



How I do it: combined petrosectomy

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Received: 1 May 2019 / Accepted: 18 July 2019 / Published online: 13 August 2019
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Abstract

Background Petroclival lesions are among the most complex to address in skull base surgery, being closely related to critical neurovascular structures and brainstem. The combined petrosectomy allows a wide exposure of large petroclival lesions with short working distance and provides multiple angles of attack, while limiting brain retraction.

Method We describe in a step-wise fashion the surgical steps of the combined petrosectomy.

Conclusion Combined petrosectomy with posterior transposition of the transverse-sigmoid sinus provides a wide surgical corridor to the ventral brainstem, middle and upper clivus, and infra-retrochiasmatic region.

Keywords Anterior petrosectomy · Combined petrosectomy · Petroclival region · Posterior petrosectomy · Skull base surgery

Introduction

Petroclival lesions are one of the most challenging lesions to treat. Various approaches can be used to approach this region [1–4]. The combined petrosectomy represents one of the best ways to access this region offering a wide array of angles of approach. We describe the combined petrosectomy technique and shed light on nuances and pitfalls.

Relevant surgical anatomy

The position, relationship, trajectory, and variations of key anatomical structure must be carefully evaluated before the operation: transverse sinus (TS) and sigmoid sinus (SS), vein of Labbe, mastoid vein, superior and inferior petrosal sinus (SPS, IPS), superior cerebellar vein (SCV), pneumatization of the mastoid, petrous apex and zygomatic root (ZR), shape of the temporal fossa floor,

foramen ovale (FO) and foramen spinosum (FS), arcuate eminence and superior semi-circular canal (SSC), cochlea, dehiscence of the SSC, geniculate ganglion and carotid canal, fallopian canal (FC), high jugular bulb.

Description of the technique

Patient positioning and preparation

The patient is in supine position with shoulder elevated, head turned 70–80°, and vertex tilted slightly downward (Fig. 1). Abdomen is prepared for closure. Cranial nerves and somatosensory and motor evoked potentials are monitored. Neuronavigation is prepared.

Skin incision and soft tissue dissection

A C-shaped incision is made beginning at the frontal region, extending around and behind the ear and ending below the mastoid tip (Fig. 1). The skin is elevated, and an interfascial dissection is made for further retraction of the skin flap. Following the deep layer of the temporalis fascia, the zygomatic root (ZR) is exposed. A retrograde elevation of the temporalis muscle is performed to retract it anteriorly. The nuchal muscles are elevated and retracted inferiorly. The pericranium is elevated anteriorly until the spine of Henle is visualized. Care is taken not to open the skin of the external auditory canal (EAC) (Fig. 1).

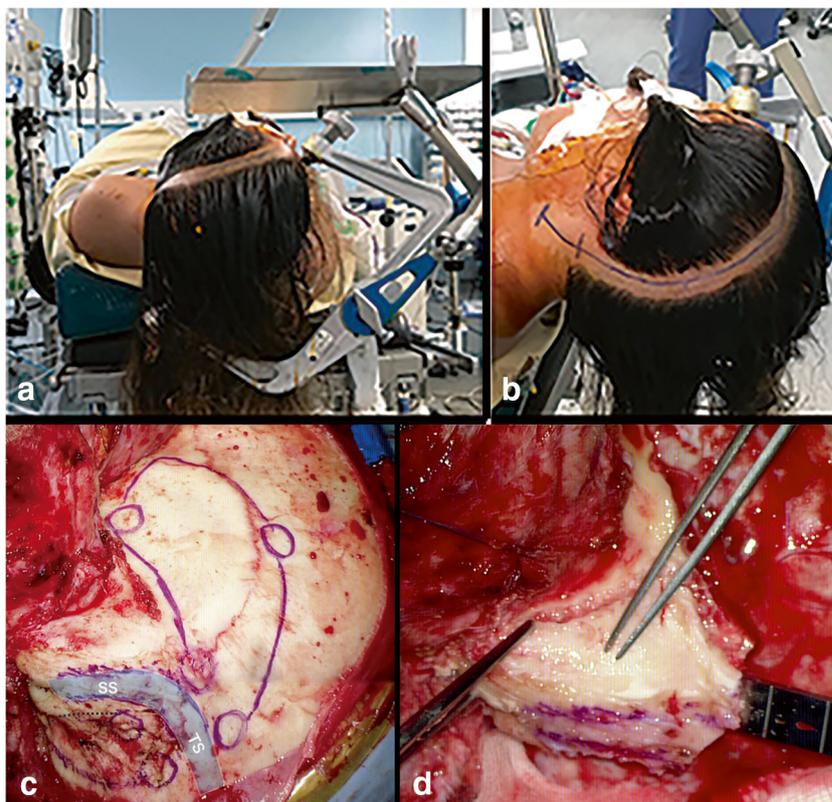
This article is part of the Topical Collection on *Neurosurgery general*

Electronic supplementary material The online version of this article (<https://doi.org/10.1007/s00701-019-04022-z>) contains supplementary material, which is available to authorized users.

