome, Italy, and at the 27th Politzer Society Meeting, September 3–5, 2009, London, UK.
- The ZR approach provides improved intraoperative exposure of the key areas around geniculate ganglion without a craniotomy, combining the advantages of the middle cranial fossa and transmastoid extralabyrinthine approaches.

32 Minimally Invasive Cochlear Implantation with Mastoidal Three-layer Flap



Minimally invasive cochlear implantation with mastoidal three-layer flap. SKF: Skin flap, TEF: Temporomastoidal flap, PTF: Palva-type flap

Definition

Execution of a minimally invasive cochlear implantation procedure with a three-layer flap (TLF) approach, which is based on using the superficial musculoaponeurotic system (SMAS) as an additional, strong flap layer. The three-layer flaps, with three different pedicles, are: an anteriorly based 4 cm skin flap; a superiorly based temporomastoidal flap, which includes SMAS; and an anteriorly based periosteal Palva-type flap in the same mastoid area.

Indications

The minimally invasive TLF technique is used in cochlear implantation.

Surgical Technique

A small 4 cm retroauricular incision, with a slight anterior curve, is made 1.5 cm posterior to the postauricular crease. Only limited subcutaneous dissection, 1.5 cm anteriorly and 1.5 cm posteriorly, is carried out with a No. 20 blade. This maneuver exposes the mastoid soft tissues, which include the SMAS and periosteum. The next step is elevation of the temporomastoidal flap. Using the same No. 20 blade, a 2 cm long vertical incision is first made along the anterior limit of the mastoid. Next, a second 2 cm long vertical incision is made along the posterior limit of the mastoid, and a third 2–3 cm long horizontal incision is made close to the mastoid tip, connecting the vertical incisions. Then, working superficially, the thin flap is elevated. At the temporal line, the plane of dissection is changed to the subperiosteal level by cutting all the soft tissues including the periosteum. Therefore, a superiorly based temporomastoidal flap is formed, which includes the mastoidal SMAS inferiorly and the temporoparietal fascia, temporal fascia, temporal muscle, and temporal periosteum superiorly. The next step of the technique is elevating a thin, anteriorly based Palva-type flap, which consists solely of periosteum of the mastoid. In this way, three flaps with three different pedicles have been developed in the same mastoid area. Although the flaps forming the second and third layers are thin, they are very strong because of the tissue nature of the SMAS and periosteum. The mastoidectomy, posterior tympanotomy, cochleostomy or round window exploration, and implant placement steps of the approach are the same as in classical cochlear implantation.

However, closure and fixation differ from the classical cochlear implantation operation. First, the Palva-type periosteal flap is sutured to the periosteum close to the mastoidooccipital junction. Second, the temporomastoidal flap is replaced into its original position and sutured to the soft tissues on the mastoid tip and to the inferior part of the Palva-type flap. This closure enables full coverage of the receiver-stimulator and mastoidectomy area, as well as fixing the receiver-stimulator firmly in place. No additional means of fixation are required. The wound incision is closed with a few subcutaneous and cutaneous sutures.

Definitions and Tips

- Ulug T, Teker AM. Minimally invasive cochlear implantation with mastoidal three-layer flap technique. ORL, 2009;71: 292–298.
- Presented at the 3rd Meeting Consensus on Auditory Implants, June 14–15, 2007, Marseilles, France, and at other later meetings.
- TLF cochlear implantation is a technique that reduces operation time, enables complete coverage and safe fixation of the receiver-stimulator, and prevents flap breakdown and implant extrusion-migration.

33 Transposed Canal Wall Tympanomastoidectomy

Definition

Enlarging the external auditory canal extensively and exenteration of the anterior part of the tympanomastoid with an outside-in technique, so that a new canal is created with a superior wall at the middle cranial fossa dural plate, and the other walls transposed 2–3 mm posteriorly, inferiorly, and anteriorly. The transposed canal wall (TCW) tympanomastoidectomy can be carried out as an isolated technique, i.e., TCW anterior tympanomastoidectomy, or combined with a posterior mastoidectomy, protecting the transposed bony wall in between, i.e., TCW combined tympanomastoidectomy.

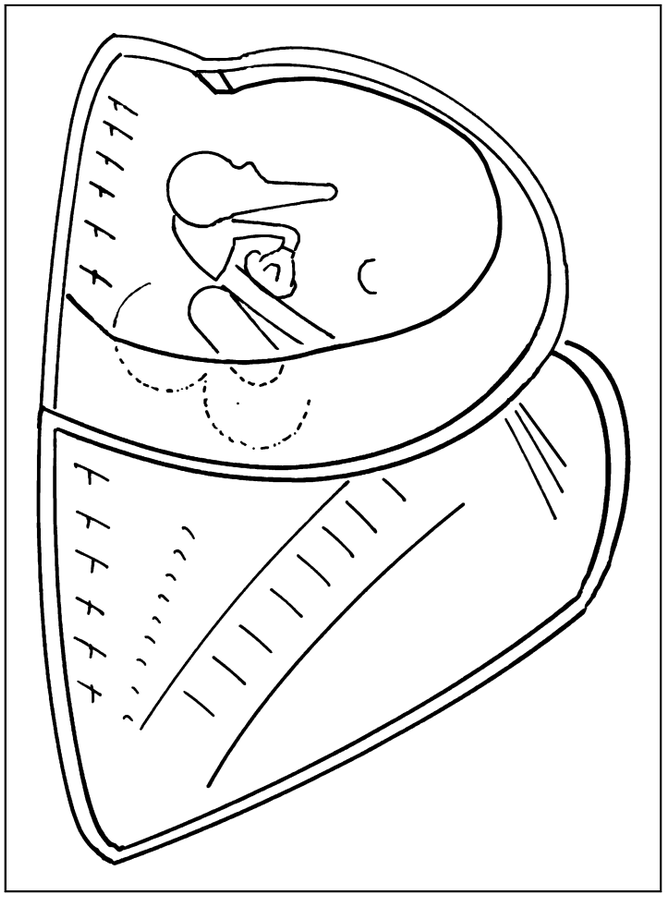
Indications

TCW tympanomastoidectomy is mainly used in surgery for chronic otitis media with cholesteatoma.

