



## LATERAL TEMPORAL BONE RESECTION SURGICAL TECHNIQUE

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Lateral temporal bone resection refers to *en bloc* resection of the external auditory canal (EAC) with the tympanic membrane (TM). It is generally performed for malignancies involving the EAC, the most common being primary squamous cell carcinoma. Tumours may arise from the skin of the external ear, parotid, glandular adnexa of the ear or may be metastases to parotid nodes.

### History and examination

History and examination are directed at making a diagnosis and determining the extent of the tumour. Refractory pain is a hallmark of advanced malignancy of the ear canal. Other presenting symptoms include chronic ear discharge and hearing loss. A lesion of the ear canal may be visible and there may be a discharge. The parotid and neck should be examined for evidence of metastases. Facial nerve function should be documented. Assessing sensation of the face on the affected side as well as the lower cranial nerves is crucial to detect intracranial and inferomedial extension to the jugular foramen. Differential diagnoses include skull base osteomyelitis and inflammatory conditions *e.g.* TB.

### Special investigations

The tumour is biopsied in the office to confirm the diagnosis. Imaging is requested to:

- Determine local extent of the tumour
- Stage the tumour (see below)
- Determine its operability
- Rule out regional nodal metastases to parotid and cervical nodes
- Plan the surgical approach

High resolution CT scans (0.5mm slices with and without contrast) of the temporal bone, brain, parotid and neck allow assess-

ment of the soft tissue extent, bony destruction, as well as clinical staging. MRI is useful to assess soft tissue involvement particularly if disease appears to have breached the EAC/TM and there is concern about involvement of dura or brain. Pure tone audiometry should be performed. Carotid angiography +/- balloon occlusion is considered if surgery is contemplated and there is concern about carotid artery involvement.

### Modified Pittsburgh Staging System

**T1:** Limited to EAC without bony or soft tissue extension into mastoid/middle ear

**T2:** Limited EAC erosion (not full thickness) or radiological findings consistent with <0.5cm soft tissue involvement

**T3:** Full thickness erosion of EAC with <0.5cm soft tissue involvement or facial nerve paralysis

**T4:** Eroding cochlea, petrous apex, carotid canal, jugular foramen, medial wall of middle ear, dura or with >0.5cm soft tissue extension

### Practical application of staging system

**T1:** Sleeve resection or lateral temporal bone resection

**T2:** Lateral temporal bone resection

**T3:** May be suited to lateral temporal bone resection with sacrifice of facial nerve

**T4:** Not amenable to lateral temporal bone resection

### Surgical Anatomy

The lateral 1/3 of the EAC is composed of fibroelastic cartilage and contains the *Fissures of Santorini* - these communicate with the parotid anteriorly and the soft tissue overlying the mastoid posteriorly. The medial 2/3 of the EAC consists mainly of the tympanic portion of the temporal bone.

Important relations of the EAC include the *tegmen tympani* superiorly, mastoid bone posteriorly, styloid process inferiorly, and temporomandibular joint (TMJ) anteriorly (Figures 1 and 2). The *foramen of Huschke* is a developmental defect in the EAC and may provide a route of communication to the parotid gland and infratemporal fossa. If disease breaches the EAC it can invade several areas including the stylomastoid foramen, carotid canal, jugular foramen, petrotympanic fissure and eustachian tube.

Lymphatic spread of SCC of the temporal bone occurs in about 10% of patients whilst inflammatory lymphadenopathy occurs more commonly. Tumours of the pinna or EAC can metastasise to preauricular, infra-auri-

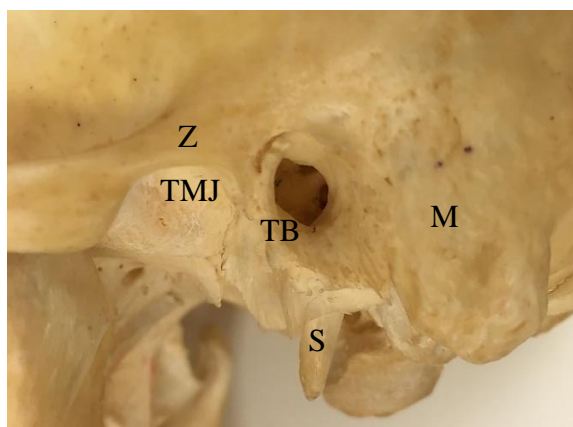


Figure 1: Lateral view of relations of EAC. TMJ = Temporomandibular joint; S = Styloid; TB = tympanic bone; M = Mastoid; Z = Zygoma

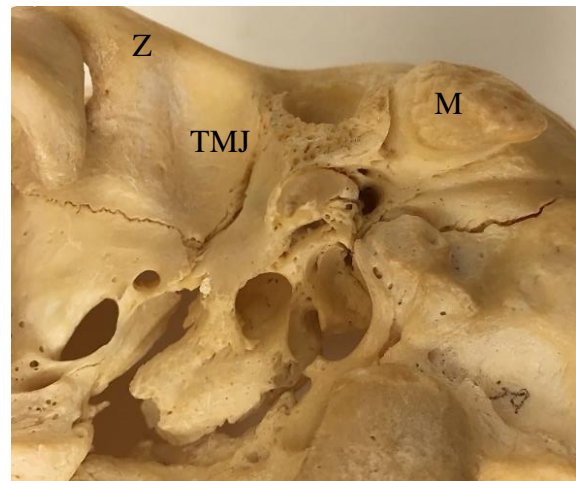


Figure 2: Inferior view of relations of EAC

cular, parotid, postauricular, or Level 2 nodes. The mucosa of the middle ear and mastoid drain to lymphatics around the eustachian tube which then drain into the deep upper jugular and retropharyngeal lymph nodes. The inner ear has no known lymphatic drainage system.

