The Middle Fossa Transpetrous Approach: Experience With 13 Cases

ABSTRACT—Surgical access to lesions of the temporal bone anterior to the internal auditory canal and medial to the petrous carotid artery has concerned surgeons for nearly a century. A variety of approaches have been developed to gain access to this region. We report our experience with the middle fossa transpetrous approach for the treatment of a variety of petroclival and/or prepontine lesions. Tentorial transection and the retrolabyrinthine approach to extend this technique is also discussed. In properly selected cases, the middle fossa transpetrous approach is successful in maintaining hearing, labyrinthine and facial function without compromising surgical exposure.

House and Hitselberger commented on the difficulty of surgical access to skull base neoplasms involving the temporal bone anteromedial to the porus acusticus and/or ventral to the brainstem.¹ Tumor removal from this area is compromised by the limited size of its bony confines and the unforgiving nature of the neurologic and vascular structures that occupy this region. For nearly a century, surgeons have developed combined approaches to this deep-seated location. These approaches all share a common theme of improved exposure at the sacrifice of normal intervening structures. Fraenkel and Hunt developed a combined suboccipital and translabyrinthine approach in 1904 in an effort to access the cerebellopontine (CPA) without cerebellar retraction.² In 1905, Borchardt developed a transsigmoid and suboccipital approach for the same reasons.³ In 1931, Eagleton approached the posterior fossa through a middle fossa and retrolabyrinthine approach for the treatment of suppurative petrous apicitis with brain abscess.⁴ Morrison and King, in 1973, described a

translabyrinthine and subtemporal approach with transection of the tentorium for combined supratentorial and infratentorial exposure of lesions ventral to the brainstem.⁵ House and Hitselberger, in 1976, developed the transcochlear approach by rerouting the facial nerve and extending the translabyrinthine dissection into the petrous apex.¹ The modified or extended transcochlear approach offers the widest and most direct access to the prepontine region; however, this increased exposure is afforded at the sacrifice of the cochlea and temporary facial palsy.^{6,7}

In the last 10 years, new attempts have been made to access lesions of the anterior petrous apex and/or ventral to the brainstem through approaches that avoid vital intervening structures. Kawase et al and House et al concomitantly described the middle fossa transpetrous (MFTP) approach to the anterior CPA angle.^{8,9} This approach differs from previous subtemporal approaches as it involves removing the petrous apex anterior to the internal auditory canal and medial to the

cochlea and petrous carotid artery. This area of bone removal has become known as Kawase's triangle. Malis developed the petrosal approach, which is a retrolabyrinthine and subtemporal approach with transection of the lateral sinus.¹⁰ This approach was modified by Al-Mefty who avoided transection of the lateral sinus.¹¹ Pensak et al presented an extended retrolabyrinthine and MFTP approach for removal of a petroclival meningioma.¹² In this approach, all of the petrous bone except the otic capsule is removed, thus avoiding removal of the cochlea and rerouting of the facial nerve.

Our report reviews our clinical experience with petroclival lesions that were managed without removal of the auditory system and avoided rerouting of the facial nerve as part of the surgical approach. This subset of petroclival pathologies were operated on utilizing the MFTP approach alone or in conjunction with another conservative approach. Illustrative case reports are presented and the advantages, disadvantages, and complications of this technique are discussed.

MATERIALS AND METHODS

Our study includes 13 patients treated from 1988 to 1996 with lesions of the petrous apex, petroclivus, or anterior CPA. All of the patients were operated on through a MFTP approach either alone or in conjunction with another procedure. The patients consisted of 7 men and 6 women. Their ages ranged from 10 to 70 years, with a mean of 50 years.

The initial symptoms are summarized in Table 1. Hearing loss, dizziness, and facial numbness were the most frequent presenting symptoms. Less frequent symptoms were tinnitus, facial paralysis, blepharospasm, aural fullness, chronic otitis media, hemiparesis, dysarthria, diplopia, dysgeusia, and headaches. The duration of symptoms ranged from 3 days to 10 years, with a mean of 27 months.

