

# OPEN ACCESS ATLAS OF OTOLARYNGOLOGY, HEAD & NECK OPERATIVE SURGERY



## HAMMER & GOUGE CORTICAL MASTOIDECTOMY FOR ACUTE MASTOIDITIS

Johan Fagan & Robert Jackler

This surgical guide is intended for the many surgeons in the lower- and middle-income countries who do not have access to modern mastoid surgery equipment such as functioning mastoid drills, or are regularly faced with power cuts and therefore may be compelled to proceed with a mastoidectomy using a hammer and gouge, and possibly only a headlight and operating loupes.

The text and illustrations are based on the description of mastoid surgery: *A Treatise on the Surgical Technique of Otorhinolaryngology* (1939) by Georges Portmann. The text has been modified to incorporate modern principles of otology. This operative guide should be read in conjunction with the chapter [Hammer and Gouge Radical Mastoidectomy for Cholesteatoma](#).

Mastoid surgery can only be safely performed when the surgeon has an intimate knowledge of temporal bone anatomy. It is imperative that surgeons practice temporal bone dissections on cadaver bones.

### ***Informed Consent***

This should include anaesthetic and surgical risks and issues relating to aggravated hearing loss, facial nerve injury, vertigo, taste disturbance, injury to the brain and meninges, and wound complications

### ***Anaesthesia***

Surgery may be performed under local or general anaesthesia.

***General anaesthesia:*** Avoid muscle paralysis to facilitate detection of facial nerve irritation or injury by noting facial muscle contractions.

***Local anaesthesia:*** See chapters

- [Local and regional anaesthesia techniques for otologic \(ear\) surgery](#)
- [Otology outreach surgery in developing countries under local and regional anaesthesia: Techniques and pitfalls](#)

### ***Magnification and lighting***

Magnification is ideally required once dissection reaches the middle ear, and for removal of the facial ridge. Should an operating microscope not be available, then operating loupes with 2.5x magnification should be used. Good lighting is essential, especially when working in the middle ear. In the absence of an operating microscope or strong operating lights, a headlight may have to suffice.

### ***Instrumentation (Figures 1a, b)***

Gouges and chisels should be extremely sharp to ensure controlled bone resection. Blunt instrumentation requires undue force to be applied, and gouges/ chisels may slip off bone and plunge and damage critical structures such as brain, lateral sinus, facial nerve, inner ear, and carotid artery. For the bone work the surgeon requires the following:

- Curved periosteal elevator
- Mallet
- Three gouges: Large, medium, small
- Flat chisel
- Curettes
- Rongeurs/bone nibblers (small, medium and large)
- Retractors (2), ideally self-retracting
- Canal elevator/McDonalds dissector
- Blunt probe
- Microinstruments: Curved needle, Plesker knife, sickle knife, curette
- Suction tips

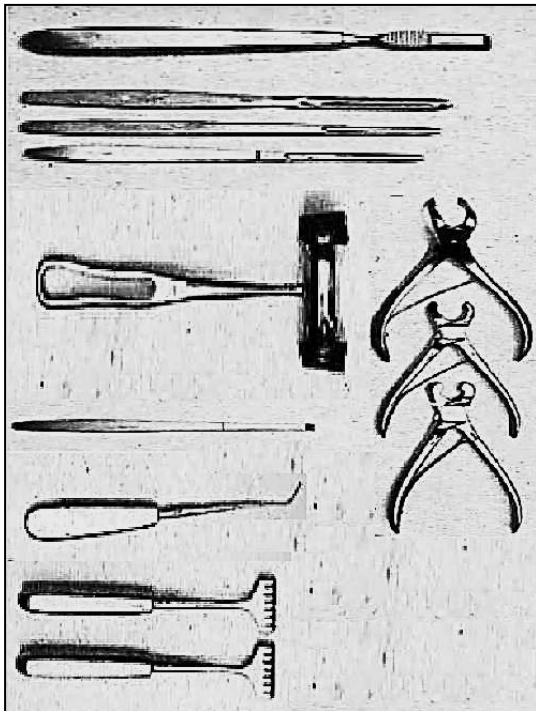


Figure 1a: Instruments for bone work



Figure 1b: Mallet, rasp, chisels, curette and gouge (From Professor Malick Diop)

### Position of Patient

The patient is laid supine with the head turned towards the normal ear.

### Position of Surgeon and Assistants

The surgeon stands on the side of the affected ear. Two assistants are stationed on the other side, facing the surgeon. The 1<sup>st</sup> assistant is nearest to the head. The 2<sup>nd</sup> assistant is exactly opposite the surgeon.

### Operative Field

The mastoid, auricle, and preauricular regions are extensively swabbed with tincture of iodine. The patient is covered to the neck with a sterile sheet. The operative field is isolated by four towels. Over them is placed a fenestrated sheet, the orifice of which encircles the auricle and mastoid.

### Antibiotics

No antibiotics are required for mastoidectomy for uncomplicated cholesteatoma, other than when there is secondary infection (mastoiditis).

