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The Middle Fossa Transpetrous Approach for Petroclival Meningiomas

Abstract—Seventeen patients with petroclival meningioma were operated on through a middle fossa transpetrous approach. This approach exposes the anterior cerebellopontine angle through a middle fossa craniotomy with removal of the petrous apex medial to the cochlea and petrous carotid artery. This approach may be enlarged by transection of the superior petrosal sinus and tentorium. The surgical technique and application of the middle fossa transpetrous approach for petroclival meningiomas is presented. (*Skull Base Surgery, 3(3):130–135, 1993*)

Middle fossa access to the skull base is not a new concept. Over 100 years ago, Hartley[1] approached the trigeminal ganglion through the middle fossa. This approach was used by Krause to perform 51 gasserian ganglionectomies from 1892 to 1895. By 1905, Cushing had reduced the mortality of this procedure to 5%,[2] and in 1959 Ruge et al[3] reported on 637 patients undergoing middle fossa access to the trigeminal ganglion from 1920 to 1957. Eagleton,[4] in 1931, was the first to expose the posterior fossa through the petrous apex. He reported a combined retrolabyrinthine and middle fossa approach to drain bulbar meningitis secondary to suppuration of the petrous apex. This approach involved removal of infected bone marrow medial to the petrous carotid artery and cochlea in the petrous tip and drainage of the prepontine (medial pontine) cistern.

In the late 1950s and early 1960s, William House and colleagues developed a middle fossa approach to the internal auditory canal for a variety of procedures, including vestibular nerve section and removal of acoustic schwannomas.[5–7] In 1969, Glasscock[8] described exposure of the petrous carotid artery through a middle fossa approach and reported the use of this technique for carotid artery ligation. The area of bone removed to expose the petrous carotid has become known as Glasscock's triangle. Paullus et al,[9] in 1977, presented the results of 50 temporal bone dissections performed to explore the petrous carotid artery as a possible site for vascular anastomosis. This study was extremely important for its detailed description of the relationship of the petrous carotid artery to the other structures within the temporal bone.

Kawase et al[10] and House et al,[11] in 1985 and 1986, respectively, exposed the anterior cerebellopontine angle through a middle fossa craniotomy with removal of bone medial to the petrous carotid artery and cochlea (Fig. 1). Kawase and colleagues used this approach to expose lower basilar aneurysms in two patients, whereas House et al used the approach for removal of a Vth nerve schwannoma in one patient and a petroclival meningioma in a second patient. The roughly triangular area of bone removed medial to the carotid artery has become known as Kawase's triangle. Several authors have subsequently used this exposure through the petrous apex for similar applications.[12–14] Although several names have been applied to this procedure, we believe it is best termed the middle fossa transpetrous approach after the original descriptions by Kawase et al and House et al.

We describe the surgical technique, application, and

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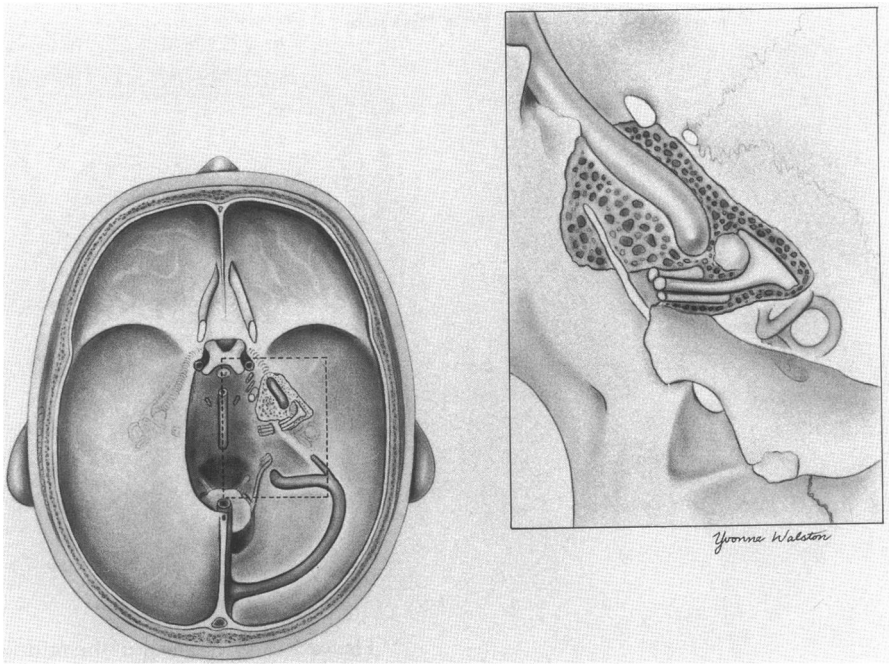