Table 2 summarizes the final diagnoses, and the sizes and anatomic sites of origin. Our series consisted

Table 1. Initial Symptoms and Signs

Hearing Loss	5 (38%)
Dizziness	5 (38%)
Facial Numbness	5 (38%)
Headaches	3 (23%)
Tinnitus	2 (17%)
Facial Paralysis	2 (17%)
Chronic Otitis Media	2 (17%)
Blepharospasm	1 (7.7%)
Dysarthria	1 (7.7%)
Diplopia	1 (7.7%)
Hemiparesis	1 (7.7%)
Dysgeusia	1 (7.7%)
Aural Fullness	1 (7.7%)

Table 2. Lesion Characteristics

Patient	Diagnosis	Size (cm)	Origin
1	Meningioma	4	Left petroclivus
2	Schwannoma	3	Right petrous apex
3	Epidermoid	4	Left CPA*
4	Epidermoid	4	Right CPA
5	Acquired Cholesteatoma	2	Middle ear
6	Acquired Cholesteatoma	1.5	Middle ear/attic
7	Meningioma	2	Right petrous apex
8	Schwannoma	3	Left petrous apex
9	Acute Petrous Apicitis	2.5	Left petrous apex
10	Chronic Petrous Apicitis	1.5	Left petrous apex
11	Chronic Petrous Apicitis	2	Left petrous apex
12	Skull Base Osteomyelitis	4	Right petrous apex
13	Meningioma	2.5	Right petrous apex

*CPA = cerebellopontine angle

of a variety of inflammatory and neoplastic lesions including meningioma, petrous apex schwannoma, epidermoid, acquired aural cholesteatoma, acute and chronic petrous apicitis, and osteomyelitis of the skull base. The lesions ranged in size from 1½ to 4 cm with an average size of 2.8 cm.

Surgical Procedures

All 13 patients underwent a MFTP approach alone or in combination with another approach (Table 3). Three patients had undergone prior surgical treatment at other institutions. The MFTP approach was combined

Table 3. Surgical Procedures

Patient	Surgical Approach	Previous Surgeries
1	MFTP*, RL**	0
2	MFTP	0
3	MFTP, RL	2
4	MFTP, RL	0
5	MFTP	1
6	MFTP	2
7	1st stage—MFTP, 2nd stage—MF**	0
8	MFTP, IF****	0
9	MFTP	0
10	MFTP	0
11	MFTP	0
12	MFTP	0
13	MFTP, RL	0

*MFTP = middle fossa transpetrous; **RL = retrolabyrinthine; ***MF = middle fossa; ****IF = infratemporal fossa

with a retrolabyrinthine approach in four patients to remove tumor extending posterior to the internal auditory canal. One patient with a schwannoma encasing the vertical petrous carotid artery underwent a concomitant Fisch type A infratemporal fossa approach. This was the only patient who underwent rerouting of the facial nerve. Prior to the advent of dividing the tentorium, one patient with a petrous apex meningioma underwent an initial MFTP-infratentorial resection, followed by a middle fossa-supratentorial excision. The two patients with acquired aural cholesteatoma underwent a subsequent second look tympanotomy in conjunction with a type II tympanoplasty.

Facial Nerve Function

Intraoperative facial nerve monitoring was performed in all cases. Table 4 summarizes preoperative and postoperative facial nerve function. Facial nerve function was graded using the House-Brackmann facial function scale.¹³ Facial nerve function was satisfactory (grades I & II) in 11 of 13 patients at presentation. Two patients had poor nerve function (grade VI) preoperatively. Postoperatively, 11 of 13 patients had satisfactory function (grade I & II), one patient had intermediate function (grade IV), and one patient had poor function (grade VI).

Auditory Function

Preoperative pure tone thresholds (PTA) were available on 12 patients with a mean of 25 decibel (dB) hearing level (HL) (Table 5). Postoperative PTAs were available in 10 patients, with a mean of 30 dB HL. Most of the patients' hearing remained clinically unchanged or improved. One patient had a maximal conductive hearing loss on the operated side secondary to obliteration of the middle ear by an infratemporal fossa approach.

Complications

There were no deaths in our series. Six patients had postoperative complications, which are summarized in

Table 4. Facial Nerve Status

Function	Preop (%)	Postop (%)
Satisfactory (grades I & II)	11 (85%)	11 (85%)
Intermediate (grades III & IV)	0 (0%)	1 (7.5%)
Poor (grades V & VI)	2 (15%)	1 (7.5%)

* Facial nerve function reported by the House-Brackmann grading system

Table 5. Auditory Function

Patient	Preoperative PTA	Postoperative PTA
1	20	30
2	25	10
3	8	14
4	35	41
5	51	48
6	38	23
7	39	13
8	15	70
9	4	NA
10	17	NA
11	20	22
12	NA	NA
13	28	36

Table 6. Table 7 lists preoperative and postoperative cranial nerve dysfunction. One patient developed mild expressive aphasia lasting several weeks. A second patient developed a right frontal subdural hematoma, which was evacuated, and cerebrospinal fluid (CSF) rhinorrhea, which was treated initially with lumbar spinal fluid drainage followed by a lumbar peritoneal shunt. The third patient developed CSF rhinorrhea which was treated with bedrest, lumbar spinal fluid drainage, and a compression dressing. Less significant complications included ophthalmoplegia, a tongue laceration from tracheal intubation, a bladder neck laceration from Foley catheterization, and temporomandibular joint dysfunction with malocclusion.