### BIPP Paste

BIPP Paste can be prepared and used to impregnate ribbon gauze. This can be used to pack the mastoid cavity or ear canal, and because of its antiseptic properties, may be left in place for a few weeks. Bismuth subnitrate 20% w/w, iodoform 40% w/w, paraffin liquid 40% w/w (w/w = weight for weight)

### Surgical anatomy for Mastoidectomy

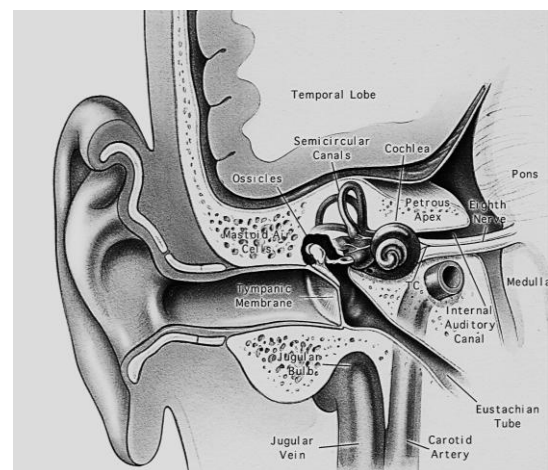


Figure 2: Coronal section through middle ear and temporal bone

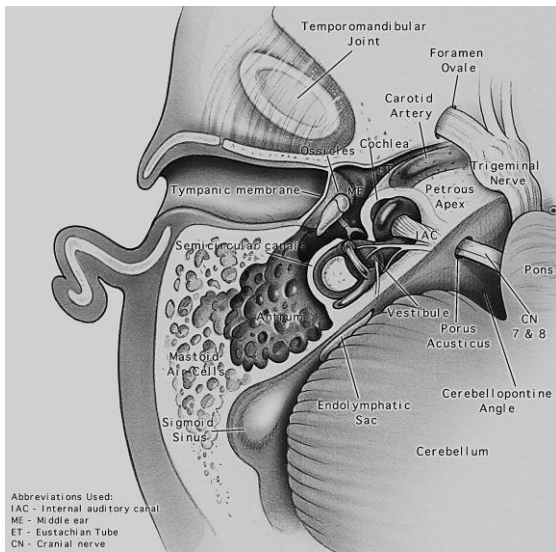
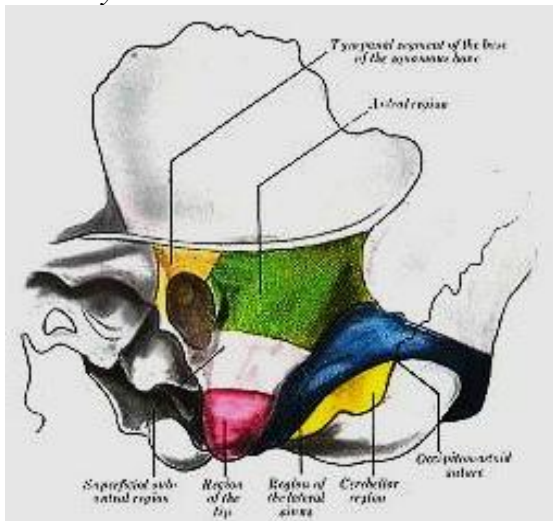


Figure 3: Axial view of temporal bone anatomy



**Brown:** Tympanic segment of base of squamous bone;  
**Green:** Antral region; **Rose:** Subantral region; **Red:** Region of tip; **Blue:** Sinus region; **Yellow:** Cerebellar region or region of mastoid vein

Figure 4: Surface boundaries of mastoid regions

### Surgical Steps: Cortical Mastoidectomy

Unlike with mastoid surgery for cholesteatoma, mastoidectomy for acute mastoiditis may be associated with **significant blood loss**, especially in the absence of mono- or bipolar coagulation. Patients may even require blood transfusion.

### First Step: Incision of Superficial Tissues



Figure 5: Incision of Superficial Tissues

The 1<sup>st</sup> assistant retracts the auricle towards himself, using both hands. The 3<sup>rd</sup> finger of the lower hand is pressed strongly under the mastoid tip in order to compress the posterior auricular artery. The other assistant is prepared to sponge/swab with mastoid sponges/swabs held in angular forceps. The surgeon incises the retroauricular crease down to bone from left to right, from the *linea temporalis* to the inferior part of the crease, or vice versa (Figure 5). In the event of a retroauricular abscess, the abscess cavity may be entered at this point or during periosteal elevation.

### Second Step: Periosteal Elevation

Following haemostasis and ligation of bleeding vessels, the mastoid is completely exposed proceeding posteriorly to the incision, **without elevating the anterior cartilaginous canal**. This is easy in the superior portion where the periosteum frees itself but becomes more laborious toward the inferior and posteroinferior portions where the muscular insertions must be sectioned with the elevator. Figure 6 demonstrates how the cartilaginous canal has been respected (Figure 6).

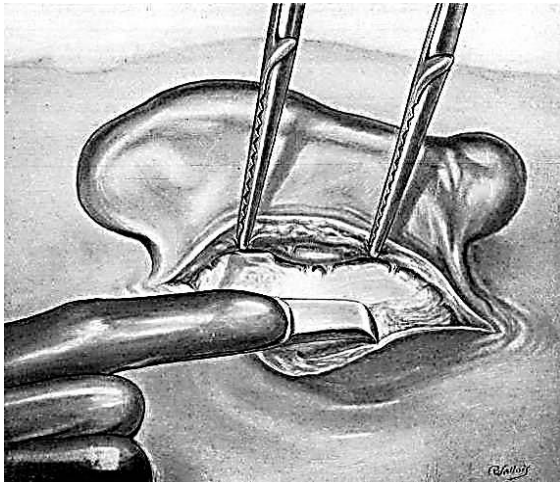


Figure 6: Periosteal elevation

### **Third Step: Exploration of Bone**

In the absence of electrocoagulation, 2 Kocher haemostats are applied to the periosteum, one in front and one in the back, assuring haemostasis. Two sharp-toothed retractors are held by the assistant. One is placed forward to retract the auricle in the canal without separating it from the bone. The other embraces the posterior lip of the wound, retracting it backward to uncover the operative surface. A self-retaining retractor may also be employed. After completing the periosteal elevation, the surgeon carefully examines the mastoid surface for changes in form, colour, and surface (Figure 7).