Figure 1. Skull base from above with area of petroclival bone removal.

limitations of the middle fossa transpetrous approach for removal of petroclival meningiomas. The results of this procedure in 17 patients are presented.

SURGICAL TECHNIQUE

The patient is operated on in the supine position with electrodes inserted for monitoring cranial nerves VI and VIII. The incision begins at the tragal notch and extends 7 to 8 cm anterosuperiorly (Fig. 2). The plane between the skin and temporalis fascia is developed with blunt dissection. The temporalis fascia is opened with an inverted T-shaped incision and the exposed temporalis muscle is reflected as an inferiorly based flap over the zygomatic arch. We have not found it necessary to transect the zygomatic arch to displace the temporalis muscle out of the field for exposure. A self-retaining retractor is placed beneath the temporalis muscle and a 3×5 cm bone flap is removed exposing temporal dura (Fig. 3). The craniotomy is located two thirds anterior and one third posterior to the external auditory canal. Bone is removed to the floor of the middle cranial fossa with ronguers and drill.

The dura is elevated from the floor of the middle cranial fossa by posterior to anterior dissection. This direction of dissection is used to avoid injury to an exposed geniculate ganglion or inadvertent elevation of the greater superficial petrosal nerve with resultant traction on the facial nerve. The dura is firmly adherent to the petrosquamousal suture and may require cauterization and sharp dissection. The greater superficial petrosal nerve is always medial to this suture. The temporal lobe is elevated with a self-retaining retractor. Hyperventilation, osmotics, and spinal drainage are used when appropriate.

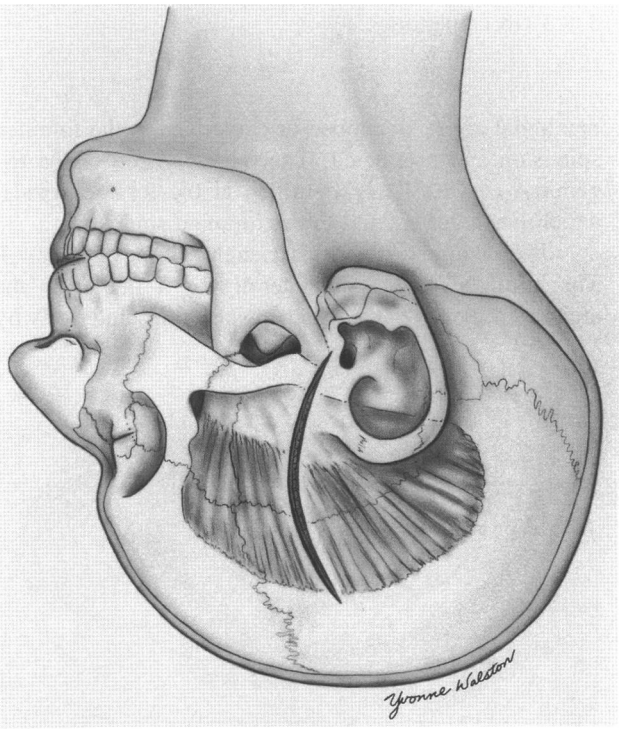

Figure 2. Skin incision extending from tragus 7 to 8 cm superiorly.