Surgical Technique

After execution of an endaural or retroauricular incision, a classical tympanomeatal flap is elevated, followed by elevation of the laterally based posterior and anterior meatal flaps. The initial steps in drilling are superior and posterior canal widening, which are followed by inferior and anterior canal widening. This is planned, outside-in, extensive drilling, which not only enlarges the external auditory canal, but also partially exenterates the anterior part of the mastoid. In this way the new canal wall is routinely recreated at the middle cranial fossa dural plate superiorly, and the other walls are transposed a couple of millimeters posteriorly, inferiorly, and anteriorly. If maximum exposure is required, a mastoid facial nerve skeletonization posteriorly, jugular bulb skeletonization inferiorly, and temporomandibular joint periosteum skeletonization anteriorly may be performed through this anterior main route.

When cholesteatoma is limited posteriorly to the aditus, all of it is removed through this anterior tympanomastoidectomy route, and when cholesteatoma is beyond the aditus (e.g., reaching the antrum), a posterior mastoidectomy is additionally carried out, protecting the newly created posterior wall. In such cases the cholesteatoma is pushed from the antrum through the aditus anteriorly into the attic. The rest of the cholesteatoma is resected through the anterior route. In either case, all the delicate structures and key areas—that is, the attic, aditus, horizontal semicircular canal, tympanic facial nerve, facial recess, sinus tympani, the ossicles, and oval and round windows—are all explored and cleared of cholesteatoma through the anterior route. After the cholesteatoma has been completely removed and the ossicles reconstructed, a piece of cartilage with perichondrium is used to partially fill the anterior mastoid tegmen adjacent to the middle cranial fossa dural plate, and the attic and tympanic membrane are reconstructed using either the same or another piece of cartilage and temporal fascia. In cases of combined TCW tympanomastoidectomy, any additional reconstructive procedure is carried out in the posterior mastoidectomy cavity.

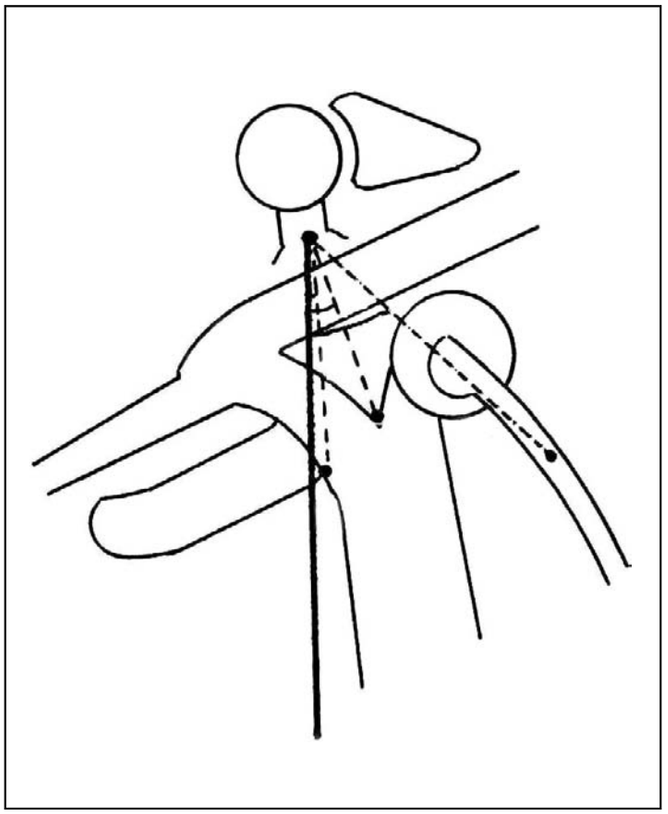


Transposed canal wall tympanomastoidectomy.

Definitions and Tips

- Ulug T. Transposed Canal Wall Tympanomastoidectomy. Accepted for publication in the Journal of International Advanced Otology, February, 2010.
- Presented at the 8th International Conference on Cholesteatoma/Ear Surgery, June 15–20, 2008, Antalya, Turkey; at the 6th Extraordinary Otitis Media Symposium, May 6–10, 2009, Seoul, Korea; and at the 27th Politzer Society Meeting, September 3–5, 2009, London, UK.
- TCW tympanomastoidectomy is a technique that provides improved exposure of the delicate anatomical structures and key areas without creating a mastoid bowl. It is a one-stage, planned, outside-in technique resulting in a small anterior tympanomastoidectomy cavity, which is two times larger than the normal external auditory canal. In addition, it affords safe cholesteatoma removal, prevention of cholesteatoma recidivism, and restoration of the hearing mechanism.

34 MCF Surgery Using Cochleariform Process as the Main Landmark



MCF surgery using cochleariform process as the main landmark.

Definition

Using the cochleariform process (CP) as a reliable landmark in middle cranial fossa surgery either alone, or in conjunction with other landmarks: The vertical crest lies at a 20° angle from the CP to the coronal plane, and at a distance of 5–6 mm from the CP; the point where the medial margin of the basal turn of the cochlea crosses the labyrinthine segment of the facial nerve is at a 0° angle from the CP to the coronal plane, and at a distance of 6.5–7.5 mm from the CP; additionally the superior semicircular canal is at a 45° angle from the CP to the coronal plane.