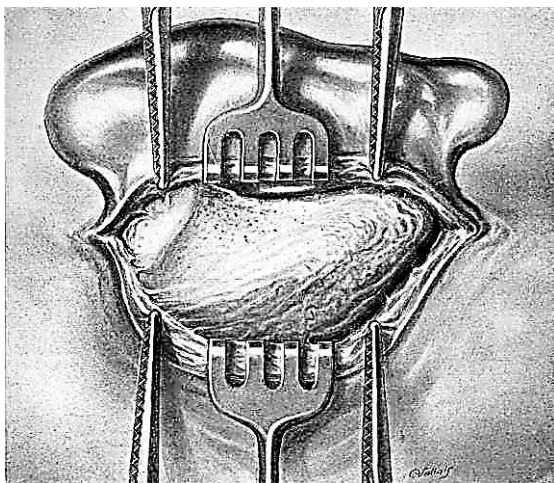


Figure 7: Examine the mastoid surface

**Form:** In the illustration one sees the crest of the *linea temporalis*, the spine of Henlé, and the sieve-like region, the retromental depression, and the bulge of the postero-superior region. The anterior mastoid portion is free of all muscular insertions. The muscles from the nape of the neck and the sternocleidomastoid muscle are inserted into the posterior portion of the mastoid. These two regions are separated by the posterior external petrosquamous suture. With acute mastoiditis these landmarks may be absent, and the mastoid may then present an evenly rounded bulge, having the appearance of an egg. The spine of Henlé remains and is the only really important landmark.

**Colour:** Normally the bone appears white or oozes blood through the porous portions of the retromental region. However, in mastoiditis the external cortex bleeds diffusely due to the deep inflammatory process. If there is underlying empyema, the wall appears bluish.

**Surface:** Some irregularities may appear along the surface of the mastoid. These often consist of inflammatory granulations which are apparent through the external posterior petrosquamous suture or of a fistula, which may be verified with the aid of a probe. The existence of a fistula is sought wherever the incision has uncovered free pus.

### **Fourth Step: Trephining - Exploration of Superficial Antral Region**

A large gouge is placed immediately below the *linea temporalis* (Figure 8). It is held between the thumb and first two fingers, with the ring finger serving as a brake. The instrument is held in the position shown in the illustration, being directed vertically at right angles to the bone surface.

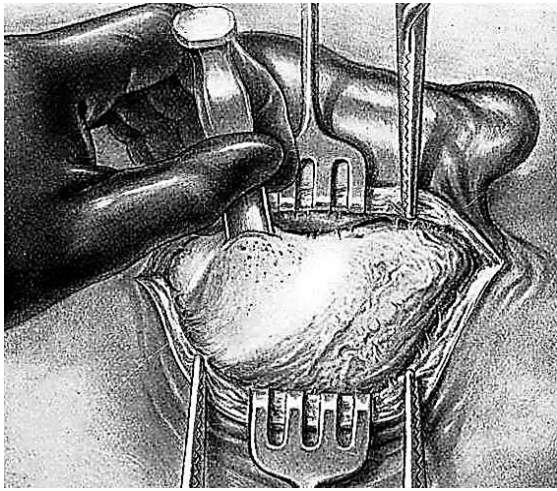


Figure 8: Trephining and exploring antral region

**Site of Trephination:** If a fistula is present and is at the level of the antral region or its immediate vicinity, the trephine is performed at that level. If no fistula exists or is very far from the antral region, the trephining is done as follows. An area of approach is outlined with the gouge by applying it above and behind the canal at the following points (Figures 9, 10):

- **1<sup>st</sup> cut:** 2 - 3mm behind spine of Henlé
- **2<sup>nd</sup> cut:** just below *linea temporalis*

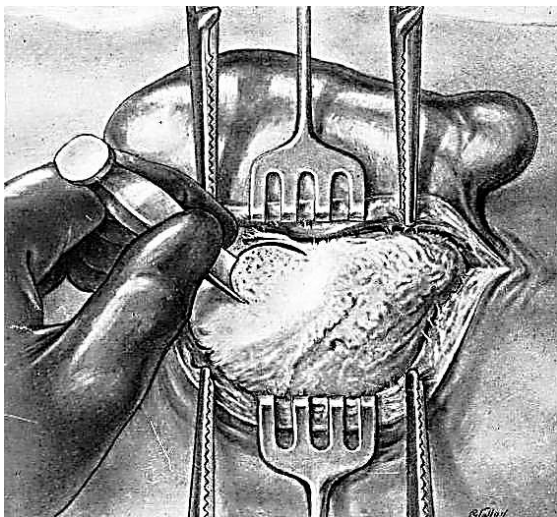


Figure 9: 1<sup>st</sup> & 2<sup>nd</sup> cuts

- **3<sup>rd</sup> cut:** parallel, but 1cm below 2<sup>nd</sup> cut
- **4<sup>th</sup> cut:** 1cm behind 1<sup>st</sup>, thus completing a circle of trephination



Figure 10: completing a circle of trephine-tion

- The 1<sup>st</sup> 3 taps of the gouge are perpendicular to the bony surface
- The 4<sup>th</sup> tap is applied obliquely to avoid the lateral sinus which may be superficial or prominent.