The middle meningial artery, the greater superficial nerve, and the arcuate eminence are identified (Fig. 4). A diamond burr is used to expose the geniculate ganglion and blue line the superior semicircular canal. The labyrinthine segment of the facial nerve is followed into the fundus of the internal auditory canal (Fig. 5). The internal auditory canal is skeletonized but not opened. The middle

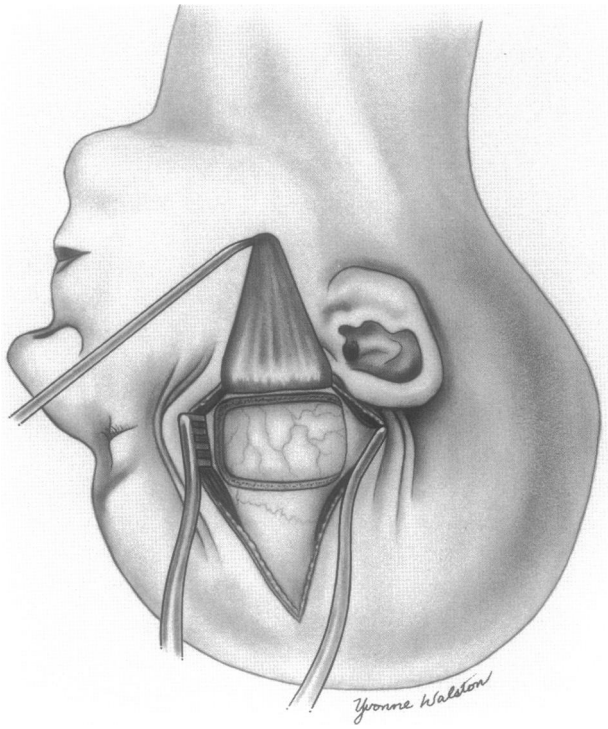

Figure 3. Reflection of temporalis muscle flap and 3 × 5 cm craniotomy.

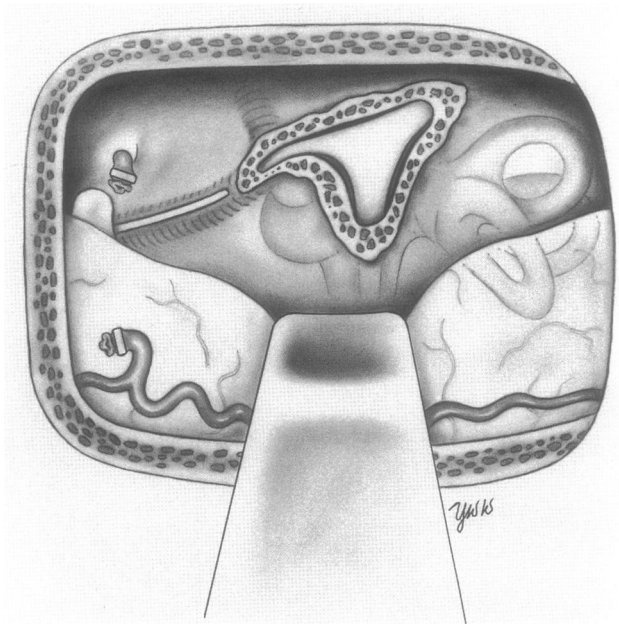

Figure 5. Transection of the middle meningial artery, and identification of the geniculate ganglion and facial nerve.

meningial artery is clipped or cauterized at the foramen spinosum and transected. The third division of the trigeminal nerve (V_3) is identified at the foramen ovale, which lies anteromedial to the foramen spinosum.