Indications

Middle cranial fossa surgery.

Surgical Technique

The main steps of the middle cranial fossa approach are similar in all described techniques, including the CP technique. The techniques differ mainly in the landmarks used, which result in differences during the final, yet most delicate stage of the procedure. In the CP technique, in contrast to the other approaches, the tegmen tympani is opened first. After the head of malleus, body of incus, and the cochleariform process have been exposed, the meatal plane is drilled in a mediolateral direction beginning 10–12 mm medially to the CP, with the center of drilling located directly medial (slightly posteromedial) to the process, which is the anticipated position of the vertical crest. The drilling process continues with ease up to a point about 7–8 mm from the CP, as neither cochlea, vestibule, nor labyrinthine facial nerve extend more medially. After reaching this point, more delicate work is required. Drilling carefully, the vertical crest is sought at a 20° angle from the CP to the coronal plane, and at a distance of 5–6 mm from the CP, also keeping in mind the other CP-related clues.

The CP may be used as the sole landmark or along with other landmarks. If it is used as the only landmark, continuous irrigation and magnification are essential to be able to observe the slightest color change, i.e., the blue discoloration that indicates the reflection of the superior semicircular canal, vestibule, or basal turn of cochlea; or the pink discoloration that indicates the reflection of the labyrinthine facial nerve, to prevent damage to these structures. If Garcia-Ibanez's direct medial approach to the meatal porus is used, the proposed landmark provides safety, as the surgeon can determine where the critical structures lie and work safely medial to these structures. If House's original approach is used, the proposed landmark enables the surgeon to bypass the delicate middle part of the labyrinthine segment, finding the vertical crest directly after exposing the distal part of the labyrinthine segment, and ultimately unroofing the middle part or leaving it intact, which reduces the risk of facial nerve damage. If Fisch's approach is used, the proposed landmark not only gives more information about the location of the internal auditory canal and vertical crest, but also defines exactly where the blue line of the superior semicircular canal should be sought, which has no other clue indicating its location in the arcuate eminence.

Definitions and Tips

- Ulug T. Using the processus cochleariformis as a multipurpose landmark in middle cranial fossa surgery. *J Laryngol Otol* 2009;123:163–9.
- Presented at Otology 2000: Achievements and Perspectives, XXII. Annual Meeting of the Politzer Society, August 15–19, 1999, Zürich, Switzerland, and at other later meetings.
- See also the related figures on page 93, where the critical anatomical structures in the middle cranial fossa approach are indicated and the relationships described above are highlighted.

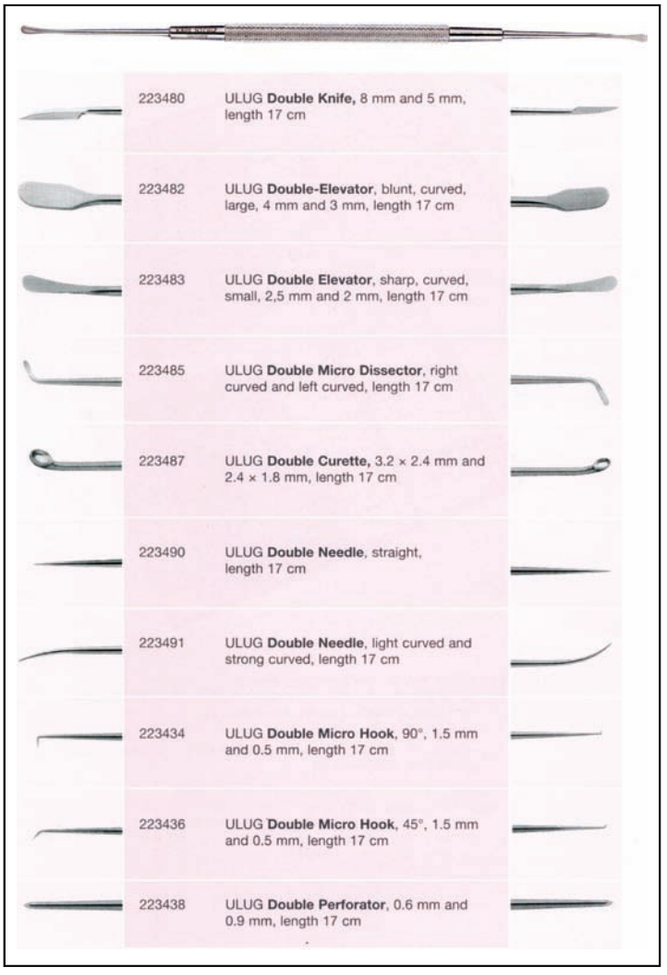
35 Ulug Double-sided Ear Microsurgery Instruments

Description

In contrast to macroscopic surgery, microscopic surgery has its own difficulties; the surgeon works alone, the left hand is used for suction in most instances, and lifting the head from the microscope may break the surgeon's concentration. For this reason, the surgeon should change instruments as few times as possible during the operation. In a quest to resolve this problem, the author had the revolutionary idea of designing instruments with both ends being usable as a set. Thus the main feature of these instruments is that they have a double-sided design, which provides the following benefits:

- It halves the number of instruments required—10 as opposed to 20.
- It significantly reduces costs, as there are fewer instruments.
- It is more ergonomic; the storage and sterilization of the instruments becomes easier.
- It provides comfort while working; only one maneuver of the fingers is required to rotate the instrument, enabling usage of the appropriate tip.
- It shortens operation time; less assistance is required by the scrub-nurse, thus saving time.

Furthermore, these instruments have not only been designed for tympanoplasty but also for stapedotomy. The addition of only a few classical micro forceps and micro scissors to this set would make it satisfactory for all types of otologic, and perhaps also neurotologic procedures.