#### **Fifth Step: Exploration of Superficial Subantral Region and Tip**

After trephining and curetting the superficial antral region, the gouge is directed toward the inferior portion of the mastoid, making a superficial vertical trench. The instrument is held between the thumb and first two fingers of the left hand with the two remaining fingers resting on the bony surface to provide control and to avoid dangerous slip of the gouge (Figure 11).

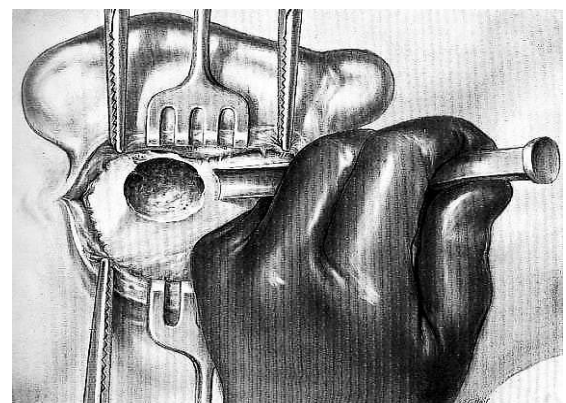
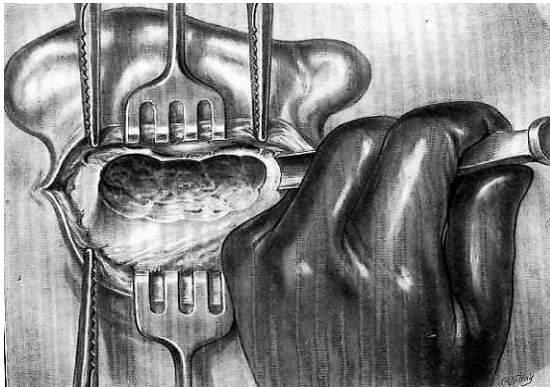


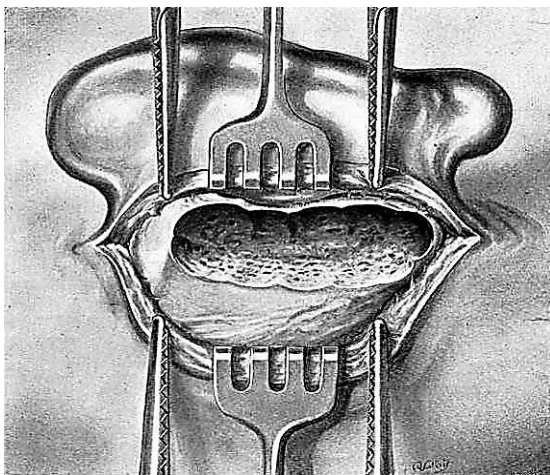
Figure 11: Gouge directed toward inferior portion of mastoid

### ***Sixth Step: Opening of Apical Region***

After exploring and curetting the antral and subantral regions, the surgeon works toward the tip, creating a superficial, vertical trench, and exposing the diseased mastoid cells (Figures 12, 13). Only if the tip is osteitic does it need to be resected with the gouge or rongeur.



*Figure 12: Creating a vertical trench*

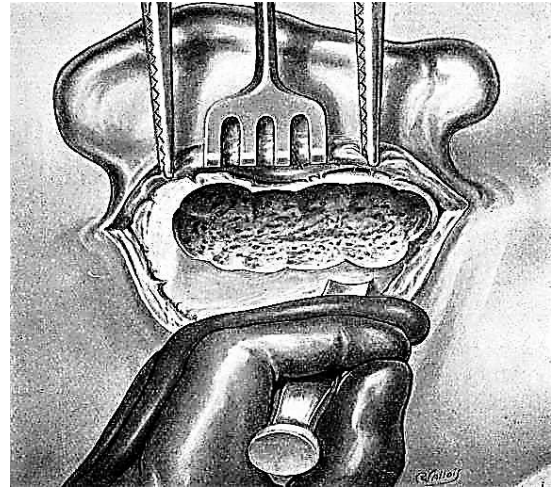


*Figure 13: Vertical trench*

### ***Seventh Step: Exploration of Posteroinferior Region***

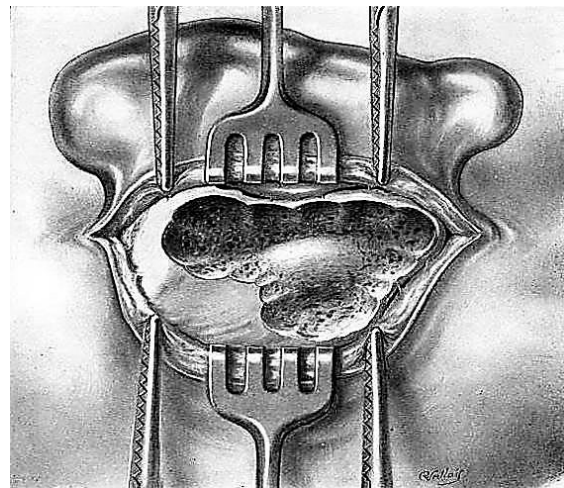
The posteroinferior region, which is also called the *region of the mastoid vein*, is opened with a gouge. The instrument is held in the same position as described previously but is slanted obliquely from behind forward and gently forced in with light taps of the mallet. The procedure pro-

gresses backward toward the posterior portion of the mastoid from below up. (Figure 14)



*Figure 14: Opening posteroinferior region*

Opening this posteroinferior region exposes the inner table of the skull which at this level forms the bony outer shell of the lateral sinus. This region is meticulously curetted (Figure 15).