Bone within Glasscock's triangle is removed (Fig. 6). This triangle is bordered laterally by a line from the arcuate eminence to the foramen spinosum, anteriorly by the third division of the Vth nerve, and medially by the groove for the greater superficial petrosal nerve. The greater superficial petrosal nerve lies over the horizontal petrous carotid artery. The nerve is severed to prevent traction on the geniculate ganglion and to allow wide exposure of the carotid artery. The horizontal petrous carotid artery is skeletonized from the posterior loop to

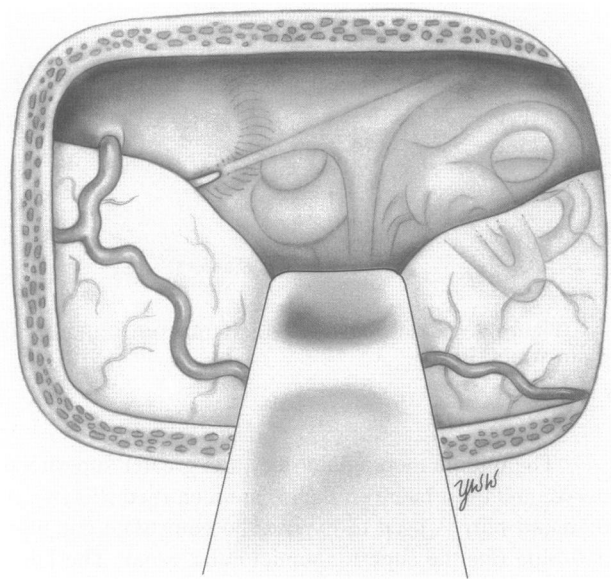

Figure 4. Elevation of dura from middle fossa floor with identification of the middle meningial artery, greater petrosal nerve, and arcuate eminence.

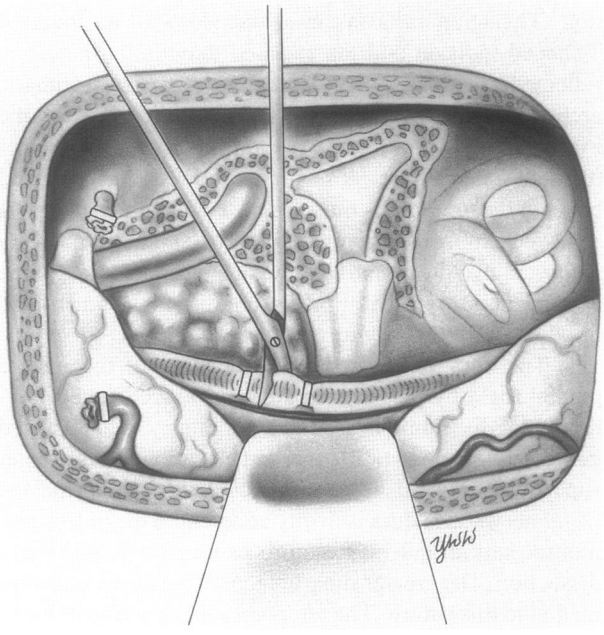

Figure 6. Removal of bone anterior to the internal auditory canal and medial to the internal carotid artery.

V_3. Dissection should not be extended behind the posterior loop of the internal carotid artery due to the close proximity of the cochlea. Dissection may be extended medial to V_3 by transection of the nerve or by bone removal from the anterolateral foramen ovale and mobilization of V_3 anterolaterally.

Removal of bone medial to the horizontal carotid canal and cochlea is continued inferiorly to the level of the inferior petrosal sinus. The posterior fossa dura has thus been exposed from the internal auditory canal to Meckel's cave and from the superior petrosal sinus above to the inferior petrosal sinus below. The dura is opened through an inferiorly based flap.