Ulug double-sided ear microsurgery instruments.

Definitions and Tips

- Ulug double-sided ear microsurgery instruments are produced by Karl Storz. The instruments shown here are available from Karl Storz GmbH, Tuttlingen, Germany (www.karlstorz.com) or from other distribution agents worldwide.

IV Appendix

Suggested Reading

Bailey BJ, Calhoun KH. Atlas of Head and Neck Surgery—Otolaryngology. Philadelphia: Lippincott Williams & Wilkins; 2001

Brackmann DE. Otologic Surgery. Philadelphia: W.B. Saunders Company; 1994

Canalis RF, Lambert PR. The Ear: Comprehensive Otology. Philadelphia: Lippincott Williams & Wilkins; 2000

Fisch U, Mattox O. Microsurgery of the Skull Base. Stuttgart: Thieme; 1991

Fisch U. Tympanoplasty, Mastoidectomy, and Stapes Surgery. Stuttgart: Thieme; 2008

Hughes GB, Pensak ML. Clinical Otology. New York: Thieme; 2007

Janecka IP, Tiedemann K. Skull Base Surgery. Philadelphia: Lippincott Raven; 1997

Lyons AS, Petrucelli RJ II. Medicine; An Illustrated History. New York: Harry N. Abrams; 1987

Nelson RA. Temporal Bone Surgical Dissection Manual. Los Angeles: House Ear Institute; 1991

Paparella MM, Saunders WH, Miglets AW. Atlas of Ear Surgery. St. Louis: C.V. Mosby; 1986

Portmann M, Portmann D. Otologic Surgery: Manual of Oto-Surgical Techniques. San Diego: Singular Publishing Group; 1998

Salvinelli F, Cruz ADP. Otoneurosurgery and Lateral Skull Base Surgery. Philadelphia: W.B. Saunders; 1996

Sanna M. Atlas of Temporal Bone and Lateral Skull Base Surgery. Stuttgart: Thieme; 1995

Sekhar LN, Janecka IP. Surgery of Cranial Base Tumors. New York: Raven Press; 1993

Tos M. Manual of Middle Ear Surgery. Vol 1. Stuttgart: Thieme; 1993

Tos M. Manual of Middle Ear Surgery. Vol 2. Stuttgart: Thieme; 1995

Waltzmann SB, Roland JT Jr. Cochlear Implants. New York: Thieme; 2006

Weir N. Otolaryngology: An Illustrated History. Kent: Butterworth; 1990

Glossary

ad: Anatomical definition: definitions adopted from anatomical literature; however, used in both anatomical and surgical literature.
sd: Surgical definition: definitions adopted from and used only in surgical literature

Aditus (aditus ad antrum)

ad

Definition: The short tunnel connecting the attic to the antrum.

Tips: The medial wall of the aditus is formed by the horizontal semicircular canal. The lateral aditus wall should be extirpated carefully because of its close proximity to the medial wall, i.e., to the horizontal semicircular canal. The horizontal semicircular canal is the most important landmark in most types of tympanomastoid surgery.

Annulus fibrosis (fibrous annulus, annulus fibrocartilaginous membrana tympani)

ad

Definition: The fibrous tissue encircling the pars tensa of the tympanic membrane.

Tips: The fibrous annulus is located in the sulcus of the tympanic annulus. The access passage for the exposure of the tympanic cavity is between the fibrous annulus and the tympanic annulus.

Anterior buttress

sd

Definition: The surgically created buttress, a couple of millimeters in size, extending posteriorly from the anterosuperior edge of the tympanic annulus.

Tips: The buttress should be preserved in partial bridge atticotomy and removed in classical atticotomy.

Antrum (mastoid antrum, antrum mastoideum)

ad

Definition: The largest of the mastoid cells.

Tips: The antrum is located approximately 1 cm deep (medially) to the Macewen triangle in adults, and more superficially in children. It is an important intermediate stage landmark in all transmastoidal procedures.

Arcuate eminence (eminentia arcuata)

ad

Definition: The bony bulge on the superior surface of the petrous bone which also contains the superior semicircular canal.

Tips: It is one of the main landmarks in middle cranial fossa surgery.

Blind sac closure

sd

Definition: Permanent closure of the external auditory canal.

Tips: It is executed with occlusion of the eustachian tube and fat obliteration of the cavity. It is the reconstruction technique of subtotal petrosectomy, infratemporal fossa "type A," "type B," "type C," and transotic approaches.

Blue line of the superior semicircular canal

sd

Definition: Execution of the blue-line technique on the superior semicircular canal, which was performed for fenestration of the horizontal semicircular canal in otosclerosis surgery in the prestapedectomy era.

Tips: Identification of the blue line of the superior semicircular canal, followed by a search for the internal auditory canal at its anterior 60° angle, is one of the main techniques used in middle cranial fossa surgery.

Bondy technique

sd

Definition: Canal wall down tympanomastoidectomy with preservation of the tympanic membrane and ossicular chain.

Tips: This procedure includes all the steps of classical radical mastoidectomy, except for the procedures on the middle ear. In the original Bondy technique, the rest of the tympanic membrane and ossicular chain are preserved and left as they are, and not reconstructed.

Cochleariform process (processus cochleariformis)

ad

Definition: The bony prominence where the tendon of the tensor tympani muscle comes out at a 90° angle from the muscle.

Tips: The cochleariform process extends toward the neck of the malleus. It is a reference point for the tympanic facial nerve, oval window, and other middle ear structures. In addition, it may be used as a landmark in middle cranial fossa surgery.