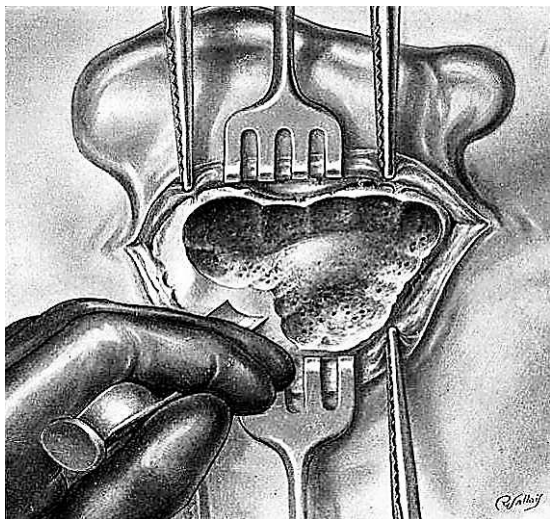


*Figure 15: Completed posteroinferior dissection*

If the bony disease is very extensive, the soft tissues may have to be sectioned by a horizontal incision perpendicular to the retro-auricular incision, forming a “T”, and additional posterior exposure of the mastoid bone is done.

***Eighth Step: Exploration of Posterosuperior Region and Lateral Sinus / Sinodural Angle (Figure 16)***

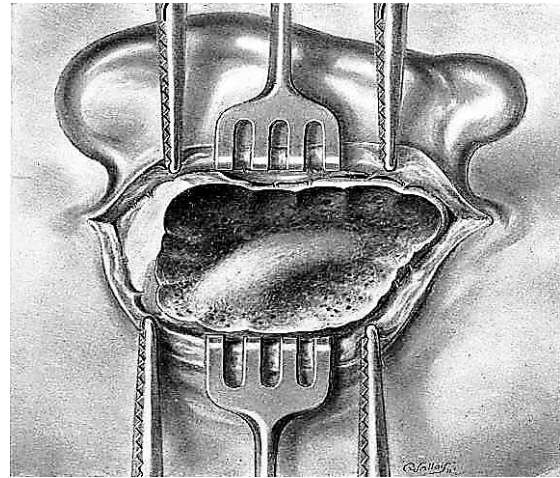
Trephination is continued from below upward and behind forward, burrowing progressively into the mastoid and to join the superficial antral region. The taps on the gouge are performed cautiously. They are made on a tangent to permit the gradual removal of the cortex over the lateral sinus or even to uncover the venous wall, if this should be necessary. The rongeur is dangerous when handled blindly and may penetrate dura and injure the brain. The gouge is much more manageable; its action more easily controlled. The posterior limit of trephination is determined by the status of the bone. The process continues until normal resistant bone, which does not bleed, is encountered. If haemorrhage occurs from the mastoid vein, this may be cauterized or occluded with bone wax. A gauze pack impregnated with the adrenaline and kept in place for several minutes may reduce bleeding.



*Figure 16: Exploring the sinodural angle*

***Ninth Step: Exploring Lateral Sinus***

The posterosuperior region of the mastoid is also called the *region of the lateral sinus* (Figure 17).



*Figure 17: The lateral sinus*

Since this vessel is sometimes very superficial, the gouge is the only instrument that should be used. It is held between the thumb and the first two fingers of the left hand and placed obliquely on the bony surface. Small slanting blows made with the gouge permit a very careful sculpturing of the cortex of the lateral sinus.

***Lateral Sinus Thrombosis and Perisinus Abscesses***

Acute mastoiditis may be complicated by a perisinus (extradural) abscess, lateral sinus thrombosis, or there may be pus within the sinus (Figure 18). In the absence of pre-operative CT scanning, the sinus should be uncapped of bone. If a perisinus abscess is encountered, it is drained into the mastoid cavity. The sinus is aspirated with a needle and syringe. Should there be no free flow of blood, it might be thrombosed, or there may be an intrasinus abscess that needs to be drained.

***Tenth Step: Search for Antrum***

The antrum is sought with a small gouge directed from behind forward towards the spine of Henlé, paralleling the canal and excavating down towards the antrum with small taps of the mallet (Figure 19).