### Surgical steps

#### Skin incisions

- Make a C-shaped postauricular incision (Figure 1)



Figure 3: Example of incision for lateral temporal bone resection involving concha/tragus resection, parotidectomy and selective neck dissection

- Place it far posterior to the postauricular crease so that the sigmoid sinus can be adequately exposed
- An adequate margin around the tumour is needed. This typically involves resecting part of the concha and tragus (*Figure 3*) or the entire pinna
- The incision can be modified depending on tumour size and location
- If a neck dissection is planned, the incision is extended into a cervical skin crease
- An anterior limb at the level of the hyoid bone is useful if a parotidectomy is to be performed

#### ***Skin flaps and soft tissue dissection***

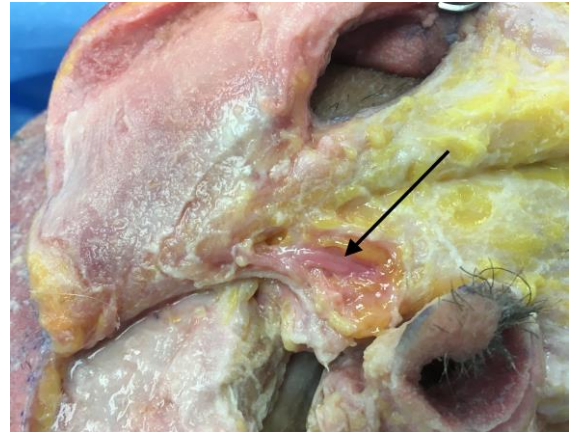
- Raise the skin flap from back-to-front (*Figure 4*)



*Figure 4: Skin flap elevated anteriorly around resection margins*

- If a parotidectomy is required, raise the skin flap with the pinna up to the anterior border of the parotid
- Preserve the superficial temporal artery (*Figure 5*) to maintain the blood supply to the ear if the pinna is being preserved
- Incise the temporalis fascia and muscle along the temporal line (*Figure 6*)

- Expose the root of the zygoma; this is critical as it is the landmark when drilling to expose the TMJ
- Elevate the soft tissue and periosteum over the mastoid bone. This soft tissue can be excised and sent for frozen section histology (*Figure 6*)



*Figure 5: Skin flap elevated forwards over parotid. The superficial temporal artery has been identified and preserved (arrow)*



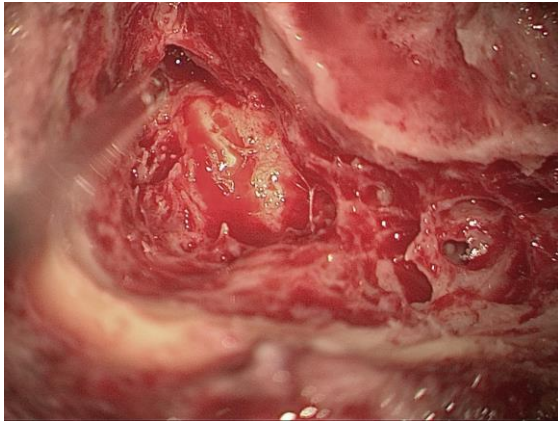
*Figure 6: Periosteum over mastoid has been excised and sent for histology. The temporalis muscle has been reflected superiorly*

#### ***Bone dissection***

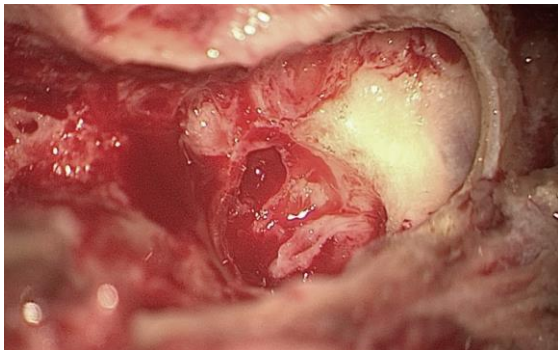
- Perform a [cortical mastoidectomy](#)
- Skeletonise the tegmen tympani and sigmoid sinus (*Figure 7*)
- Drill out the mastoid tip to expose the digastric ridge and retrofacial air cells (*Figure 8*)