Cochleostomy

sd

Definition: Drilling a window through the promontory into the scala tympani of the basal turn of the cochlea, 1–2 mm anteroinferior to the round window.

Tips: Using a cochleostomy for electrode array insertion simplifies the surgical technique, requiring a smaller posterior tympanotomy. However, the round window insertion technique, while requiring a larger posterior tympanotomy that extends adjacent to the facial nerve, presents the advantage of less trauma to the inner ear structures.

Cog

sd

Definition: The bony spine extending from the anterosuperior area of the malleus to the tegmen tympani.

Tips: The cog is roughly located next to the vertical crest intracranially. Extirpation of the cog allows access to the supratubal area.

Crotch (jugulocarotid septum)

sd

Definition: The bony septum separating the jugular bulb and petrosal internal carotid artery. Its superior edge is formed as a bony spine by drilling the bone between these two structures; this spine is called crotch.

Tips: It is an important structure in glomus jugulare surgery.

Digastric ridge

sd

Definition: The ridge that is formed by the bulge created by the insertion of the digastric muscle into the mastoid tip.

Tips: The digastric ridge is skeletonized during mastoidectomy and followed up to the stylomastoid foramen to locate the facial canal. The digastric ridge and the periosteum of the stylomastoid foramen are important landmarks for identification of the distal mastoid segment of the facial nerve.

Donaldson line

sd

Definition: The line that extends from the ampulla of the horizontal semicircular canal, along its arc, to the sigmoid sinus.

Tips: The endolymphatic sac is located inferior to this line, that is, posteroinferior to the posterior semicircular canal in the presigmoid area. It is one of the clues used in endolymphatic sac decompression surgery.

Elliptical recess (recessus ellipticus)

ad

Definition: The cavity in the posterosuperior part of the vestibule, containing a little sac—the utricle (utriculus).

Tips: Knowledge of the location of the elliptical recess and the utricle is essential for precise destruction of the labyrinth during a labyrinthectomy.

Endolymphatic duct (ductus endolymphaticus)

ad

Definition: The membranous canal that connects the endolymphatic sac to the vestibule. The bony canal in which it runs is called the vestibular aqueduct (aquaeductus vestibuli).

Tips: The endolymphatic duct begins anteromedial to the aperture of the common crus to the vestibule, runs medial to this crus posteriorly, and then appears posteroinferior to the posterior semicircular canal, leading to the endolymphatic sac in the posterior cranial fossa dura.

Endolymphatic sac (saccus endolymphaticus)

ad

Definition: The membranous sac containing endolymphatic fluid, located in, and posterior to, the indentation approximately 15 mm posterior to the internal auditory canal.

Tips: It is important during execution of techniques such as endolymphatic sac decompression or translabyrinthine approach. The junction of the endolymphatic sac with the endolymphatic duct is embedded in the bone; because of this, this junctional area may be mistaken for damaged dura.

Epitympanectomy

sd

Definition: Following an epitympanotomy, resection of the head of malleus, the incus, and the chorda-tensor fold, and drilling of the supratubal and supralabyrinthine recesses.

Tips: An epitympanectomy may be required for removal of cholesteatoma.

Epitympanum (attic)

ad

Definition: The superior part of the tympanic cavity.

Tips: The epitympanum comprises the area medial to the pars flaccida and scutum, and includes the head of malleus, the body of incus, and the surrounding structures. It is divided into two parts by the cog—the anterior epitympanum (supratubal recess) and the posterior epitympanum.

Exenteration

sd

Definition: Removal of bone, especially the bony cells, to eradicate the pathologic tissues or to gain sufficient exposure of the surgical site.

Tips: This is one of the main techniques in temporal bone surgery. Insufficient exenteration results in incomplete removal of the pathologic tissues or inadequate surgical exposure.

Exteriorization (saucerization)

sd

Definition: Removal of the sharp edges of bone, resulting in a saucerized cavity.

Tips: This is a technique which enables self-cleaning of cavities due to the wide opening toward the exterior. In addition, with regard to the main mastoid cavity, it allows the soft tissues to fall into the cavity, resulting in a reduction of the cavity size.

External genu (external genu of the facial nerve, pyramidal facial nerve, pyramidal turn)

ad

Definition: The bend of the facial nerve between its tympanic and mastoid segments, behind the pyramidal prominence.

Tips: The external genu forms the most posterior point of the intratemporal facial nerve. Good knowledge of its location is important to prevent damage to the facial nerve when the mastoid bone is drilled too far anteriorly in this area.

Facial prominence (prominentia canalis facialis)

ad

Definition: The bony bulge of the distal part of the tympanic facial nerve, in the tympanic cavity superior to the stapes.

Tips: This is one of the main landmarks in stapedotomy or chronic otitis media surgery. The rate of facial canal dehiscence is quite high in this area.

Facial recess (posterior tympanotomy area, suprapyramidal recess)

sd

Definition: The triangular area limited anteriorly (anterolaterally) by the chorda tympani, posteriorly (posteromedially) by the facial nerve, and superiorly by the fossa incudis (or posterior buttress).

Tips: Drilling of this area, i.e., carrying out a posterior tympanotomy procedure, enables the connection of the mastoid cavity with the meso- and hypotympanic parts of the tympanic cavity via a tunnel, in operations such as intact canal wall tympanomastoidectomy or cochlear implantation. In addition, this is one of the areas where cholesteatoma may be concealed.

Facial ridge

sd

Definition: The bony ridge covering the mastoid segment of the facial nerve.

Tips: Anatomically, there is no such natural structure, rather it is created during drilling in a mastoidectomy by leaving a little of the bone close to the mastoid segment of the facial nerve.

Fluid test

sd

Definition: Filling the antrum with fluid and then suctioning it through the tympanic cavity.