Outcome

Five patients are thought to have residual pathology. Of the three patients with meningioma, one is free of tumor, one had a small area of tumor left in the cavernous sinus which is unchanged 8 years after gamma knife radiosurgery, and the third patient had a large recurrence noted 4 years after resection. One patient with a posterior fossa epidermoid is clinically and radiologically free of disease. The second patient with a posterior fossa epidermoid had residual tumor left in the opposite CPA near the porus acousticus. One patient with a

Table 6. Complications

Patient	Complications
1	Temporary expressive aphasia, CSF leak
2	Tongue laceration from an ET tube
5	Bladder neck laceration from a Foley catheter
7	Ophthalmoplegia
8	Left temporomandibular joint dysfunction
13	Right frontal subdural hematoma, CSF leak

Table 7. Cranial Nerve Dysfunction

<i>Cranial Nerve</i>	<i>Preop (%)</i>	<i>Postop (%)</i>
V	5 (38%)	5 (38%)
VI	1 (7.7%)	1 (7.7%)
VII	2 (15%)	2 (15%)

petrous apex schwannoma has residual tumor in the cavernous sinus, which has remained unchanged for 4 years postoperatively. The second patient with petrous apex schwannoma had tumor left on the posterior petrous carotid artery. This tumor is not seen on postoperative magnetic resonance imaging (MRI) scanning, and the patient remains free of disease 2 years postoperatively. The patients with petrous apicitis and skull base osteomyelitis remain clinically and radiologically free of disease, as do the patients with acquired aural cholesteatoma.

CASE REPORTS

Case JM is a 45-year-old woman with right progressive hearing loss, facial numbness, and episodic vertigo for 1 year. Otologic examination was normal and audiologic evaluation revealed a mild hearing loss. No balance testing was performed. Neurologic examination demonstrated an absent right corneal reflex and decreased sensation of all branches of the fifth nerve. MRI demonstrated a 2 cm enhancing right hyperostotic petroclival meningioma with extension on to the posterior clinoid process (Fig. 1). The patient underwent a MFTP approach. All infratentorial tumor was removed; however, tumor extending through the incisura could not be removed. Postoperative MRI demonstrated residual supratentorial tumor. The patient underwent a supratentorial middle fossa approach for removal of residual tumor. All tumor except a small component in the cavernous sinus was removed (Fig. 2). Computed tomography (CT) revealed resection of most of the hyperostotic bone (Fig. 3). The area of residual tumor in the cavernous sinus was treated with gamma knife radiosurgery. Postoperatively, the patient had a sixth nerve ophthalmoplegia. Her hearing loss resolved, and her facial nerve function was perfect. She remains free of recurrent tumor 8 years after treatment.

Comment: This was the first patient in our series operated by the MFTP approach. She was found to have residual supratentorial tumor on postoperative imaging. She underwent a second procedure for removal of the supratentorial component. This case illustrates the supratentorial and infratentorial components frequently found in petroclival meningiomas. In most cases with tumor above and below the tentorium, we now transect

Figure 1. Gadolinium enhanced T_2 -weighted MRI scan demonstrating a right hyperostotic petroclival meningioma (arrow).

Figure 2. Postoperative gadolinium enhanced T_2 -weighted MRI scan revealing clival dural enhancement (small arrow) and intracavernous residual meningioma (large arrow).

Figure 3. Postoperative CT scan with bone algorithm demonstrating resection of petrous apex and hyperostotic bone.

Figure 4. T₁-weighted MRI scan revealing opacification of the left pneumatized petrous apex (arrow).

the tentorium in at least one area and, if necessary for operative exposure or tentorial resection, the tentorium may be opened both anterior and posterior to the lesion.

This case also demonstrates extension of the meningioma into the cavernous sinus. While it is now recognized that the cavernous sinus is not an inviolable structure, there is no consensus on removal of benign tumors from this region. In most cases, we feel that it is more judicious to leave a small piece of tumor in the sinus rather than risk ophthalmoplegia. Residual tumor in the cavernous sinus may be observed for growth with serial MRIs or treated primarily with gamma knife radiosurgery.