Figure 18: Thrombosed (L) lateral sinus with posterior fossa abscess

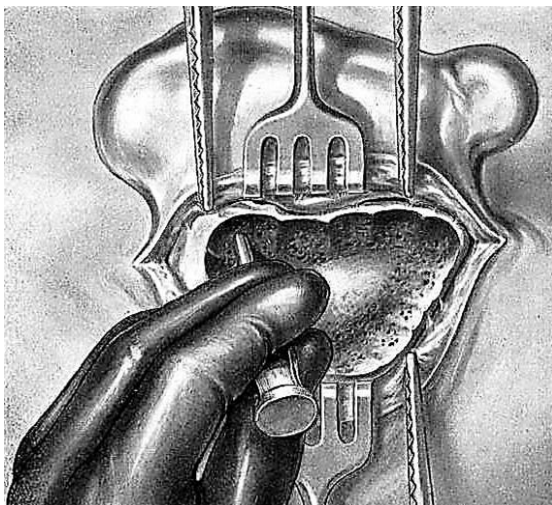


Figure 19: Accessing the antrum

With the superficial antral region open, this step is particularly easy, and the antrum is accessible even when small and deeply located. The antrum is enlarged above and posteriorly, either with a gouge or curette. Small curettes which may result in dangerous slips should not be used. The *aditus ad antrum* is located with a blunt angular probe. This permits a determination of the status of the *tegmen tympani* superiorly, especially at the level of the antral roof.

### Eleventh Step: Opening the Deep Antral Region

After widely opening the antrum, the *aditus* is sought with a blunt curved probe (Figure 20). It is carefully cleansed with a medium sized curette. Very small curettes should not be used as they may slip and cause serious injuries.

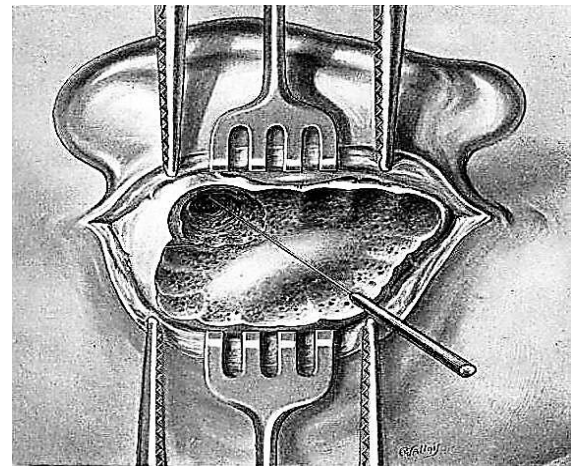


Figure 20: Probing the aditus

### Twelfth Step: Opening the Deep Antral Region (Figure 21)

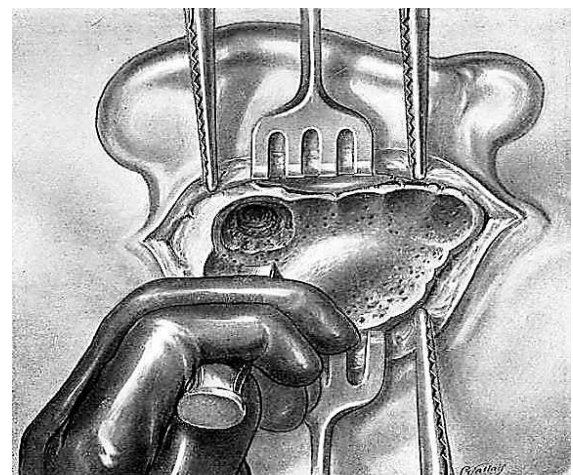


Figure 21: Approaching deep antral region

The antrum is enlarged toward its posterior part. Between the posterosuperior region just opened and the antrum there is a bony ridge which should be resected. This resec-



tion is performed with a gouge of medium calibre held obliquely from behind forward between the thumb and first two fingers of the left hand; the remaining two fingers rest on the bony surface. Thus, a horizontal trench is made which is almost perpendicular to the anterior vertical one.

**Thirteenth Step: Exploration of Deep Subantral Region (Retrofacial Groove)**

Between the deep antrum and mastoid tip there remains a bony, often cellular, mass which it is wise to remove. The antrum is thus continued below by a deep vertical trench. Exploration of this region sometimes reveals large cells located very deep in the bone. This resection may be performed with the gouge, using vertical blows first in front of the sinus then against the posterior wall of the canal which must be preserved. The curette, directed from above downwards, may be used. It is controlled by the index finger of the left of hand to avoid injury to the lateral sinus or a too deep curettage towards the facial nerve anteriorly. If the deep subantral region is narrow and the lateral sinus prominent, it is preferable to use a narrow-jawed curved rongeur (Figure 22).

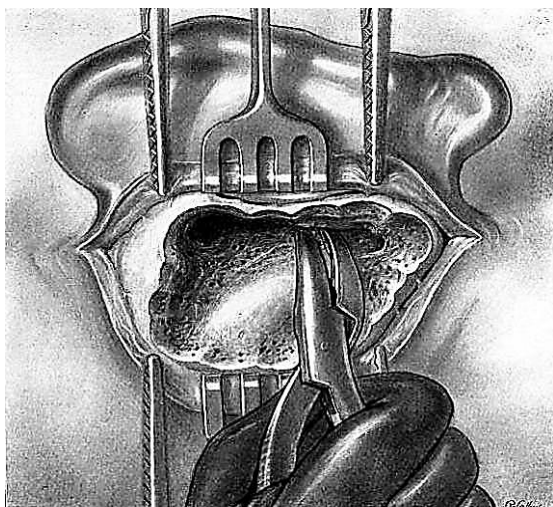


Figure 22: Using a narrow-jawed curved rongeur in the deep subantral region

The instrument is held in the right hand with the jaws parallel to the anterior aspect of the mastoid; this permits safe progress into the deeper re-gions between the facial nerve in front and the lateral sinus at the back.

