

CHAPTER 9.

MIDDLE EAR SURGERY

1. OTOSCLEROSIS

Otosclerosis is an aberrant proliferation of immature bone that develops on the footplate of the stapes.

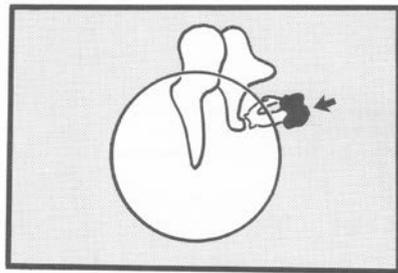


Figure 1: Otosclerosis. The stapes is fixed by a microfocus of immature bone that develops on the footplate, preventing sound transmission.

The problem is a congenital abnormality, usually transmitted as an autosomal dominant pattern, with a family history and which has a peak onset occurrence at 20-30 years age. Clinical evidence emerges in 0.5% of the population, more in Caucasians. The bone thickening fixes the stapes footplate, preventing sound transmission into the cochlea. The immature bone formation may extend further into the otic capsule causing a progressive sensorineural deafness later in life, such that some cases require cochlear implantation. The condition is not a neoplasm and

has no other clinical implications other than its effect on hearing

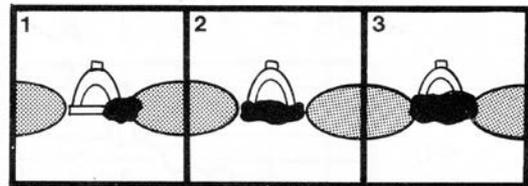


Figure 2: Variants of otosclerotic fixation patterns: 1. Focal, 2. "Biscuit" formation. 3. Obliterative.

Otosclerosis presents with gradually worsening conductive deafness, usually asymmetrical, perhaps unilateral, and without a preceding history of ear disease.

Tinnitus may be noted, either due to mild ototoxic effects, or by masking out the environmental noises, but no pain discharge or vertigo.

The drum is normal on examination, the weber refers to the deaf side and the Rinne is negative on that side. Rarely, a pink blush may be observed through the drum on the promontory and around the stapes (Schwarz's sign).

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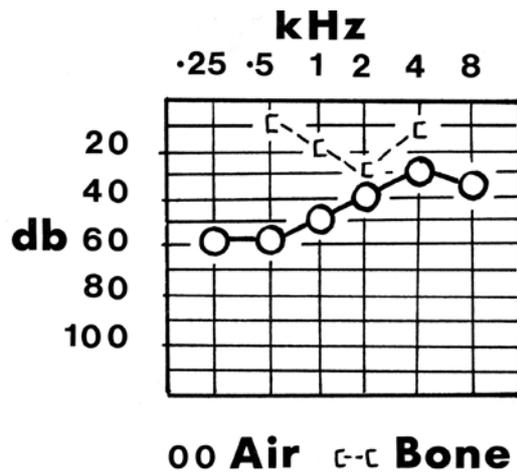


Figure 3: Pure tone audiometry in otosclerosis. A conductive deafness is evident, mainly in the lower frequencies. A small depression of the sensorineural reserves at 2000cps – a “Carhart’s Notch” – is typical for ossicular fixation, usually otosclerosis if the drum appears otherwise normal.

Audiology shows a low frequency conductive loss in the affected ear, and, typically, a subtle dip in the sensorineural response at 2000 cps – a “Carhart’s Notch”. In unilateral cases, tympanometry may show a slightly flattened Type A (normal pressure) curve, compared with its opposite number. In later stages, normally an elderly case, sensorineural deafness may be extreme or total.

Management

In its early to moderate phases, otosclerosis responds well to air conduction hearing aids.

Surgery, however, is normally highly effective. Original surgical treatment employed fenestration procedures; these were similar to simple mastoidectomy procedures, combined with the creation of a small entrance (fistula) into the lateral semicircular canal by high speed drilling.

The surgery was effective in many cases but was difficult, complicated and often unsuccessful.