Case JF is a 21-year-old male with a 5-month history of left retrobulbar headaches and episodic vertigo. Otologic and neurologic examination were unremarkable. Electronystagmography and Equitest dynamic posturography were normal. MRI of the head revealed a left anterior petrous apex lesion that was isointense to slightly hyperintense on both contrasted and uncontrasted T₁-weighted images and hyperintense on T₂-weighted images (Fig. 4). There was no intracranial extension of the lesion. High resolution CT demonstrated opacification of a pneumatized anterior petrous apex with some destruction of the bony septa (Fig. 5). The differential diagnosis included chronic petrositis, cholesterol granuloma, or primary petrous apex neoplasm.

Figure 5. Computed tomography with bone algorithm showing opacification of the left petrous apex (arrow).

Figure 6. Postoperative CT scan revealing exenterated left petrous apex (arrow).

Figure 7. T₁-weighted MRI scan illustrating left CPA epidermoid with extension into the foramen of Luschka (arrow).

The patient underwent a MFTP exploration of the anterior petrous apex. He was found to have mucoid material with cholesterol crystals filling the air cells of the petrous apex. The lesion was most consistent with a mucocele of the petrous apex. The involved area was opened completely until normal air cells were encountered. The defect was obliterated with temporalis muscle. Postoperative CT imaging demonstrated the exenterated petrous apex (Fig. 6). Additionally, the patient has normal hearing and facial nerve function.

Comment: This patient was found to have an inflammatory lesion of the petrous apex. These lesions have been recognized more frequently with the advent of MRI. Jackler and Parker have recently summarized the radiographic findings in petrous apex lesions.¹⁴ Operative findings were most compatible with a mucocele of the petrous apex. While the MFTP approach offers excellent exposure for surgical exploration of the petrous apex, it is not the treatment of choice for cholesterol granuloma of the petrous apex. These lesions are best treated with approaches that provide ventilation of the lesion through the mastoid or middle ear.

Case MP is a 49-year-old female who had undergone a right ventriculoperitoneal shunt for obstructive hydrocephalus and a left suboccipital craniotomy for removal of a large left posterior fossa epidermoid. Postoperative imaging demonstrated significant removal of the lesion and decompression of the hydrocephalus. However, tumor was still noted in the prepontine cistern

and left CPA (Fig. 7). The patient underwent combined MFTP-retrolabyrinthine removal of the residual tumor. The tumor extended anterior and posterior to the fifth nerve, into the internal auditory canal, and into the foramen of Luschka. The middle fossa dura was opened above the superior petrosal sinus, and supratentorial debris was removed. All gross tumor was thought to have been removed. A CT obtained 2 years postoperatively demonstrated complete resection of the petrous bone except for the otic capsule (Fig. 8). No residual tumor was noted. MRI demonstrated prominent enhancement of the meninges but no recurrent mass (Fig. 9). Postoperatively, the patient had normal hearing and facial nerve function.

Case MM is a 68-year-old woman with a history of nonspecific headaches and right blepharospasm for 3 years. Otologic examination was normal, and audiologic testing demonstrated a mild sensorineural loss. Neurologic examination was unremarkable except for right blepharospasm. The patient had previously undergone a right craniotomy for a small right tuberculum sellae meningioma adjacent to the optic nerve. Her original imaging had also noted an incidental right petrotentorial tumor. Serial MRI scans demonstrated slow growth of the right petrotentorial lesion. The most recent MRI scan revealed an enhancing 2½ cm petrotentorial mass consistent with a meningioma (Fig. 10). The tumor was removed via a MFTP-retrolabyrinthine approach. All gross tumor was removed. In the immediate

Figure 8. Postoperative CT scan with bone algorithm demonstrating MFTP-retrolabyrinthine bone removal. Note postoperative adipose graft atrophy.

Figure 9. Postoperative T₁-weighted MRI scan after MFTP-retrolabyrinthine removal of left CPA epidermoid. Note otic capsule surrounded by adipose graft (arrow).

Figure 10. A.) Axial T₂-weighted MRI scan showing a right petrotentorial meningioma. B.) Coronal T₂-weighted MRI scan demonstrating a meningioma centered above the internal auditory canal.

Figure 11. Postoperative axial CT. A.) Bone algorithm revealing resection of the petrous apex and preservation of the otic capsule. B.) Soft-tissue algorithm demonstrating a resected meningeoma and obliteration of the operative defect with an adipose graft.

postoperative period, the patient underwent placement of a lumbar peritoneal shunt for recalcitrant CSF rhinorrhea. Several weeks later, a right frontal subdural hematoma was noted and evacuated, and the lumbar peritoneal shunt was removed. Postoperative CT scanning revealed complete tumor resection (Fig. 11).