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Fig. 1 Patient positioning, skin incision, craniotomy, and cosmetic mastoidectomy. **a** Patient in the supine position with an elevated shoulder and 80° rotation of the head. **b** C-shape skin incision. **c** The location of transverse sinus and sigmoid sinus is verified with neuronavigation. **d** Cosmetic mastoidectomy is performed. SS, sigmoid sinus; TS, transverse sinus



Temporo-parieto-occipital L-shape craniotomy

An L-Shape craniotomy is performed over the TS. This procedure can be done in two or three pieces to avoid sinus injury (Fig. 1). We favor performing the craniotomy first to go along with the philosophy that mastoidectomy represents the refinement of the angle between the temporal lobe and cerebellum. Exposure of the retrosigmoid dura allows for the posterior retraction of the sigmoid sinus after dura opening and for early access to the lower cranial nerves cistern if CSF drainage is required for brain relaxation.

Posterior petrosectomy

A cosmetic mastoidectomy, keeping the cortical bone for closure, is performed (Fig. 1). The ZR is drilled until the level of the temporal fossa floor is reached. The transverse-sigmoid sinus junction (TSSJ) and SS are skeletonized, and the antrum is opened above the EAC. The lateral canal (LSC) and short arm of the incus, which indicate the course of the facial nerve (FN) below LSC, are identified. The sino-dural angle and retro- and infralabyrinthine volume are drilled, and the posterior canal (PSC) and superior canal are shaved. The mastoid segment of the FC in the mastoid is

identified. The thin shell of bone over the SS is removed with a blunt tip rongeur (Fig. 2).

Anterior petrosectomy

The temporal fossa dura (TFD) is elevated. FS is identified. The FO is located a few millimeters antero-medial to FS. The middle meningeal artery is sectioned, and the dura is elevated from back to front. The greater superior petrosal nerve (GSPN) is identified using electric stimulation. The dura is peeled from the mandibular nerve (V3). Kawase triangle, delineated by the arcuate eminence, GSPN, V3, and petrous ridge, is drilled, and posterior fossa dura (PFD), internal auditory canal (IAC), petrous ICA, SPS, and IPS are identified (Fig. 3). Once both the anterior and posterior petrosectomy are completed, the line of sight can revolve around the bony labyrinth to offer either a posterior to anterior view (from the posterior petrosectomy) or an anterior to posterior view (from the anterior petrosectomy).

Dural incision and tentorium detachment

Dural incisions are performed based on the pathology. For PC meningiomas, a tentorium resection is required for devascularization and resection of the dural base. For other pathologies, incisions are made to unlock the TSSJ and mobilize it posteriorly and inferiorly.

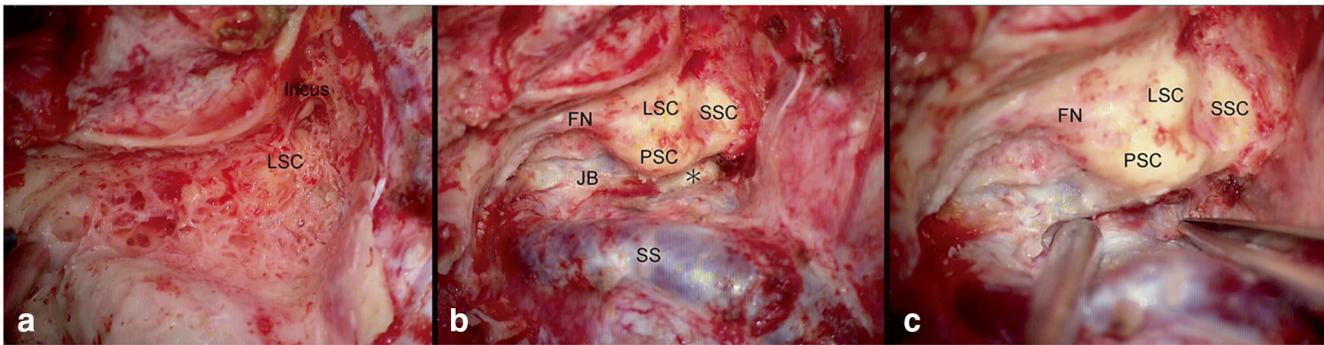


Fig. 2 Posterior petrosectomy. **a** After opening the antrum, the lateral semi-circular canal and incus are identified. **b** and **c** The facial nerve, jugular bulb, and semicircular canals are exposed. The bone behind