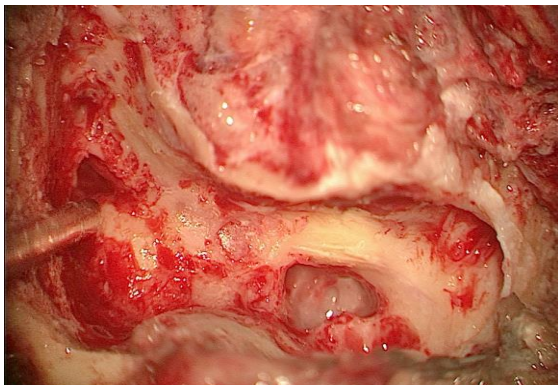
- Skeletonise the mastoid segment of the facial nerve (*Figure 9*)
- Keep the posterior bony ear canal relatively thick to avoid inadvertent exposure of cancer
- Perform a posterior tympanotomy (*Figures 10ab*)



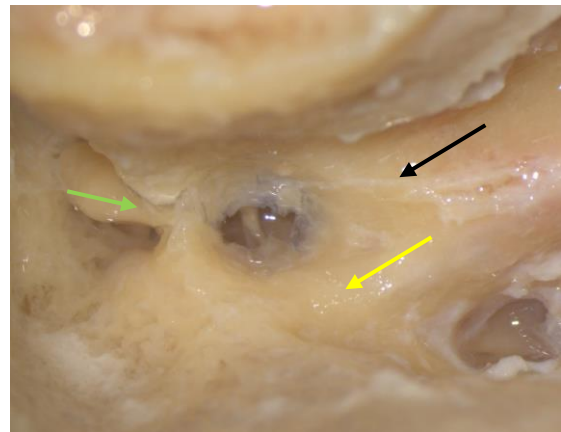
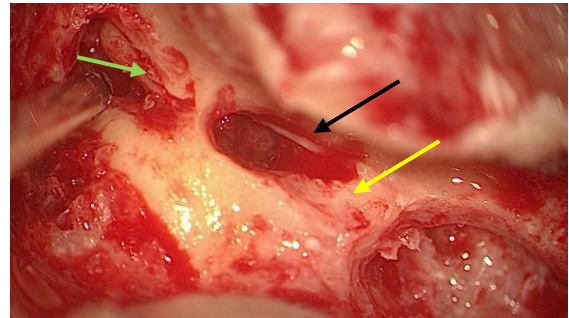
*Figure 7: Skeletonise tegmen tympani and sigmoid sinus*



*Figure 8: Drill out the mastoid tip to expose digastric ridge and retrofacial air cells*

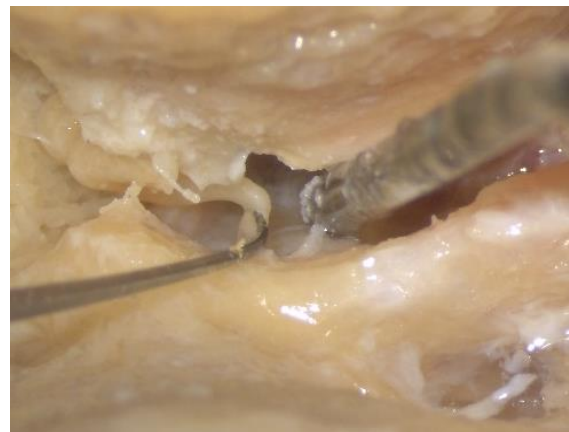


*Figure 9: Skeletonise the mastoid segment of the facial nerve*



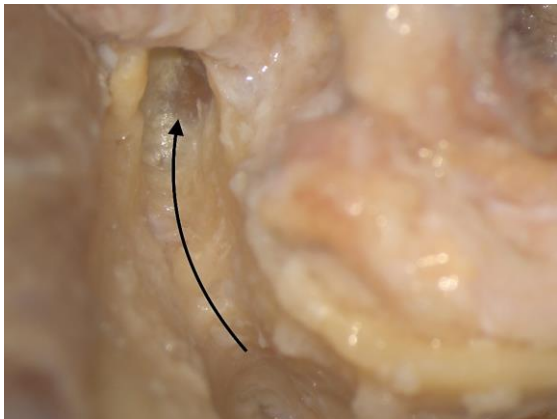
*Figures 10ab: The beginnings of a posterior tympanotomy. The chorda tympani (black arrow) forms the anterior boundary and the facial nerve (yellow arrow) the posterior boundary. Note short process of incus in fossa incudes (green arrow)*

- Separate the incudostapedial joint with a joint knife to avoid causing sensorineural hearing loss when drilling in the epitympanum should the burr touch the ossicles (*Figure 11*)



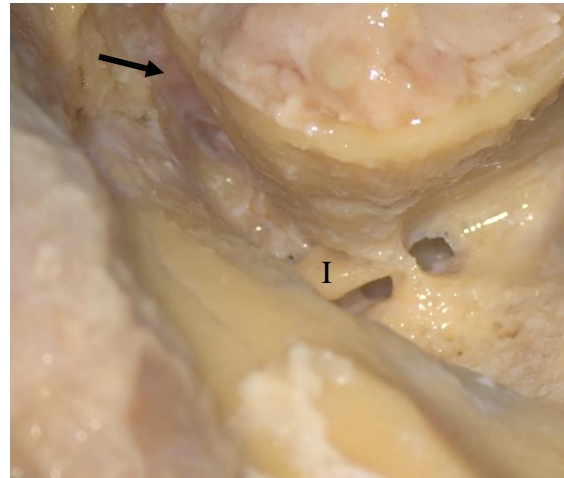
*Figure 11: Disarticulating incudostapedial joint*

