Anatomy of the combined retrolabyrinthine–middle fossa craniotomy

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The goal of combined retrolabyrinthine–middle fossa craniotomy is to provide exposure of both the middle and posterior cranial fossae via a partial petrosectomy and division of the tentorium. Its major benefits over others are that hearing and facial nerve function are preserved and only minimal brain retraction is required. The retrolabyrinthine approach involves a presigmoid posterior fossa craniotomy that preserves the structures of the inner ear. Additionally, a middle fossa craniotomy, extending to the zygomatic root, is performed to gain access to the superior aspect of the temporal bone in the middle cranial fossa. This approach works well in cases of lesions involving the petroclival junction, including petroclival meningiomas, trigeminal schwannomas, epidermoids, and large chondrosarcomas or chordomas with intradural components. The authors describe the surgical technique of this approach.

KEY WORDS • transpetrosal approach • petroclival junction • skull base surgery • neurotology

We describe the surgical technique for combined retrolabyrinthine–middle fossa craniotomy, an approach well suited to resecting tumors of the petroclival junction.

PATIENT PREPARATION

The side of the head is prepared and draped in a sterile fashion. The head needs to be shaved nearly up to the vertex of the scalp to permit a large anteriorly based skin flap. For stability and as a base for retraction, we place a Mayfield head holder. Because in many of these cases the tumor abuts critical vascular structures such as the cavernous sinus, carotid artery, and the basilar artery, computer-assisted localization technology is often beneficial in avoiding injury to these structures. Cranial nerve monitoring is vital in these cases.³ The typical cranial nerves to be monitored include the third through eighth, and the eleventh. The eighth cranial nerve is monitored by performing auditory evoked brainstem response with an earphone placed in the ear canal. For this reason, the ear canal is separated by sterile drapes from the operative field.

SURGICAL TECHNIQUE

A C-shaped skin incision is made, extending from the root of the auricular helix, around the superior border of the temporalis muscle, and coursing posteriorly and infe-

riorly down behind the mastoid tip (Fig. 1). Dissection is continued down to the skull, and the periosteum is elevated off of the bone. The flap is retracted anteriorly by using large fishhook retractors. The ear canal must not be entered because the earphone has rendered it unsterile.

Once the soft tissues have been elevated off of the skull, a standard cortical mastoidectomy is performed using a large cutting burr, and the retrosigmoid dura and sigmoid sinus are skeletonized using a diamond burr. The last “eggshell” of bone is removed manually with an elevator. Sigmoid sinus or superior petrosal sinus bleeding can be controlled with Surgicel and a cottonoid. The sigmoid sinus needs to be differentiated from the transverse–sigmoid junction and followed down to the level of the jugular bulb. Connected to the Mayfield head holder, malleable retractors are used during this process for gentle retraction of the sigmoid sinus while removing the bone overlying the posterior and middle fossa dura to the level of the labyrinth.

The mastoid antrum and lateral semicircular canal are exposed through a cortical mastoidectomy. The ridge of bone at the junction of the middle and posterior fossa dura (the crest of the petrous pyramid) is often adherent to the underlying superior petrosal sinus. Gentle dissection in this area is needed to avoid disrupting the small venous sinus. The fossa incudis (connection between the mastoid antrum and middle ear space) should be visualized but not opened widely because it is a potential pathway for postoperative cerebrospinal fluid otorrhea.¹

The facial nerve is identified within the mastoid cavity

Abbreviation used in this paper: IAC = internal auditory canal.

Fig. 1. Skin incision for the combined retrolabyrinthine-subtemporal craniotomy.

at its second genu, just inferior to the lateral semicircular canal. Left in place beneath a thin osseous shell, it is then followed down along its vertical portion toward the stylo-mastoid foramen. Once the nerve has been skeletonized, the air cells between the facial nerve and the posterior fossa dura (the retrofacial air cells) are removed, permitting exposure of the sigmoid sinus to the level of the jugular bulb. The endolymphatic sac sits in the dura just superior and posterior to the jugular bulb. To preserve hearing, it is important that it not be traumatized.

All three semicircular canals should now be visible; however, some bone may remain in the spaces around them. This bone needs to be carefully removed to maximize exposure along the petrous ridge. Care should be taken not to enter the semicircular canal because this can cause deafness. If a semicircular canal is accidentally en-

tered, bone wax should be used to seal the defect immediately.

A middle fossa bone flap is then created. Typically the size of the flap is 4×4 cm, but it may be tailored according to anatomical peculiarities of the tumor. The posterior margin of the flap is the transverse-sigmoid sinus junction, whereas the anterior limit is usually the zygomatic root. A trough is drilled superior to the ear canal, extending from the mastoidectomy defect to the zygomatic root. The craniotome is engaged on the temporal squamosa at the back edge of the mastoidectomy defect near the transverse-sigmoid sinus junction. This bone flap is preserved and replaced at the conclusion of the procedure.

The floor of the middle fossa can then be dissected, if necessary (Fig. 2). The area of bone anterior to the IAC is also termed the Kawase triangle.⁴ Removal of this bone can be performed selectively in cases of petroclival meningiomas because the blood is primarily supplied by the highly vascularized bone marrow in this region. This removal then simplifies the later tumor dissection because the primary source of the blood supply has already been impeded. This additional exposure, however, is not required for most petroclival lesions.