(asterisk in **b**) and below the labyrinth is fully resected. FN, facial nerve; JB, jugular bulb; LSC, lateral semi-circular canal; PSC, posterior semi-circular canal; SS, sigmoid sinus; SSC, superior semi-circular canal

The incision in the TFD is parallel to the superior petrosal sinus (SPS) toward the TSSJ. The incision extends posteriorly above the TS to allow its inferior mobilization. A vertical incision, coursing posterior to the endolymphatic sac, is made on the presigmoid dura. Superiorly, this incision curves forward parallel and below the SPS in the direction of the PC region and ends lateral to the IPS. A counter incision is made over the IAC (Fig. 4). Both temporal and presigmoid incisions are joined together by sectioning the SPS medial to the SCV complex draining into SPS. The tentorium is sectioned. Care is taken not to injure the trochlear nerve when reaching the free edge. Once the tentorium is cut, the TSSJ is retracted posteriorly to create a corridor between the inferior surface of the temporal lobe and cerebellum. Care is taken to protect temporal vein draining into the TS.

In case of lesions extending into MC, an incision is made along the lateral aspect of V3, which opens the MC. For PC meningiomas, the layer of dura that forms the roof of MC can be sectioned toward the porus. The SPS, which is most often infiltrated, is cut above the porus, and the tentorium is further cut to achieve the anterior cut of the tentorium resection.

Closure

An important step is the closure of the middle ear with a thin layer of bone wax covered with pericranium and fibrin glue. Care must be taken not to plug the middle ear with bone wax. The dural flaps are approximated with sutures. Pieces of abdominal fat are used to file the dural defect and the dead space of the petrous apex and mastoid. The bone flap is reconstructed using titanium microplates (Fig. 5).

Indications Large petroclival tumors (meningiomas, epidermoid cyst, chondrosarcomas, chordomas), and retroinfundibular craniopharyngiomas.

Limitations Venous anatomy, non-pneumatized petrous bone.

How to avoid complications

- Proper preoperative work up with careful examination of the anatomy and variations
 - Monitoring of the cranial nerves
 - Adequate closure technique to prevent CSF leakage

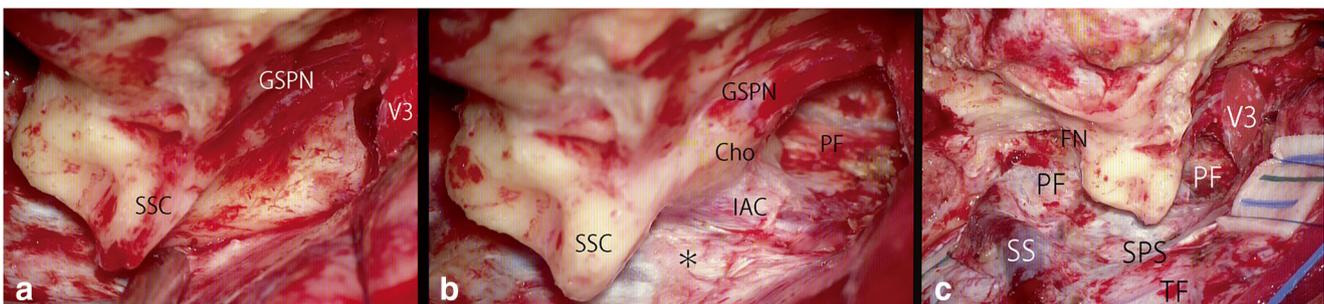


Fig. 3 Anterior petrosectomy. **a** and **b** The rhomboid region, including the postmeatal triangle (asterisk in **b**), is drilled. **c** Final view following combined petrosectomy. Cho, cholea; FN, facial nerve; GSPN, greater

superior petrosal nerve; IAC, internal auditory canal; PF, posterior fossa dura; SS, sigmoid sinus; SPS, superior petrosal sinus; SSC, superior semi-circular canal; TF, temporal fossa dura