Stapedectomy was introduced in 1958, and represented definitive management that remains the treatment of choice. The surgery is performed via the ear canal without external incisions. The eardrum is raised and then the stapes arch removed. A small hole is created in the stapes footplate by a micro-drill or laser and a piston-like prosthesis is attached to the incus by a small hook, the cylinder of the piston passing into the cochlea.

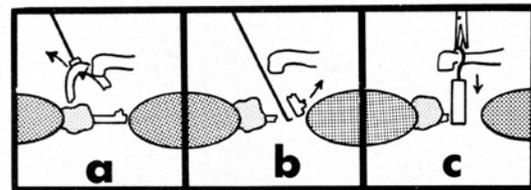


Figure 4: Stapedectomy: a. The stapes superstructure is removed after initial division of the incudostapedial joint and the stapedius tendon. b. A small area of the footplate is removed by instrumentation, a microdrill, or laser (stapedotomy). c. A micropiston prosthesis is placed on the long process of the incus, passing into the stapedotomy site. The piston has a fine platinum loop which passes around the long process and is crimped into position for stability.

The results are excellent, with optimal outcomes being achieved in over 90%, in expert hands.

Postoperatively The stapedectomy patient notices crackling echoing or hollow sounds that generally herald good restoration of hearing. Ringing tinnitus may be noted for several days after surgery but remits spontaneously. Generally hearing is restored very close to the preoperative sensorineural levels.

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Figure 5: Stapedectomy piston in situ, clipped to the long process of the incus.

Complications are unusual. Unexplained severe sensorineural losses are rare, but well documented. Some are due to small granulation formation at the stapedectomy site, others due to leakage of fluid from the cochlea (perilymph fistula). Prompt surgery is required to salvage the hearing in the latter instance.

2. CHRONIC MIDDLE EAR DISEASE SURGERY

Surgical Aims

- a) Elimination of disease
- b) Restoration of function
- c) Prevention of complications

Middle ear surgery, after relatively limited beginnings, became much more sophisticated with the development of the operating microscope in Sweden.

Being confined in small dark anatomical recesses, the surgery requires steady hands, fine instrumentation, good lighting and magnification and considerable expertise. It is difficult to both master and teach.

Classification

1. Drum Repair: Myringoplasty
2. Ossicular Chain Reconstruction: Ossiculoplasty
 - Assembly
 - Columella
 - Other
3. Mastoidectomy
 - Intact Canal Wall Mastoidectomy
 - Open Cavity Mastoidectomy
 - Mastoidectomy Elimination
 - Obliteration
 - Reconstruction
 - Ablation
4. Surgery for Otosclerosis
 - Fenestration
 - Stapedectomy
5. Adjunct EAC Widening Surgery
 - Superficial Meatoplasty
 - Anterior Wall Drill-back
 - Total Canalplasty

2.1 MYRINGOPLASTY

Myringoplasty requires not only closure of a drum defect, but also adequate exposure, removal of disease present, whether in the drum or its surrounds, and also steps to prevent recurrent problems. The canal will need to be widened for access.

Initial steps then remove disease. Heavy tympanosclerotic plaques, squamous epithelial ungergrowth or chronic myringitis may necessitate sacrifice of sections of the drum. Myringitis must be removed to avoid ongoing infection, whilst cholesteatoma must be cleared

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Some defects may be repaired with growth hormone techniques that avoid surgery. Otherwise, repairs can use several graft types, which are mainly autologous.

Graft Options

- Temporalis fascia or areolar tissue
- Perichondrium (tragal)
- Periosteum
- Split skin.
- Cartilage-perichondrial grafts (cymba cochae, intercrural fossa, tragal)



Figure 6: Myringoplasty. Temporalis fascia donor site.

In the past, homograft tissues have been used (dura or whole eardrums), but the associated technical and potential infectious aspects have rendered these obsolete.

Drum grafts can be placed upon the drum remnants (onlay), beneath (underlay), or the graft may be placed between separated layers of a thickened drum (inlay). Underlay methods are most widely used.