The dissection may be extended medially into the clivus by transection of the inferior petrosal sinus in the petro-occipital synchondrosis. Dissection above the level of the tentorium may be accomplished by transection of the superior petrosal sinus and tentorium. This is performed by an incision in the middle fossa dura just lateral to the superior petrosal sinus from the internal auditory canal to the third root of the trigeminal nerve. The superior petrosal sinus is clipped or coagulated and the tentorium is transected in the midportion of this incision. Special care is taken to avoid injury to the petrosal vein or trochlear nerve. The tumor is debulked with mechanical techniques or the fiberoptic argon laser (Fig. 7). After tumor removal, the defect is obliterated with abdominal adipose tissue and the bone flap is wired or plated in place. The would is closed in layers.

SUMMARY OF PATIENTS

A total of 17 patients have undergone a middle fossa transpetrous approach for removal of petroclival meningioma from 1984 to 1992. There have been no deaths. One patient developed an expressive aphasia that resolved after 3 months. There have been no patients with postoperative meningitis or cerebrospinal fluid leakage.

Since 1989, the superior petrosal sinus and tentorium have routinely been transected to improve surgical exposure and remove lesions extending above the incisura. Prior to this time, one patient required a second surgical procedure for removal of supratentorial tumor. Also since 1989, the third division of the trigeminal nerve has routinely been cut to improve anterior exposure of the petrous tip.

Although transient facial weakness from manipulation of tumor on nerve VII has been noted in several patients, there are no patients with permanent facial palsy. Likewise, although transient abducens weakness often occurs in tumors extending onto the superior clivus, only one patient has permanent VIth nerve paresis. One patient has profound hearing loss in the operated ear.

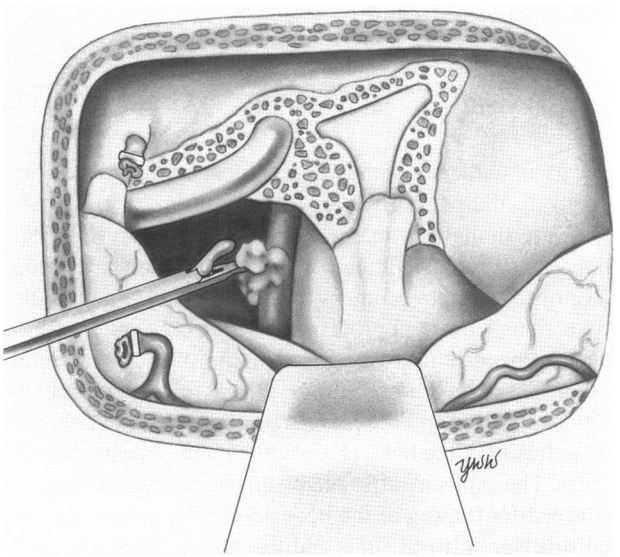

Figure 7. Tumor removal from the anterior cerebellopontine angle.

DISCUSSION

Although meningiomas account for 13 to 18% of all intracranial tumors, only 8 to 12% are found in the posterior fossa.[15] In the posterior fossa, they have a predilection for the posterior surface of the petrous bone, particularly between the porus acousticus and the jugular foramen. Meningioma isolated to the petroclival junction is relatively uncommon.

Compounding the management of an infrequently encountered tumor has been surgical access. All surgical approaches to this area require the surgeon to make difficult decisions in regard to working around structures of the temporal bone and cerellopontine angle or removing vital structures to improve exposure. These difficulties have led to the use of a number of surgical approaches to the petroclival region.

The conventional suboccipital approach is difficult because of interposed cerebellum, brainstem, vascular structures, and cranial nerves, which obscure the antersuperior cerebellopontine angle. Overhanging cerebellum requires at least minimal retraction and the surgeon must work at an uncomfortable distance from the lesion.

Midline transpalatal-transclival approaches also have major limitations.[16] The surgeon is a considerable distance from the operative field once the tumor is exposed. Tumor manipulation is difficult because of the restricted surgical field. Hemostasis and cerebrospinal fluid leakage are difficult to manage and the potential for postoperative meningitis is significant.