Tips: If the fluid test is negative, it means that the connection between the tympanic cavity and the mastoid is blocked, in which case an extension of the procedure may be required.

Fossa arcuata

sd

Definition: The fossa described by the author, which is exposed when the arcuate eminence of the petrous bone is skeletonized through the mastoid. It lies in the deep part of the dural plate of the middle cranial fossa close to the superior semicircular canal.

Tips: This fossa is, as expected, immediately next to the superior semicircular canal. The dural plate of the middle cranial fossa is more inferiorly located laterally and more superiorly located medially, because of the fossa arcuata. It is important to be aware of this when exposing the area around the superior semicircular canal.

Hard angle

sd

Definition: The angle between the superior line that extends 10 mm from the short process of the incus along the arc of the horizontal semicircular canal and the inferior line that extends 12 mm from the same point to the inferior margin of the posterior semicircular canal arc.

Tips: This angle contains the posterior semicircular canal, and the endolymphatic sac is located posteroinferior to this angle.

Henle spine (spine of Henle, suprameatal spine)

ad

Definition: The bony spine at the posterosuperior part of the entrance to the external auditory canal.

Tips: The spine of Henle is an important landmark for all mastoidal and transmastoidal procedures in otologic and neurotologic surgery. The Macewen triangle (suprameatal triangle) is located immediately behind the suprameatal spine.

Hiatus facialis (hiatus canalis facialis, facial hiatus)

ad

Definition: The foramen on the superior surface of the petrous bone, which continues with a fissure in a posteroanterior direction.

Tips: The greater superficial petrosal nerve runs through the facial hiatus from the geniculate ganglion toward the dura. The hiatus facialis is one of the main landmarks in middle cranial fossa surgery.

Incisura Rivini (incisura tympanica)

ad

Definition: The crescentic bony edge located superiorly between the lesser and greater tympanic spines.

Tips: After removal of the tympanic membrane, a bony circular margin within the temporal bone is observed, which is separated into two parts by the greater and lesser tympanic spines. The smaller, superior part is called the incisura Rivini, and the larger, inferior part is called the tympanic annulus. The incisura Rivini is an important structure during all types of middle ear procedures.

Internal auditory canal (meatus acusticus internus)

ad

Definition: The inner ear canal, located on the posterior face of the petrous, opening to the posterior cranial fossa.

Tips: The internal auditory canal transmits the facial nerve as well as the three divisions of the vestibulocochlear nerve, namely the cochlear, superior vestibular, and inferior vestibular nerves.

Intratemporal internal carotid artery (intratemporal arteria carotis interna, petrosal internal carotid artery)

ad

Definition: The intratemporal part of the internal carotid artery which runs in a canal called canalis caroticus.

Tips: The internal carotid artery enters medial to the processus styloideus, the carotid canal, and exits at the foramen lacerum from the carotid canal leading into the intracranial space. It has three segments; the vertical segment is located anterior to the jugular bulb, the genu is located anterior to the cochlea, and the horizontal segment is located medial to the eustachian tube.

Isthmus of the external auditory canal

ad

Definition: The bulge in the anterior canal wall approximately 5 mm lateral to the tympanic membrane.

Tips: The external auditory canal narrows in this area and, medial to this bulge, forms the anterior recess. The anterior margin of a perforation may not be adequately seen due to this anterior bulge at the isthmus, thus requiring canalplasty. Also, in most cases, an inferior bulge accompanies the anterior bulge in this area.

Jacobson nerve (tympanic nerve)

ad

Definition: The thin branch of the glossopharyngeal nerve which runs along the promontory inferosuperiorly.

Tips: It supplies sensory innervation to the middle ear and parasymphathetic innervation to the parotid gland. This is the area where the glomus tympanicum develops.

Koerner septum

sd

Definition: The area of fusion between the squamous and petrous bones. It consists of nonpneumatized, solid bone that begins at the petrosquamous suture and extends across the entire mastoid cavity, at a depth of 0.5–1 cm from the mastoid cortex.

Tips: The Koerner septum separates the superficial cells from the deeper cells and the antrum. Because of its solid nature, it can be mistaken for the labyrinth. If it becomes difficult to identify the antrum when the Koerner septum is encountered, the middle cranial fossa dura should be skeletonized and followed medially to locate the antrum and epitympanum.

Labyrinth (otic capsule)

ad

Definition: The inner ear.

Tips: The labyrinth is traditionally described as consisting of two parts; the anterior labyrinth and the posterior labyrinth. The anterior labyrinth, i.e., the anterior otic capsule, is formed by the cochlea. The posterior labyrinth, i.e., the posterior otic capsule, is formed by the vestibule and semicircular canals.

Landmark

sd

Definition: Reference point.

Tips: Temporal bone surgery is based on detailed anatomical knowledge and good drilling technique. Landmarks, as a part of anatomical knowledge, have a major role in surgery. Some landmarks are important only as landmarks, i.e., they do not have any functional significance, for example the spine of Henle or the vertical crest. However, other landmarks have functional significance in addition to their utilization as reference points, such as the horizontal semicircular canal.

Light-bending refraction of incus

sd

Definition: Observation of the incus in a fluid environment before its actual exposure.

Tips: As a result of the phenomenon of light refraction in fluid, if the antrum is filled with fluid, the incus can be seen under the microscope before the actual exposure. This maneuver allows early identification of the incus, and prevents damage to it.

Macewen triangle (suprameatal triangle, mastoid fossa)

sd

Definition: The cribriform area located posterosuperior to the spine of Henle and limited superiorly by the temporal line.

Tips: This triangle is the area where the antrum is sought in transmastoidal procedures. In adults, the antrum lies approximately 1 cm deep (medially) to this triangle.