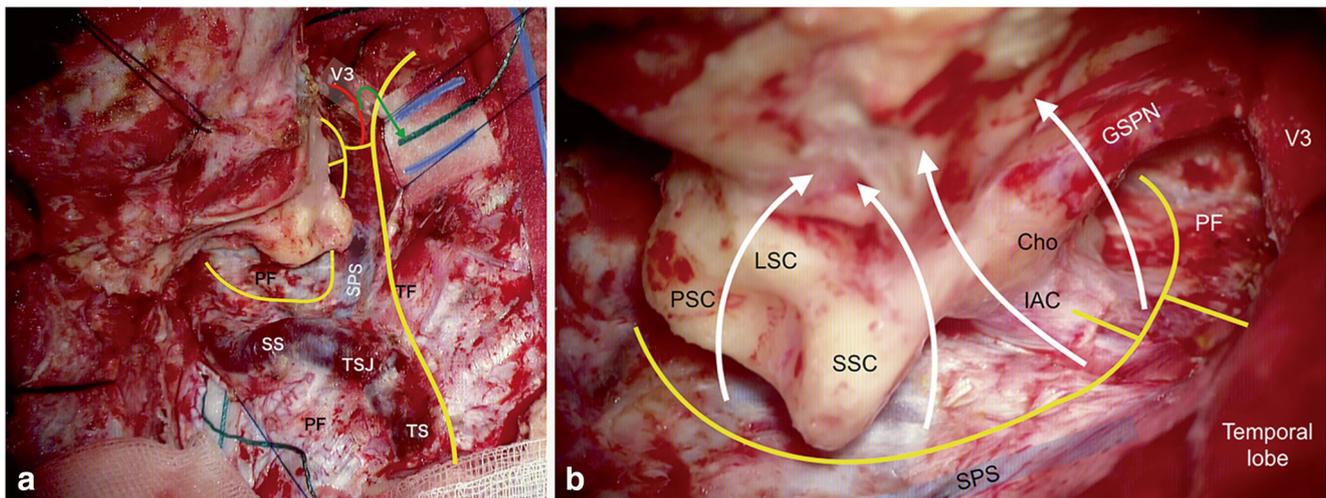


Fig. 4 Dural opening. **a** Yellow lines indicate the cuts for pathologies that do not require tentorial resection. The red line is the dural incision to open the Meckel's cave. The green arrow is the anterior cut of the tentorium starting on the roof of Meckel's cave toward the superior part of the trigeminal ring. The ring and superior petrosal sinus are sectioned, and the tentorium is cut. **b** Incision and retraction of the posterior fossa dura

(white arrows). Cho, cochlea; GSPN, greater superior petrosal nerve; IAC, internal auditory canal; LSC, lateral semi-circular canal; PF, posterior fossa dura; PSC, posterior semi-circular canal; SPS, superior petrosal sinus; SS, sigmoid sinus; SSC, superior semi-circular canal; TF, temporal fossa dura; TS, transverse sinus; TSSJ, transverse-sigmoid junction

Specific perioperative considerations

- CT for the assessment of pneumatization of the petrous bone, dehiscence of the carotid canal and geniculate ganglion, high jugular bulb.
 - Cerebral angiography to identify the major feeding vessels and venous drainage.
 - In petroclival meningiomas, preoperative embolization of arterial feeders can be useful.

- There is a risk of facial palsy, hearing loss, vertigo, facial numbness and pain, diplopia, dysphagia, vessel injury, stroke, and death.
- Venous injury and venous infarct.
- Risk of CSF leak, meningocele, and infection.

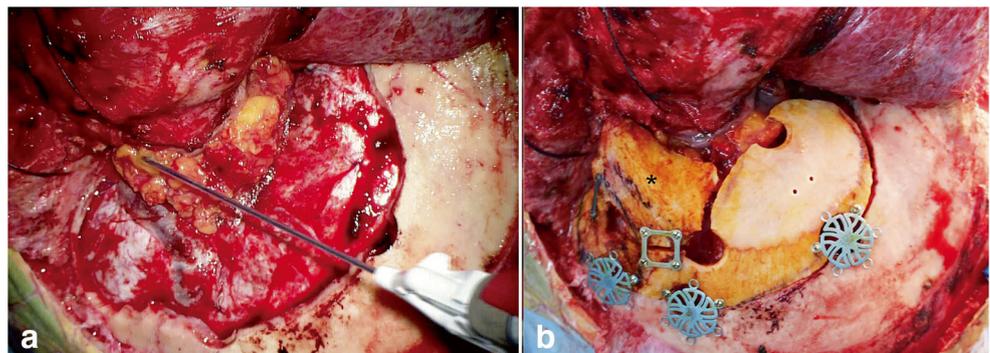
Specific information to the patient about the surgery and its potential risks

- The combined petrosectomy is a long and strenuous approach that may increase “time-dependent” complications, including ulcers and thrombo-embolic events.

Relevant points

- Posterior mobilization of the TSSJ to obtain the adequate working corridor and lines of sight.
 - In-depth knowledge of the petrous bone anatomy.
 - Careful assessment of pre-operative imaging workup.
 - Preoperative embolization.
 - Cranial nerves monitoring.
 - Cosmetic mastoidectomy.
 - CSF drainage through a lumbar drain or a small retro-sigmoid dural opening for brain relaxation.

Fig. 5 Closure technique. **a** Abdominal fat is added to fill the dead space. **b** The bone flap including the mastoid cortical bone (asterisk) is replaced



- Tailored dural opening depending on the lesion and venous circulation.
- Careful closure but without filing of the middle ear.
- Use of free fat graft to achieve watertight closure.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Patient consent The patient has consented to the submission of this How I Do It for submission to the journal.

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