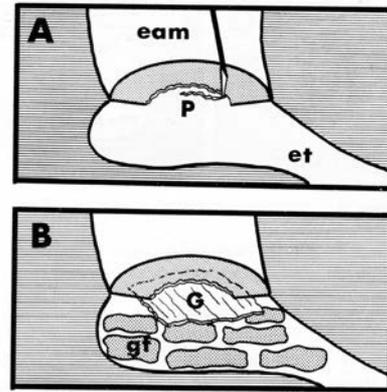


Figure 7: Underlay Myringoplasty Technique:

- The drum perforation (P) is de-edged to provide a raw surface to promote revascularisation of a soft tissue graft applied to the drum undersurface.
- A bed of soluble gelatin sponge is prepared in the middle ear and a soft tissue graft is laid over this. The drum is then replaced over the graft that becomes adherent to the drum.

Eac: external auditory meatus; et: Eustachian tube; gf: gelatin sponge; G: graft

For a successful procedure, the graft must be stabilised on a bed of soluble gelatin sponge, and the edge of the perforation is detached to induce vascular ingrowth to revitalise the graft, which is positioned to completely seal the undersurface of the drum defect. Non-adherent EAC micro-dressings are used to further stabilise the graft in its site, until it is firmly adherent. The EAC dressings are removed after 2-3 weeks.

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Figure 8: Perichondrial repair site, three years postoperative.

When there is evidence of Eustachian tubal insufficiency, soft grafts risk collapse into the middle ear. In these instances the cartilage-perichondrial grafts are useful to avoid this problem, being used as underlays.

In expert hands, myringoplasty succeeds in sealing the drum in over 90% of cases, but graft breakdown may occur in infected fields, compromised tissues, continuing tubal insufficiency, or other causes.

2.2 OSSICULOPLASTY

Chronic infection, cholesteatoma or trauma may result in chain damage and conductive deafness that requires repair to recover hearing. Chain repair is essentially micro-orthoapedics, utilising the patient's ossicles, refashioned to fit the site, or alternatively commercial prostheses. The surgery may be undertaken in its own right or combined with other disease removal or reparative procedures. In the great majority of cases, the incus is diseased or removed, possibly accompanied by an absent malleus and/or stapes superstructure.

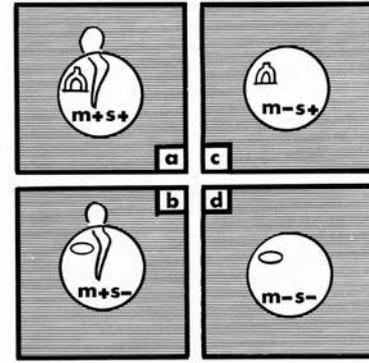


Figure 9: Ossicular Pathology, Austin ossicular classification: a. Malleus handle (MH) and stapes superstructure (SSS) both present. b. MH present, SSS absent. c. MH absent, SSS present. d. MH, SSS both absent. A fifth category (e) warrants addition, where the stapes function is compromised. This group is notorious for poor outcomes.

Chain repair aims to recreate sound transmission by columellar techniques (drum to the stapes head/footplate) or assembly methods (malleus to stapes head/footplate). Thus, there are four common situations.

Columellas are relatively simple to use, have good success rates, but may be unstable and prone to fixation or extrusion of biomaterials through the drum. Assemblies require slightly more technical skill and correct angulation for optimal results, but are favoured by experienced otologists.

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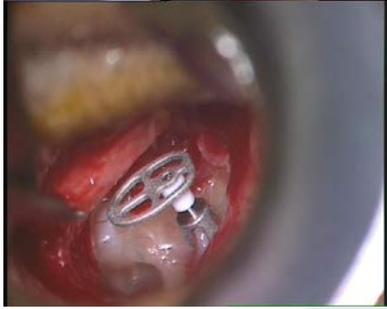


Figure 10: Ossiculoplasty: Titanium columellar prosthesis, sited on the stapes head.

Hydroxylapatite ceramic (calcium phosphate), or titanium in composition. Experts report success rates up to 90% in favourable situations, but less in more challenging circumstances.

2.3.MASTOIDECTOMY SURGERY

Intact Canal Wall Techniques

- a) Simple/Cortical Mastoidectomy
- b) ICW, Canal Wall Up (CWU) Mastoidectomy



Figure 11: Incision for postaural approach surgery.