- Drill the bone superior to the EAC towards the root of the zygoma in the space between the tegmen tympani and the EAC, using progressively smaller burs (Figure 12)



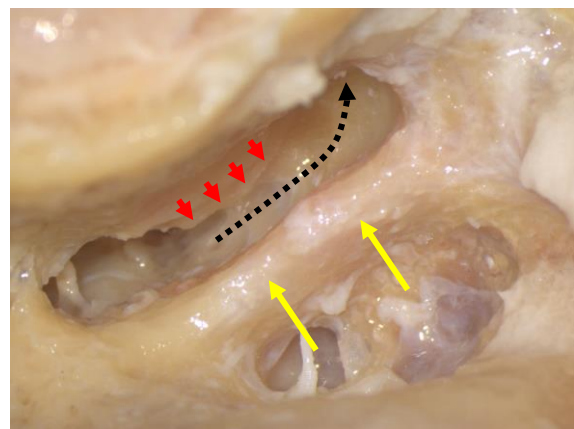
*Figure 12: The curved arrow shows the drilling trajectory towards the root of zygoma. Arrowhead points to the TMJ capsule*

- When there is limited space between the tegmen and the ear canal, it may be necessary to remove the bone of the tegmen and expose dura rather than to overthin the ear canal and expose cancer
- Use a diamond burr to avoid injuring the dura and causing a CSF leak
- Avoid sharp ledges of bone over the dura to allow good light into the surgical field
- Once one reaches the 12 o'clock position of the ear canal, direct the drilling trajectory inferiorly
- Expose the anterior epitympanum
- At this point one can remove the incus and use a malleus nipper to remove the malleus head
- Keep drilling anteriorly until the TMJ capsule becomes apparent. It is soft and whiter in colour (Figures 12, 13)
- Ensure that the TMJ capsule is exposed all the way from the ossicular heads medially to the squamous temporal bone laterally
- Perform an extended posterior tympanotomy by drilling inferiorly along the anterior border of the mastoid segment of



*Figure 13: The TMJ (arrow) has been exposed anterior to the ossicular heads, medial to the squamous temporal bone (I = Incus)*

the facial nerve – this requires transection of the chorda; the fibrous (tympanic) annulus becomes the medial border of the resection (Figure 14)



*Figure 14: Extended posterior tympanotomy (chorda transected). Facial nerve (Yellow arrow), Annulus (Red arrows)*

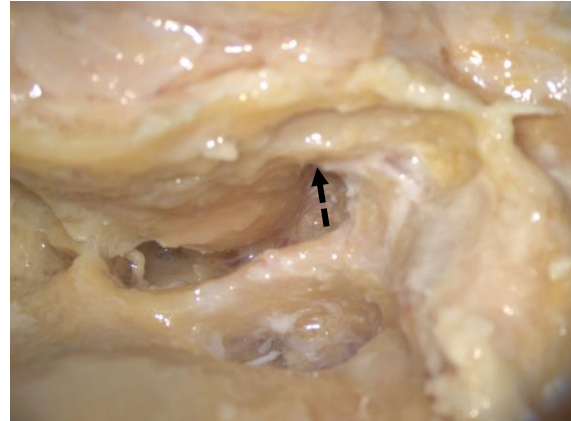
- Continue the dissection inferior to the bony ear canal in an anterolateral direction (deep to superficial) towards the glenoid fossa
- It is important to use the correct burr: Never use a cutting burr as one needs a longer burr to drill anteriorly. It is dangerous to use a cutting burr, as a long cutting burr can “jump” risking injury to the carotid and jugular bulb. An appropriate-



sized (2-2.5mm) diamond burr should rather be used

- It is important to check the height of the jugular bulb on the CT scan to ensure that the jugular bulb is not inadvertently injured!
- Continue drilling until soft tissue is encountered (*Figure 15*)
- The 2<sup>nd</sup> author (TH) favours a different technique to reduce the risk of the drill injuring the carotid. She drills into the bone in the hypotympanum under direct vision to weaken it, then switches to an osteotome which is directed lateral to the Eustachian tube (carotid forms medial wall of Eustachian tube)
- With an anterior sigmoid sinus, a favourable angle for drilling is obtained by ensuring the bone over the sigmoid is removed - this enables a flatter trajectory so that the jugular bulb and carotid are avoided
- While drilling, it is useful to gently rock the block of bone encasing the EAC anteriorly to determine where it is still attached
- With TMJ capsule exposed superiorly, and glenoid cavity exposed inferiorly, only the thin tympanic bone remains intact anteriorly and is therefore the only remaining bony attachment of the block of bone enclosing the EAC
- Apply gentle anterograde pressure to fracture this thin tympanic bone of the anterior canal (*Figure 16*)
- If the bone does not fracture readily, then a 2mm osteotome or 2mm burr can be used through the posterior tympanotomy to fracture the anterior ear canal
- Alternatively, a curved osteotome is passed medial to the TM, malleus and incus (this has been removed) to fracture the tympanic bone, taking care to remain lateral to the Eustachian tube (internal carotid artery passes medial to Eustachian tube). A useful trick is to turn the osteotome so that the bevelled edge faces the promontory and to angle the osteo-