The apparent shortcomings of these approaches led to the development of the transcochlear approach, which is an anterior extension of the translabyrinthine approach to the cerebellopontine angle.[17] In this exposure, bone removal is extended anterior to the internal auditory canal after rerouting the facial nerve posteriorly and removing

the cochlea. In its modified form, the complete petrous apex is removed and dissection may continue into the clivus.[18] The major advantage of this approach is wide exposure of the cerebellopontine angle and the petroclival area. The major disadvantages to this technique are unilateral deafness and transient facial weakness.

The disadvantages of hearing loss and transient facial weakness have led several authors to avoid removal of the optic capsule. Al-Mefty et al[19] developed the petrosal approach in which the retrolabyrinthine exposure is extended by transection of the superior petrosal sinus and the tentorium. This approach allows wide exposure of the petroclival region, but does not remove bone of the petroclival region that may be involved with tumor. The subtemporal-preauricular infratemporal approach of Sekhar et al[20] provides removal of the bone of the petrous apex and clivus. This approach, however, requires removal of the petrous carotid from its bony canal, transection of the eustachian tube, and often removal of the mandibular condyle. Spetzler and colleagues[21,22] have recently organized many of the concepts just discussed into three supratentorial and infratentorial approaches in which the superior petrosal sinus and tentorium are always cut. The amount of temporal bone removed varies and may include retrolabyrinthine, translabyrinthine, and transcochlear techniques.

Although all of the above approaches may be used to remove petroclival lesions, they are formidable procedures that may not be necessary for most petroclival meningiomas. As we have demonstrated, meningiomas that involve the petroclival junction anterior to the internal auditory canal may be removed through the middle fossa transpetrous approach. This approach, through Kawase's triangle, allows access to the petroclival area anterior to the internal auditory canal, posterior to Meckel's cave, inferior to the superior petrosal sinus, and superior to the inferior sinus (Fig. 8). The dissection may be extended more medially into the clivus by removal of the inferior petrosal sinus in the petro-occipital synchondrosis. Supratentorial tumor extension may be removed by transection of the superior petrosal sinus and the tentorium.

Advantages to the middle fossa transpetrous approach include avoidance of cerebellar retraction and preservation of hearing and facial nerve function. This approach is more anteriorly centered than most other techniques and requires removal of few if any vital structures. The area of bone removal in the petrous tip usually coincides with the base of the meningioma. Removal of this bone interrupts the nutrient blood supply to the tumor from the internal carotid artery. Because this technique is a modification of the middle fossa technique that has been in use for many years for acoustic tumor surgery, most of the anatomy and techniques are familiar to skull base surgeons.

The limiting factor in this technique is not tumor size; indeed this approach has been used to remove large tumors extending well across the midline and above the anterior incisura. Transection of the superior petrosal sinus and tentorium greatly improves exposure of the upper clivus for tumors extending through the incisura. The most significant limiting factor for this approach is tumor location. This approach is not appropriate for tumors located posterior to the internal auditory canal. In this situation, we use either a transcochlear approach or an addition technique, such as the suboccipital or extended retrolabyrinthine approaches.

Figure 8. Computed tomography demonstrating area of petrous apex dissection for petroclival meningioma removal.

The most significant disadvantage of the middle fossa transpetrous approach is the frequent necessity to transect V_3 for removal of bone at the petrous tip. Except for numbness of the chin, transection of V_3 has caused little functional disability.

SUMMARY

Prior to the use of the transcochlear approach, tumors arising in the petroclival area carried a grave prognosis and were thought in many instances to be unresectable. Since that time, a number of new techniques have been developed to remove tumors from this region. The middle fossa transpetrous approach is an old concept that has recently been rediscovered for tumors of the petroclival region. This technique allows access to the petroclival region through a middle fossa craniotomy with removal of the petrous tip medial to the cochlea and petrous carotid artery. The exposure afforded by this bone removal may be enlarged for tumors of the upper clivus by transection of the superior petrosal sinus and tentorium. This approach has been used in 17 patients with petroclival meningiomas.

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