Mastoid emissary vein

ad

Definition: The vein that appears through the bone 3–4 cm posteriorly to the spine of Henle on the mastoid cortex.

Tips: The mastoid emissary vein extends from the sigmoid sinus and passes through the mastoid foramen to drain into the posterior auricular or occipital veins. It is used as a surface landmark for topographic orientation and for locating the sigmoid sinus.

Meatal plane

sd

Definition: The flat plane on the superior surface of the petrous bone, anterior to the arcuate eminence.

Tips: It is one of the reference points used in middle cranial fossa surgery. The internal auditory canal is found 0.5–1 cm deep (inferior) to this plane.

Middle cranial fossa dural plate (middle fossa dural plate)

sd

Definition: The eggshell-thin bone covering the middle cranial fossa dura.

Tips: The delineation of the dural plate of the middle cranial fossa allows for the identification of a safe landmark, maximal exposure, extirpation of any pathologic tissue if present, and the preservation of the intracranial structures.

Modified radical mastoidectomy

sd

Definition: Canal wall down tympanomastoidectomy with reconstruction of the tympanic membrane and ossicular chain, preserving the aeration of the tympanic cavity.

Tips: This technique is the contemporary modification of classical radical mastoidectomy. It includes all the steps of the basic technique, except for the procedures on the middle ear.

Perilymphatic duct (ductus perilymphaticus)

ad

Definition: The membranous canal that connects the perilymphatic space of the cochlea with the subarachnoid space. The bony canal in which it runs is called the cochlear aqueduct (aqua-eductus cochlea).

Tips: The perilymphatic duct begins at the entrance of the scala tympani and then runs inferiorly, ending inferior to the internal auditory canal and anterior to the jugular fossa in the triagonal depression known as the fossula petrosa, where it joins with the subarachnoid space of the posterior cranial fossa. During neurotologic procedures, the opening of this duct results in decompression of cerebrospinal fluid.

Periosteum of stylomastoid foramen

sd

Definition: The periosteum covering the stylomastoid foramen.

Tips: It is found by following the digastric ridge while drilling in an anterosuperomedial direction. The periosteum of the stylomastoid foramen is the most defining landmark for the distal part of the mastoid segment of the facial nerve.

Petrotympanic fissure (fissura petrotympanica, glasserian fissure)

ad

Definition: The fissure at the junction of the tympanic and petrous bones, located on the anterior wall of the tympanic cavity.

Tips: The petrotympanic fissure transmits the chorda tympani, the anterior tympanic artery, and the anterior ligament of malleus.

Ponticulus (ponticulus promontorii)

ad

Definition: The small bony spine extending from the promontory to the pyramidal process, posteroinferior to the oval window, parallel to the stapedial tendon.

Tips: Ponticulus is an important reference point in cholesteatoma surgery. The sinus tympani is located inferior to this spine.

Posterior buttress (incus buttress)

sd

Definition: The bony bridge surgically created between the facial recess and the fossa incudis, which extends from the posterior wall of the external auditory canal to the horizontal semicircular canal.

Tips: Preservation of the posterior buttress during posterior tympanotomy prevents contact of the drill with the posterior ligament of the incus and consequent sensorineural hearing loss.

Pyramidal process (eminentia pyramidalis)

ad

Definition: The bony bulge of the stapedius muscle, in the tympanic cavity posterior to the stapes.

Tips This is one of the main landmarks in stapedotomy or chronic otitis media surgery. The tendon of the stapedius muscle extends from the pyramidal process to the neck of stapes.

Scutum (shield)

sd

Definition: The bony area superior to the incisura Rivini, forming the lateral wall of the attic. It is the deepest area on the superior wall of the external auditory canal adjacent to the tympanic membrane.

Tips: The scutum is the area where procedures of different extents are executed in atticotomy-related techniques.

Sigmoid sinus dural plate (sinus sigmoideus dural plate)

sd

Definition: The eggshell-thin bone covering the sigmoid sinus.

Tips: The posterior surface of mastoid and petrous bone is covered with the dura of the posterior cranial fossa. The sigmoid sinus occupies only part of this dura. The fact that the sigmoid sinus is the prominent and critical structure in the posterior cranial fossa accounts for its influence on the terminology.

Sinodural angle

sd

Definition: The longitudinal area limited by the dural plates of the sigmoid sinus and middle cranial fossa.

Tips: This area is next to the superior petrosal sinus intracranially. Thorough delineation of this angle during mastoidectomy allows good exposure of the posterior labyrinth.

Sinus tympani (infrapyramidal recess)

ad

Definition: The anatomical cavity beginning between the ponticulus and subiculum, and continuing posteriorly, inferior to the facial nerve and pyramidal process.

Tips: The sinus tympani, which may vary in size, is a recess of the tympanic cavity posteriorly, and is one of the areas where a cholesteatoma may be concealed.

Skeletonization

sd

Definition: By drilling: careful exposure of the last shell of bone covering the critical structures, which should be preserved.

Tips: Skeletonization is a principal feature of surgery in otology and neurotology. Instead of steering clear of the critical structures, searching for and identifying them lowers the rate of complication, contrary to common belief.

Specific air cells

sd

Definition: Air cells that are of particular importance in otologic surgery.

Tips: Although there are different classifications, these cells can be described as: supralabyrinthine, interlabyrinthine, retrolabyrinthine, retrofacial, presigmoid, retrosigmoid, apical, hypotympanic, infralabyrinthine, facial recess, peritubal, and petrosal. Apart from these specific cells, the temporal bone includes the superficial mastoid cells, the antrum, and the zygomatic root cells.

Spherical recess (recessus sphericus)

ad

Definition: The cavity in the anteroinferior part of the vestibule containing a little sac—the saccule (sacculus).