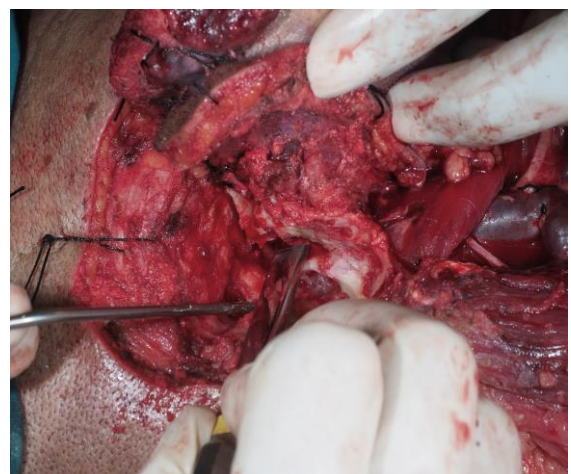
tome so that it points upwards (*Figure 17*)



*Figure 15: Drilling inferior to the ear canal*

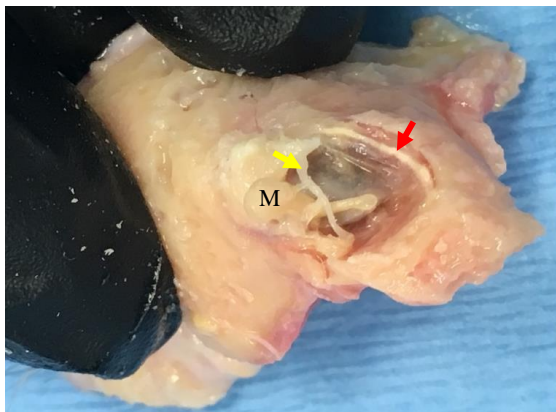


*Figure 16: Gentle anterior pressure applied to the bone encasing the EAC to fracture the medial part of the anterior wall of the EAC*



*Figure 17: Curved osteotome passed medial to the TM, malleus and incus to fracture the tympanic bone*

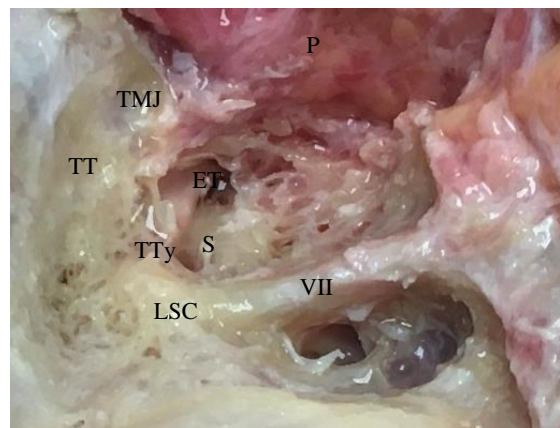
- At this point, the anterior soft tissue attachments of the EAC can be dissected to remove the bone encasing the EAC with the TM and malleus (*Figures 18 and 19*)



*Figure 18: Surgical specimen viewed from medial side. Note the fibrous annulus (red arrow), the malleus (M), the medial surface of the EAC and the chorda tympani (yellow arrow)*

### **Managing bleeding**

- **Minor sigmoid sinus bleeds with intact bone around the sinus** can be controlled with bone wax
- **Bleeding from the sigmoid sinus** can be **managed** with application of haemostatic agents such as *Haemopatch*, *Surgicel* or *Flowseal* with a patty for compression. It is important to remember that venous bleeding should not cause panic and gentle pressure is much better than undue force which will only make the bleeding site widen.
- **Jugular bulb bleeding** can be more troublesome. A small bleed from the bulb tip can easily be dealt with using bone wax. However, significant bleeding can occur **because** of excess force used when cracking off the last bony attachments, leading to the bone fracturing along the jugular bulb or even the carotid canal.



*Figure 19: Surgical bed following lateral temporal bone resection; P = parotid; tensor tympani = TTy; tegmen tympani = TT; TMJ = temporomandibular joint; facial nerve = VII; Eustachian tube = ET; stapes = S; lateral semicircular canal = LSC*

- This can occur if the bone of the styloid apparatus has not been adequately drilled off the tympanic ring or there has **been inadequate drilling around the anterior canal towards the glenoid fossa inferiorly**. Jugular bulb bleeding at this site can rapidly fill the surgical field due to brisk sigmoid and inferior petrosal sinus blood flow. Sternocleidomastoid muscle can be mobilised and applied with gentle pressure to plug the area. Free muscle can be oversewn between the glenoid/parotid tissue and the sternomastoid muscle as a patch. In the event of

uncontrolled bleeding, the jugular vein is ligated in the upper neck and the sigmoid sinus and inferior petrosal sinuses are packed with *Surgicel* through the tear in the jugular bulb.