Once the osseous exposure has been completed, the dura mater is opened (Fig. 3). The incision is started as inferiorly as possible, at the crotch between the sigmoid sinus and the jugular bulb. To avoid the endolymphatic sac, it should then course immediately anterior to the sigmoid sinus. To enhance inferior exposure, the incision is continued between the posterior semicircular canal and the dome of the jugular bulb. A second incision is made horizontally in the middle fossa dura at the corner of the temporal lobe. Relaxing incisions can be made in the middle fossa dural opening so that the dural flap can be retracted superiorly. This should allow visualization and preservation of the vein of Labbé.

In this approach the key portion of opening the dura is safely connecting the two dural incisions through the superior petrosal sinus. The vein of Labbé, however, can have several different anatomical variants.⁵ If the vein

Fig. 2. *Left:* The floor of the middle cranial fossa. Landmarks include the greater superficial petrosal nerve (GSPN) and the arcuate eminence (AE). *Right:* The underlying structures within the petrous apex of the temporal bone. Drilling of the IAC is performed for tumors that enter the canal or for removal of Kawase triangle (the anterior petrous apex). It must be precisely performed to skeletonize, but not damage the facial nerve (7), superior vestibular nerve (SVN), cochlea (CO), or superior semicircular canal (SSCC). Also shown are the middle meningeal artery (MMA), superior petrosal sinus (SPS), geniculate ganglion (GG), external auditory canal (EAC), and the middle ear (ME).

Fig. 3. After drilling has been completed. A mastoidectomy has been followed by decompression of the sigmoid sinus and posterior fossa dura. The middle fossa bone flap has been removed, exposing the temporal lobe dura. The dotted line represents the intended dural opening. The specific site of the dural opening across the superior petrosal sinus may vary depending on the location of the entry of the vein of Labbé.

runs the most common course (that is, from the temporal lobe directly into the transverse sinus), the two dural openings can be connected across the superior petrosal sinus in any convenient location by using Weck clips and/or bipolar cautery to ligate the sinus. Occasionally, however, the vein of Labbé will run through a dural fold before entering the superior petrosal sinus. In this situation, it is judicious to divide the superior petrosal sinus in a more medial position (near the labyrinth). We have found it helpful to open the middle fossa incision and gently retract the temporal lobe to determine the precise anatomy of the vein of Labbé prior to dividing the superior petrosal sinus, to preserve the integrity of the venous drainage pathway.

Once the two dural incisions have been joined, the final step is to divide the tentorium. The tentorium occasionally contains venous lakes that need to be cauterized as it is divided. Lahey scissors are used to nibble carefully through the tentorium. It is important to identify the fourth cranial nerve at the tentorial notch. Although it is normally found just superior to the free edge of the tentorium, tumors in this region often deflect it into unusual positions. It is easy to divide or stretch the fourth cranial nerve inadvertently. Once the tentorium has been completely divided, the incision will relax and a wide opening is visible. Only minimal support of the temporal lobe and cerebellum are needed to obtain adequate exposure. The dural flaps can be sutured up to the surrounding tissue and the third to eleventh cranial nerves are easily seen through this opening (Fig. 4).

Standard procedures can be used to remove the tumor. These involve internal tumor debulking followed by capsular dissection along the arachnoid planes surrounding the tumor capsule. Tumors of the petroclival region usually involve regional cranial nerves. Because these tumors are usually benign, however, the best strategy is maximal tumor resection and preservation of cranial nerve function. Often this may require leaving a small remnant of tumor attached to the fourth and sixth cranial nerves. When a tumor enters the IAC, the lesion can usually be completely removed by first opening the IAC from above and then carefully dissecting tumor off of the seventh and eighth cranial nerves. Tumors that extend into the Meckel cave can be exposed using a blade to open the dural roof. Cavernous sinus bleeding can be managed using Surgicel, and total tumor removal in this region is usually difficult. It is reasonable to leave a small well-cauterized fragment of tumor along the cavernous sinus.

When the tumor has been dissected, the dural opening is closed as much as possible. Often the temporal lobe dura can be closed completely but the posterior dura cannot. In any case, abdominal fat is harvested from an incision in the left lower quadrant, cut into strips, and packed

Fig. 4. Left: Illustration of a petroclival meningioma or epidermoid (T) after the combined retrolabyrinthine–subtemporal approach has been performed. The cranial nerves are identified by their number in the figure. The temporal lobe (TL), midbrain (MB), pons (P), and cerebellum (Cb) are also shown. Right: Illustration of a trigeminal schwannoma after the combined retrolabyrinthine–subtemporal approach has been performed. Note that the dural fold forming the Meckel cave remains to be opened.

into the mastoid cavity. Additionally, a 1-in square piece of the outer layer of the rectus sheath is harvested and placed over the fossa of incus to prevent cerebrospinal fluid leakage. The soft-tissue incisions are closed in a three-layer fashion and a standard mastoid dressing is applied. In most cases immediately after surgery the patient can be awakened from anesthesia.

Neurological complications associated with this approach include temporal lobe aphasia due to retraction of the temporal lobe (uncommon) as well as cranial nerve palsies. The most commonly injured cranial nerves in this area are the fourth and sixth. Even if these nerves are clearly visualized and preserved intraoperatively, they can be weak postoperatively. If this occurs, however, normal function typically returns within a few weeks to months.

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