**Fourteenth Step: Exploration and Cleansing of Operative Cavity (Figures 23, 24)**

The cavity is thoroughly explored and cleared of loose or adherent bony spicules. The edges and bottom are smoothed with a curette or rongeur. Suspicious areas are explored with a blunt probe which locates previously unnoticed cells and determines the presence of inflammatory granulations on the dura mater.

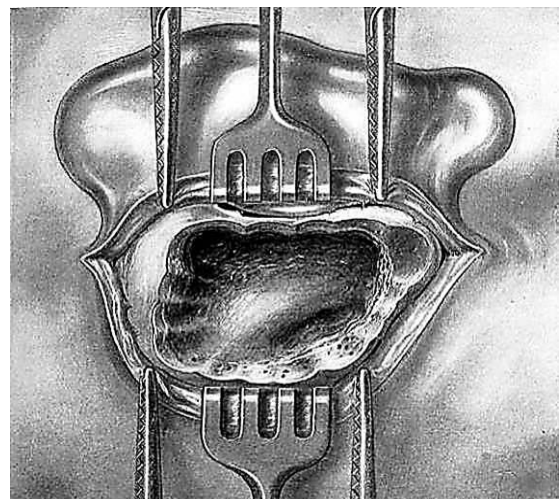


Figure 23: Cleaned cavity

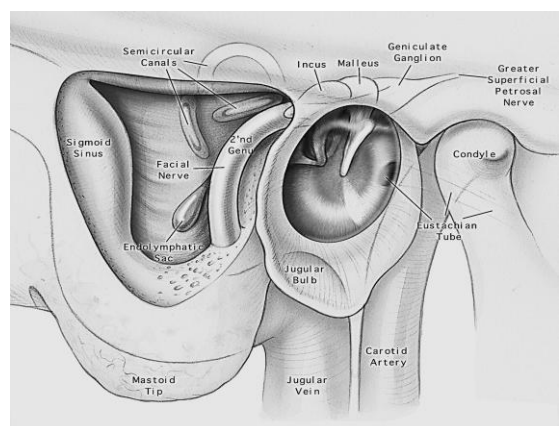


Figure 24: Schematic representation of anatomy of final cavity

### ***Fifteenth Step: Drainage and suturing and postoperative Care***

A glove/corrugated/pencil drain is inserted (Figure 25). The skin edges are carefully approximated. A pressure dressing is applied, held in place by a bandage wrapped around the head.

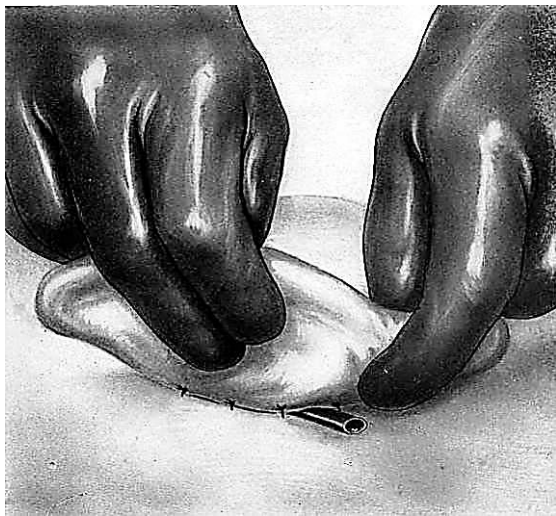


Figure 25: Pencil drain protruding from wound

Postoperative antibiotics are administered. The patient should be carefully monitored for several days to detect intracranial septic complications, as posterior fossa collections can have subtle clinical signs.

### **TEMPOROZYGOMATIC MASTOIDITIS**

The pneumatic cells adjacent to the middle ear may develop not only in the mastoid but also above the canal and the temporomandibular joint *i.e.* at the base of the squamous temporal bone (zygomatic arch). The base of the *squamosa* may be pneumatised either by way of the intermediary of the antral system or through the cells opening directly into the attic. This pneumatisation, however, may extend very high into the *squama temporalis*. Infection of the cells in the base of the squamous bone constitutes a paramastoiditis or temporozygo-

matic mastoiditis and necessitates a special operative technique.

If the infection in the base of the squamous bone is a consequence of an infection of the antral system, *i.e.* a true mastoiditis, the opening of the cells of the tympanic and temporomaxillary segments will only be an additional procedure to the mastoidectomy, which has previously been described.

If, on the other hand, the temporo-zygomatic mastoiditis is the result of an infection arising directly from the tympanic cavity and not including the mastoid itself, which may be verified easily by the absence of clinical symptoms at this level and by a normal radiographic picture of the mastoid, the operation will consist only of the opening of the cells in the temporozygomatic region.

### ***First Step: Incision***

The cutaneous incision of the mastoidectomy is extended 3.0 or 4.0 cm. above and in front of the auricle of the ear. This incision obliquely crosses the *linea temporalis*; it goes through to the bone, including the temporal muscle and the periosteum.

### ***Second Step: Periosteal Elevation***

The bone of the *squama temporalis* is exposed above and in front of the canal, if necessary, as far as the zygomatic arch. Whenever temporozygomatic mastoiditis is a complication of mastoiditis, the periosteal elevation naturally extends to include the entire external surface of the mastoid.