- The 2<sup>nd</sup> author applies pressure by packing with *Surgicel*, then ligates the jugular vein in the neck and the sigmoid in the mastoid cavity
- Skeletonise the sigmoid sinus, then remove the thin shell of bone over a small section of the sigmoid by using a Plester knife
- Use an aneurysm needle threaded with a double silk ligature and pass it behind the sigmoid sinus by making small slits in the dura next to the sigmoid sinus. Remove the needle, leaving behind the double ligature and tie these. This may cause a small CSF leak. This can be plugged using fat



Figure 20: Aneurysm needle

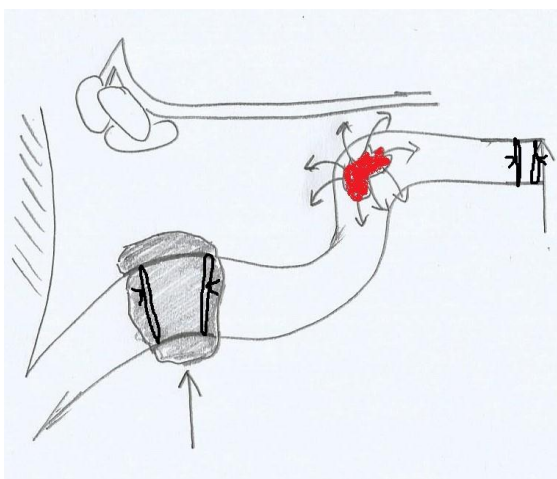


Figure 21: Double ligatures tied around sigmoid sinus

- Complete the operation by obliterating the cavity with a temporalis muscle flap

## Ancillary procedures

**Parotidectomy:** If parotidectomy is to be done, it is best to do it before the lateral temporal bone resection. Superficial parotidectomy is usually performed for T1/2 tumours. Total parotidectomy is done for T3/4 tumours. For BCC without parotid invasion, parotidectomy is not required.

**Temporomandibular joint:** If tumour extends into or near the TMJ, a partial mandibulectomy is performed. Typically, this involves a condylectomy (*Figure 22*), but for more extensive disease the resection may extend from the mandibular notch to the angle of mandible.

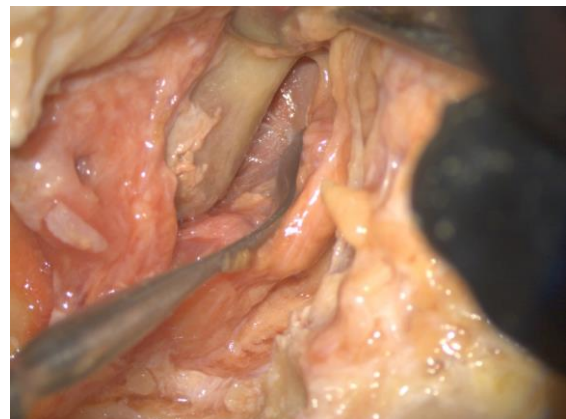


Figure 22: Exposure of mandibular condyle. An incision has been made on the condyle and the periosteum has been elevated so that it can be drilled

**Neck dissection:** For SCC with or without nodal metastasis, neck dissection including Levels 1b, 2-5 should be considered.

## Reconstruction

If the **pinna is preserved** but the concha and tragus are removed, then reconstruction can be performed using a pedicled muscle flap e.g. [temporalis muscle](#) can be rotated over the cavity and sutured to the sternocleidomastoid muscle (*Figure 23*). The canal can be oversewn and the pinna placed back in position. If the pinna is resected, a split skin



graft can also be placed over the temporalis muscle: this usually works quite well if one can't do a free flap (*Figure 24*).



*Figure 23: Temporalis muscle reflected over temporal bone defect*



*Figure 24: Split skin graft over temporalis muscle*

- An alternative is to fashion an open mastoid cavity, but such a cavity will take a long time to heal and regular debridement in the office is required
- When the **pinna is removed**, local flaps ([temporalis](#); [cervicofacial](#) (*Figure 25*),

[submental](#), [supraclavicular](#) (*See clinical example*), [latissimus dorsi](#)) or free flaps are required. The [anterolateral thigh flap](#) is a particularly useful flap as it provides both bulk and skin cover.



*Figure 25: Cervicofacial flap*

- Bone anchored hearing aids are an excellent choice for rehabilitation. Ideally it should be fitted at the time of the resection, as irradiation may compromise osseointegration. Although there may be some artefact with CT scans, most bone anchored hearing aid systems are MRI safe up to 3T with no adverse effects.
- Nonimplanted bone conduction hearing aids or even contralateral routing of sound hearing aids can also be used

### Related procedures

**Sleeve resection:** This can be done for non-aggressive tumours of the cartilaginous EAC without bony invasion. However, patients rarely present early enough for it to be done.

**Near-total temporal bone resection:** This should be considered for tumours extending medial to the TM or into the mastoid. The resection involves removing the temporal

bone leaving only the petrous apex attached to the clivus. The facial and vestibulocochlear nerves are sacrificed. The surgical technique involves a temporal craniotomy, transmastoid and transcervical approaches. If dura is involved, it can be resected with the specimen, but involvement of the brain implies the tumour should be considered incurable.

**Total temporal bone resection:** This involves *en bloc* resection of the temporal bone including the petrous apex and sigmoid sinus. There is no evidence that this improves survival and is not part of the authors' practice.