Tips: Knowledge of the location of the spherical recess and saccule is essential for precise destruction of the labyrinth during a labyrinthectomy.

Spina tympanica major (greater tympanic spine)

ad

Definition: The relatively larger bony spine located anteriorly between the tympanic annulus and incisura tympanica.

Tips: This spine may be used as a landmark in cases in which cholesteatoma extends into the supratubal recess or the eustachian tube.

Spina tympanica minor (lesser tympanic spine)

ad

Definition: The bony spine located posteriorly between the tympanic annulus and incisura tympanica.

Tips: This is the landmark used in the first stage of any type of middle ear procedure, such as a tympanoplasty or stapedotomy.

Stapedotomy drilling (stapedotomy notch)

sd

Definition: Drilling away the bone around the lesser tympanic spine.

Tips: This procedure is mainly performed in stapedotomy and in chronic otitis media surgery to get a good exposure of the facial prominence and pyramidal process. It involves only limited removal; drilling of the area located more anterosuperiorly transforms the procedure into a partial atticotomy.

Subarcuate artery

ad

Definition: The artery that runs through the hard bone in the arc of the superior semicircular canal.

Tips: Knowing the location of the subarcuate artery may enhance accuracy during the drilling process, and it may also be used as an additional reference point in subsequent stages of the procedure.

Subiculum (subiculum promontorii)

ad

Definition: The small bony spine extending from the promontory posteriorly, posterosuperior to the round window.

Tips: The subiculum is an important reference point in cholesteatoma surgery. The sinus tympani is located superior to this spine.

Supralabyrinthine recess

sd

Definition: The area consisting of cells located on the medial wall of the epitympanum, around the cog. The recess is limited by the tympanic and labyrinthine segments of the facial canal inferiorly, the middle cranial fossa dura superiorly, and the horizontal and superior semicircular canal ampullae posteriorly.

Tips: Cholesteatoma and granulation tissue may be concealed in this recess.

Supratubal recess (anterior epitympanum)

sd

Definition: The area located anterior to the cog and superior to the eustachian tube and tensor tympani muscle.

Tips: Cholesteatoma and granulation tissue may be concealed in this recess.

Tegmen tympani (roof of tympanum)

ad

Definition: The thin bony plate covering the roof of the epitympanum.

Tips: It is the thin bone that separates the middle ear and the basal dura of the temporal lobe. Sometimes, the roof of the antrum and mastoid are also mistakenly called the tegmen tympani. The correct terminology should include the tegmen tympani, the tegmen antri, and the tegmen mastoideum.

Transverse crest (falciform crest, crista transversa)

ad

Definition: The horizontal spine that separates the fundus of the internal auditory canal into two parts.

Tips: On the upper part of the fundus separated by the transverse crest are the facial nerve (anterosuperiorly) and the superior vestibular nerve (posterosuperiorly). On the lower part of the fundus are the cochlear nerve (anteroinferiorly) and the inferior vestibular nerve (posteroinferiorly). The transverse crest is an important reference point for all procedures involving the internal auditory canal.

Trautmann triangle

sd

Definition: The triagonal area limited by the dural plate of the middle cranial fossa superiorly, horizontal and posterior semicircular canals anteriorly, and the dural plate of the sigmoid sinus posteriorly.

Tips: This area consists of the retrolabyrinthine and presigmoid cells and is the access passageway to the posterior cranial fossa in the retrolabyrinthine approach.

Tympanic annulus (annulus tympanicus, sulcus tympanicus, tympanic ring)

ad

Definition: The bony sulcus in which lies the tympanic membrane with the annulus fibrosis.

Tips: It forms the crescentic area inferior to the greater and lesser tympanic spines, and enables firm attachment of the pars tensa to the bone.

Tympanic cavity (middle ear)

ad

Definition: The middle ear.

Tips: The tympanic cavity can be divided into five regions: epitympanum (attic), the superior part; mesotympanum, the middle part; hypotympanum, the inferior part; protympanum, the anterior part; and retrotympanum, the posterior part.

Tympanomastoid suture (fissura tympanomastoidea)

ad

Definition: The suture on the junction of the tympanic and mastoid bones.

Tips: The suture crosses the posterior wall of the external auditory canal. The inexperienced surgeon can use this suture as a rough landmark; the facial canal lies more medially, i.e., deeper to this suture.

Tympanosquamous suture (fissura tympanosquamosa)

ad

Definition: The suture on the junction of the tympanic and squamous bones.

Tips: The suture crosses the anterior part of the superior canal wall. Removal of this suture allows better exposure around the short process of malleus.

Vascular strip

sd

Definition: The area between the tympanosquamous and tympanomastoid sutures that covers the deep, posterosuperior wall of the external auditory canal, where the skin becomes thick and more vascular.

Tips: Preparation of tympanomeatal and meatal flaps in some tympanoplasty techniques is based on the preservation of the vascular strip, such as the onlay technique of Sheehy.

Vertical crest (Bill bar)

ad

Definition: The bony spine that divides the superior portion of the fundus of the internal auditory canal into two parts—the anterior part with the facial nerve and the posterior part with the superior vestibular nerve.

Tips: Although the vertical crest is anatomically very small, because of the exposure of the bone behind the proximal labyrinthine facial nerve during drilling, it becomes larger. This is an indispensable reference point in middle cranial fossa surgery.

Vestibulofacial triangle

sd

Definition: The triagonal area surrounded by the tympanic and labyrinthine segments of the facial nerve and the superior vestibular nerve.

Tips: This is the bony area that extends from the vertical crest laterally. Parts of the vestibule and basal turn of the cochlea are located deep, i.e., inferior to this triangle.

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