Simple, or cortical mastoidectomy was originally devised for acute or chronic mastoiditis in the 19th century, effectively exenterating the mastoid air cell system, but retaining the external canal wall.

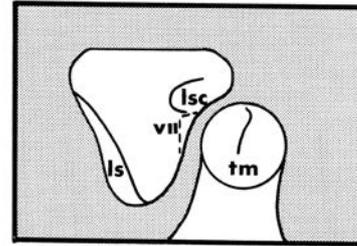


Figure 12: Simple, or cortical mastoidectomy, undertaken for non-cholesteatomatous chronic mastoiditis. The mastoid cell system is cleared to completely eradicate infection from the site. The middle ear, drum and chain remain intact.

The surgery is performed via a postaural incision, or sometimes an endaural approach (widening the EAC via an incision that passes from within the upper canal superiorly along the anterior margin of the helix, above the canal). Clearing disease was effective for chronic mastoiditis, and the technique remains valid in this role, but not for cholesteatoma, due to retained foci of this pathology; the technique therefore was discontinued in this role.

From the later 1950s this limited mastoidectomy surgery was revived for use in cholesteatoma cases as ICW/CWU surgery, using more extensive exposure and microsurgery for meticulous clearance, and also employing a posterior tympanotomy to view the middle ear. Drum and chain repair are undertaken concurrently.

The main drawbacks of the surgery are the risks of residual and recurrent cholesteatoma. To counter the former frequently requires a planned two stage surgery, twelve months apart. The second is minimised by composite cartilage-perichondrial drum grafts, plus careful canal wall

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repairs using combinations of bone, cartilage, hydroxylapatite or titanium.

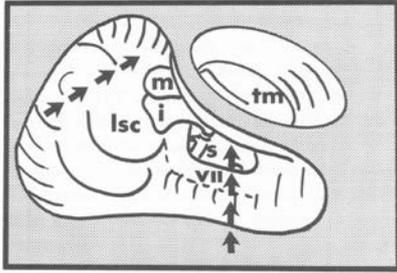


Figure 13: Intact canal wall (ICW)/Canal wall up (CWU) mastoidectomy / Combined approach tympanoplasty (CAT), surgeon's view from posteriorly. The ICW approach resembles an extended simple mastoidectomy, but with extensive attic exposure, and here with a posterior tympanotomy into the rear of the middle ear. Lsc: lateral semicircular canal; m: malleus; i: incus; s: stapes; tm: tympanic membrane (via the eam).

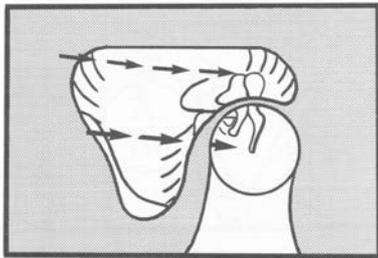


Figure 14: ICW mastoidectomy, lateral view demonstrating the surgical approaches to the attic and middle ear for cholesteatoma removal

ICW is the preferred technique by a majority of specialist otologists, as it gives the best chance of a fully rehabilitated ear after cholesteatoma.

Open Cavity Mastoidectomy Techniques

- Radical Mastoidectomy
- Modified Radical Mastoidectomy
- Atticotomy

In the late 1800s, recurrent/residual cholesteatoma complications of simple mastoidectomy lead to more aggressive surgical methods. To avoid major life-threatening complications, the surgeons instead opened the cleared mastoid into the external auditory canal, effectively employing tumour surgery principles to evacuate the problem and minimise the risk of recurrence. In addition, the drum and chain were removed, possibly leaving an open drum site.

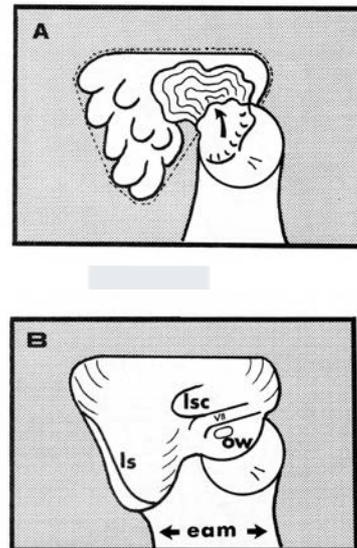


Figure 15: Radical mastoidectomy. (A) Extent of tissue removal. Radical open cavity surgery is performed for pars tensa type cholesteatoma, clearing the middle ear, attic and mastoid cell system. (B) Resultant mastoid cavity, partial drum defect.