### Clinical Example

This patient had extensive squamous carcinoma of the pinna extending into the ear canal and the parotid and nodal metastases. The incision was extended into the neck ("hockey stick") for a modified radical neck dissection and parotidectomy (Figure 26). The facial nerve was intact and a superficial parotidectomy was done by retrograde dissection of the facial nerve.



Figure 26: Extensive squamous cell carcinoma



Figure 27: Mastoid being exposed after neck dissection and superficial parotidectomy have been completed

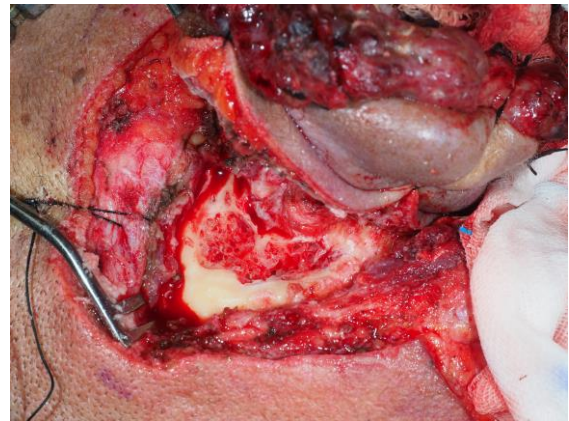


Figure 28: Commencement of cortical mastoidectomy

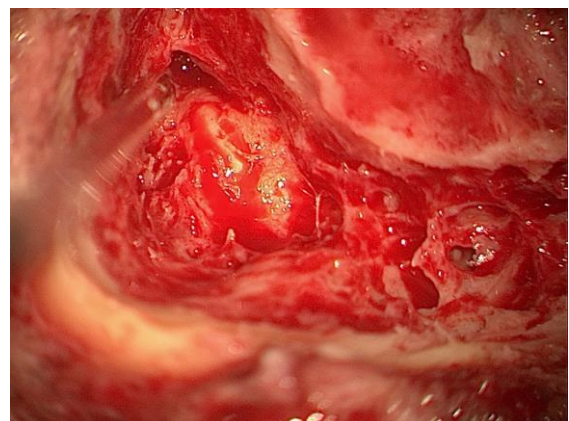
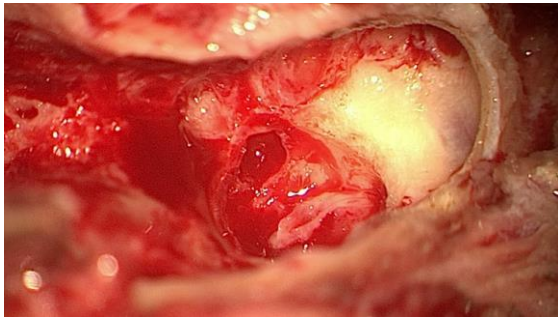
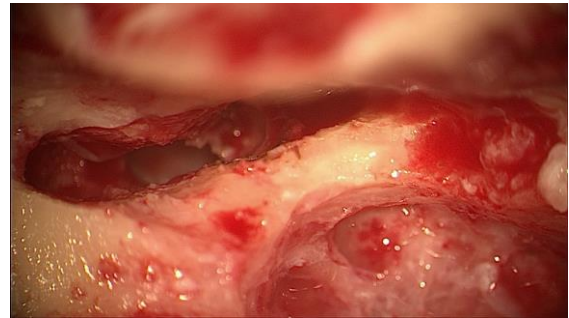


Figure 29: Cortical mastoidectomy with exposure of lateral semicircular canal

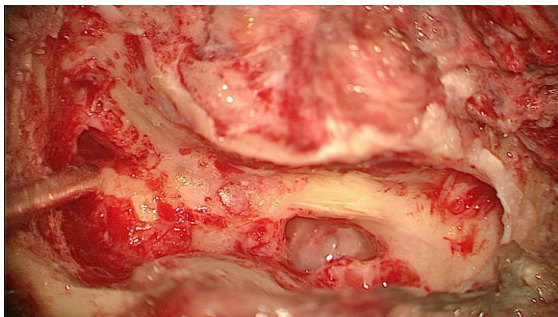




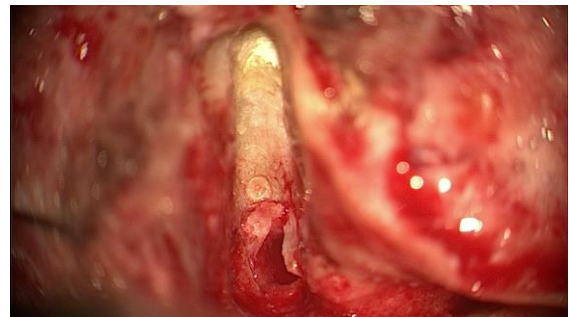
*Figure 30: Mastoid tip drilled to expose digastric ridge*



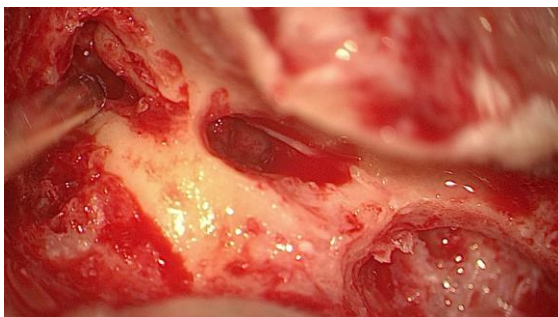
*Figure 34: Completed extended posterior tympanotomy*