Figure 26: Exposed bone

### **Third Step: Exploration of the Bone**

Kocher haemostats are applied to the periosteal flaps and the portion of the temporal muscle, which bleed freely. Ligatures are applied to the muscular vessels. Two hooked retractors are held by the second assistant. The region being well exposed, the surgeon examines it for alterations in colour, form, and surface. The surgeon verifies the areas of osteitis and the possible presence of a fistula, which may be located in the *squama temporalis* under the muscle (deep temporozygomatic mastoiditis) or on the zygomatic arch immediately above the canal (superficial temporozygomatic mastoiditis).

### **Fourth Step: Trephining**

If a complete mastoidectomy has been performed, systematic exploration is carried out with a small gouge, starting from the antral region and including the entire base of the squamous bone, being guided by the existing lesions. If the mastoid is normal and if the radiological and clinical examinations have shown absolute integrity of the antral system, trephination is done above the canal in order to curette and cleanse the cavities of empyema and osteitic foci (Figure 27). This is continued until normal bone is encountered.



Figure 27: Trephination done above ear canal

### **Fifth Step: Exploration and Cleansing of the Operative Cavity**

The cavity is explored with great care. All the bony spicules, whether free or adherent are removed. The edges of the interior of the cavity are smoothed with the fine angular rongeur (Figure 28). The succeeding steps of this operation are the same as those for the mastoidectomy.

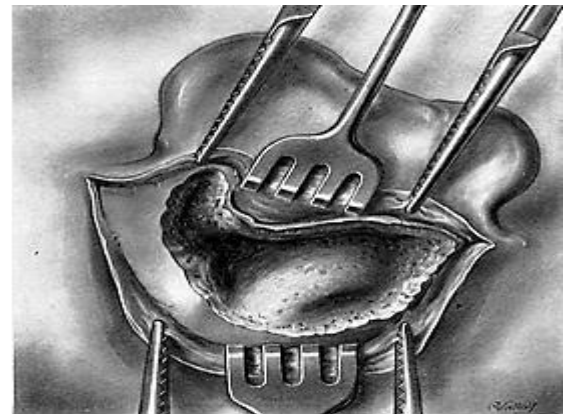


Figure 28: Final cavity

## **CERVICAL SEPSIS**

Lateral sinus thrombosis may be complicated by extension of sepsis down the internal jugular vein into the neck (Figure 29).

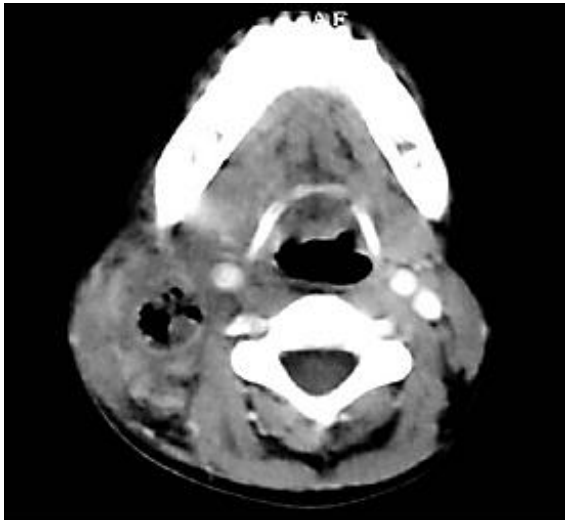


Figure 29: Extension of sepsis down internal jugular vein

Infection of the mastoid may also lead to the formation of cervical abscesses which vary according to their form of exteriorisation:

- Abscess of nape of neck in posteroinferior mastoiditis
- Substernomastoid abscess (Bezold's abscess)
- Internal aspect of mastoid tip, along digastric muscle
- Deep jugulodigastric cervical abscess (mastoiditis of *Mouret*)

## INTRAOPERATIVE INCIDENTS

### *Accidental Opening of Lateral Sinus or Mastoid Vein*

Opening of the lateral sinus is more severe if accidentally produced with a rongeur. The use of this instrument is therefore discouraged in the posterior region of the mastoid. Injury to the venous wall with the gouge is usually very limited and quickly settles. Bleeding can usually be controlled by packing off the sinus with Surgicel. If the haemorrhage persists or threatens to recur, the cavity is firmly packed with iodoform impregnated ribbon gauze, the end of which exits from the wound next to the drain. It is removed a few days later.

**Exposure of Meninges:** Exposure of the meninges is not a concern. No change in management is required.

**Tear of Meninges with Cerebrospinal Fluid leak:** A tear of the meninges is simply repaired with silk or other suture. If necessary, muscle or fascia can be used to augment the repair.

**Opening of lateral or posterior semicircular canal:** The canal is simply covered with fascia, which is held in place by muscle or gauze packing

## ANTROTOMY IN THE INFANT

Antrotomy is the surgical opening of the antrum, which is the principal mastoid cavity in the infant. The antrum is fully developed in the infant, as opposed to the mastoid that is not yet fully developed. The facial nerve is more superficial at the mastoid tip than in the adult. Indications for antrostomy include: Early acute mastoiditis unresponsive to antibiotics; complicated mastoiditis; subperiosteal abscess; intracranial complications (meningitis, abscess); facial paralysis secondary to mastoiditis; suspected tuberculous mastoiditis (remove sequestrum and obtain tissue for diagnosis of TB); and mastoiditis secondary to cholesteatoma

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