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The eviscerated mastoid bowl is generally left to self-epithelialise, or a soft tissue flap may be placed to line the site. However, healing problems are frequent. The surgery effectively destroys the vascular supply to the site, and the self-cleaning epithelial flow is commonly disrupted. This gives rise to debris accumulation, chronic myringitic changes and a need for perpetual regular cleaning of a severely deafened ear

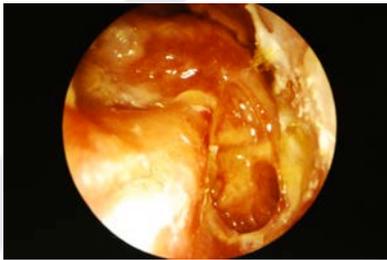


Figure 16. Radical mastoidectomy, outcome. The middle ear cleft is totally cleared by the open cavity technique, leaving only drum remnants. The external canal is widened by a meatoplasty.

To improve the technique, drum and ossicular retention/repair were appended, the result being a modified open cavity situation, but with lingering risk of cavity symptomatology.

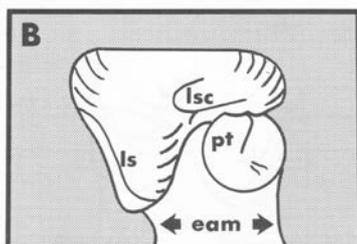
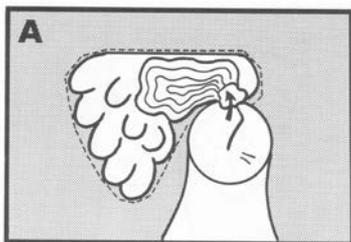


Figure 17: Modified radical mastoidectomy open cavity. (A) Extent of mastoid and middle ear clearance. The drum remains intact and the middle ear sealed off. (B) Surgical result, drum intact. As with radical procedures, the external canal is widened. lsc: lateral semicircular canal; ls: lateral sinus; pt: pars tensa; eam: external auditory canal.



Figure 18: Modified radical mastoidectomy site. In contrast to the radical procedure, the drum remains intact; this permits an ossiculoplasty, if appropriate.

Atticotomy was developed as a minimalist open cavity procedure for small cholesteatomas. The attic and middle ear are cleared by limited removal of the canal wall, leaving a small cavity at the site of the attic and aditus.



Figure 19: Atticotomy. Limited open cavity resection for smaller cholesteatomas. Potential risk of recurrent disease into the mastoid, also possible retention of mastoid infection.

This however remains at risk of recurrent disease into the remaining mastoid and also exposed respiratory epithelium. If these are sealed off,

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there is a risk of enclosed residual disease in the sensitive attic site. The technique is applicable only to smaller disease, and may need to be modified to a full open cavity if the cholesteatoma is more extensive or if the mastoid is infected.

Mastoidectomy Elimination Surgery

Open cavity mastoidectomy procedures commonly result in ongoing adverse outcomes related to the cavity creation. To overcome the problem, the cavity site may need to be eliminated.

Three options are available

- a) Obliteration
- b) Reconstruction
- c) Ablation (EAC closure).

a) Obliteration

These techniques aim to solve the cavity problem by filling the site with either tissue flaps or “filler” – avascular organic or commercial products. The technique risks infection, resorption of the material used, or residual disease buried under the repair.

b) Canal Wall Reconstruction

Mastoidectomy reconstruction requires exact repair of the EAC canal wall with a durable (hydroxylapatite ceramic or titanium) support material, overlain with a middle temporal vascular flap that restores canal vitality. The risks are similar to ICW surgery.

c) Cavity Ablation (EAC closure)

Ablation totally closes off the middle ear site from the exterior, and is effective in severely damaged cases. Previously used more in cases with irreparable sensorineural deafness, the procedure is now extended to cases that may benefit from the use of active implants to restore hearing, concurrent with second stage surgery to check for residual disease.