*Figure 31: Mastoid segment of facial nerve exposed*



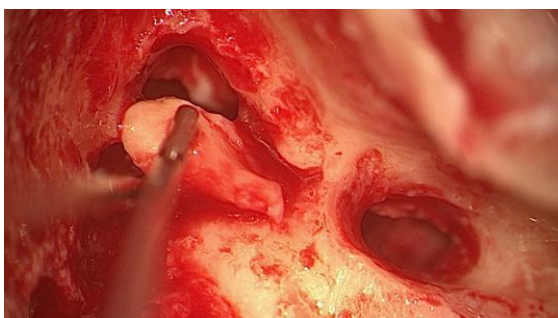
*Figure 35: Drilling superiorly toward TMJ*



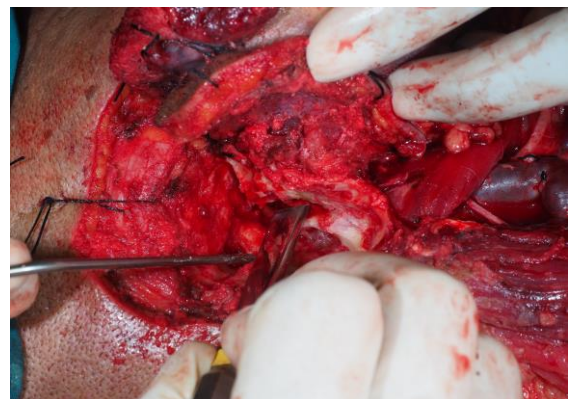
*Figure 32: Posterior tympanotomy with chorda tympani visible; sucker tip points to incus*



*Figure 36: Drilling superiorly toward TMJ*

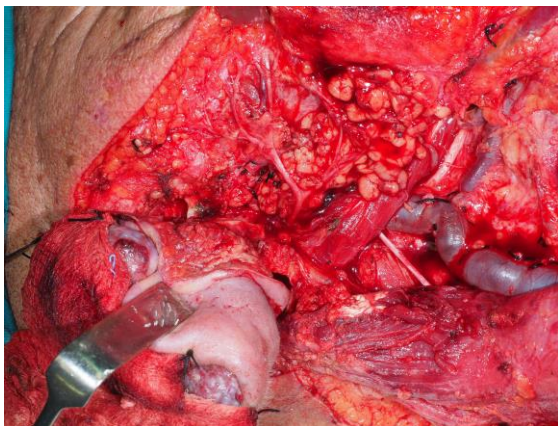


*Figure 33: Incus being removed*

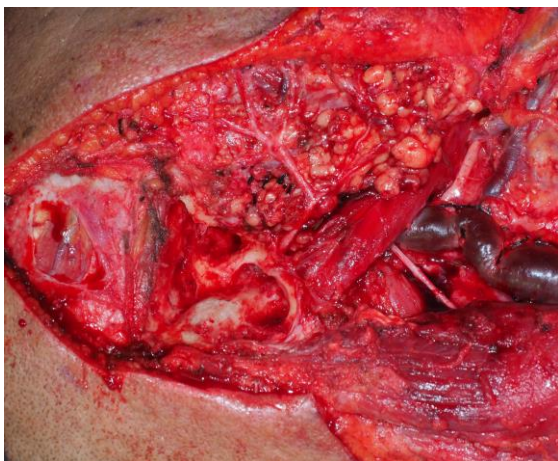


*Figure 37: Osteotome used fracture anterior tympanic bone*





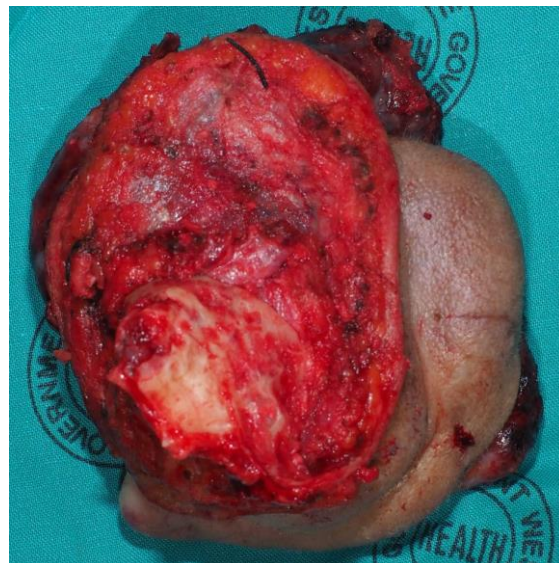
*Figure 38: Before removal of specimen*



*Figure 39: View of completed lateral temporal bone resection and superficial parotidectomy and neck dissection*



*Figure 40: Temporalis muscle reflected over temporal bone defect*



*Figure 41: Medial view of specimen*



*Figure 42: Lateral view of specimen*



*Figure 43: Supraclavicular flap*





Figure 44: Supraclavicular flap

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