2.4. CANAL WIDENING SURGERY

When possible, reparative ear surgery is optimally performed via the EAC rather than a postaural incision. Also, in various situations it is desirable to enlarge or repair the canal, using one or combinations of several procedures.

Techniques

- a) Meatoplasty (enlarging the EAC entrance)
- b) Anterior wall drill-back
- c) Total Canalplasty (grafting extensive loss of canal skin)

a) Meatoplasty

Widening the canal entrance alone is best undertaken using Hunsaker method. The canal has an S-bend course, sometimes pronounced, which is intended to prevent penetrating injury to the middle ear. To enlarge a narrowed canal entrance, a crescent of anterior conchal bowl skin is elevated, together with the skin of the posterior canal wall, down to the level of the bony canal. The superficial cartilage and soft tissues thus exposed are excised, which straightens and widens the canal. The straightening effect produces a surplus of skin in the raised conchal bowl skin; this is detached and used as a free full

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thickness graft to cover any bare surface caused by widening the entry.

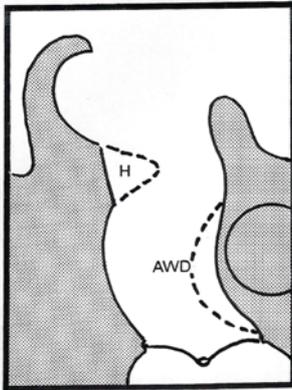


Figure 20: Widening the EAC. Combined Hunsaker meatoplasty (H) and anterior wall drill-back (AWD).

b) Anterior Canal Wall Drill-back

The overhang of the anterior bony wall of a curved EAC commonly obscures the anterior eardrum. If an anterior drum perforation is present access for repair is impeded. A postaural approach will suffice, but is more traumatic, scarred, and the graft site remains obscured postoperatively. Drilling back the anterior wall permits transcanal access and postoperative monitoring.

The anterior wall skin is raised as a thin flap, from an incision placed a few millimetres superficial to the bony-cartilaginous junction. Underlying soft tissue is incised along the anterior edge of the tympanic plate, and the overlying soft tissue is removed to display the thickness of the plate. Skin elevation off the bony wall is carried medially as far as possible, then the skin is guarded with a sheet of 0.020 inch Silastic sheeting, while the anterior wall is drilled back, avoiding the temporomandibular joint. The skin is laid back whilst the drum is grafted and then packed into position.

c) Total Canalplasty

Deep canal pathology is a not uncommon cause of loss of all or part of the deep canal skin. Severely stenosed canals may leave significant skin deficits if the canal is widened. Chronic myringitis that extends from an old perforation, and obliterative fibrosis from onlay surgery or other deep canal disease may cause similar problems. Loss of the skin is difficult to correct without resorting to split skin grafting. These grafts poorly withstand humidity; superficial EAC widening is advisable to dry out the deep canal.

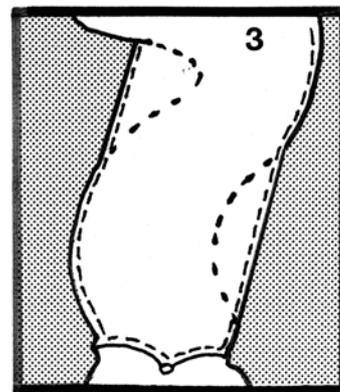


Figure 21: Total Canalplasty. The entry and anterior wall are widened, and the canal totally lined with split skin.

Whilst skin rotation flaps and other manoeuvres have been described, it is often simpler to “core-out” the remaining canal skin to a wider diameter canal, then skin graft the entirety. Also, the deep canal can be concurrently drilled out to fashion a wider lumen and to prevent overhang. Drum and chain repair can also proceed.

The resultant more cylindrical EAC is covered entirely by split skin harvested from the axilla, to avoid bare bone defects that delay healing or soft tissue that granulates, possibly causing strictures. The grafts are packed into place and are stable around the 5-week mark. They require occasional cleaning on a 6-12 monthly basis in the long term.

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