Comment: This case demonstrates posterior extension of the MFTP approach for lesions that pass above the internal auditory canal. The retrolabyrinthine approach affords exposure posterior to the otic capsule from the superior petrosal sinus to the jugular foramen. The combined MFTP-retrolabyrinthine exposure is inadequate for tumors that extend posteriorly below the internal auditory canal. This region is best accessed by the modified transcochlear approach.

DISCUSSION

Petroclival lesions that are primarily situated anterior to the internal auditory canal and medial to the petrous carotid artery are most widely accessed through

the modified transcochlear approach.^{6,7} Many of these lesions may also be removed through a middle fossa transpetrous approach, especially when hearing preservation is considered.¹⁵⁻¹⁸ Experience over the last 10 years has demonstrated that this basic approach may be tailored to tumors extending beyond this site. Tumors extending supratentorially may be exposed by opening the middle fossa dura along the superior petrosal sinus. The tentorium may be left intact in tumors that are more easily removed, such as an epidermoid. However, in fibrous tumors that may be densely adherent to the dura and the tentorium, the tentorium is also transected for improved access. If necessary, tentorium that is invaded by tumor may be resected. The MFTP approach has also been used with the infratemporal fossa approach for lesions that extend to the vertical petrous carotid artery. While this combination of approaches results in maximal conductive hearing loss and temporary facial paralysis, the otic capsule may be left in place to avoid the morbidity of acute vestibular deafferentation.

Petrous ridge neoplasms may extend posterior to the internal auditory canal through growth either above or below the internal auditory canal. Tumors above

the internal auditory canal, such as a petrotentorial meningioma, may be exposed by combining MFTP and retrolabyrinthine approaches as described by Pensak et al.¹² In this technique, the entire petrous apex except the otic capsule is removed. This approach differs from the petrosal approaches of Malis¹⁰ and Al-Mefty¹¹ by the removal of bone in Kawase's triangle. The removal of bone from the anterior petrous apex not only decreases retraction of the temporal lobe and improves exposure of the prepontine region, it also allows removal of bone from the petroclival region that may supply tumor vascularity or that is infiltrated with tumor.

For complex lesions of the petrous apex that extend inferoposterior to the internal auditory canal, the MFTP approach is inadequate for complete tumor exposure. These broad-based tumors require complete removal of the petrous apex. We continue to prefer the modified transcochlear approach in these situations.⁷ The modified transcochlear approach affords wide exposure of the petroclival junction and CPA. Tumor extension through the incisura often necessitates transection of the tentorium for supratentorial access as suggested by Spetzler et al.¹⁹ For tumors invading the jugular foramen or foramen magnum, a transsigmoid or lateral transcondylar approach may also be included.

The advantage of the MFTP approach over the modified transcochlear approach is preservation of the otic capsule to avoid ipsilateral total hearing loss, vestibular dysfunction, and facial nerve palsy. In our series, only 1 of 13 patients had postoperative loss of hearing. The hearing loss in this patient is conductive from obliteration of the middle ear rather than from loss of sensorineural function. Two of our 13 patients had preoperative facial paralysis. This was due to osteomyelitis in one case and acquired cholesteatoma in the second. The patient with osteomyelitis has a grade VI facial function, while the patient with cholesteatoma has grade IV facial function at 3 years postoperatively.

While our series demonstrates that the MFTP approach is generally successful in maintaining hearing, and labyrinthine and facial function, one must ask whether this conservation is accomplished at the sacrifice of exposure and subsequent inadequate treatment. Five of our patients are thought to have residual disease. Two patients had residual tumor left electively in the cavernous sinus. One patient with a meningioma was treated with gamma knife radiosurgery and the second patient with a schwannoma of the petrous apex has been treated with observation. A third patient had schwannoma left on the posterior carotid genu; however, no residual tumor is apparent on postoperative MRI scanning at 2 years. A fourth patient has residual epidermoid in the opposite CPA and has been scheduled for a MFTP removal. The fifth patient had residual meningioma left inferior to the internal auditory canal. This patient was lost to follow-up and presented 4 years postoperatively

with a large recurrent tumor. This is the only patient in our series that had inadequate exposure for tumor removal and would have been more adequately treated with a modified transcochlear approach.

SUMMARY

Surgical access to petroclival lesions that are centered anterior to the internal auditory canal and medial to the petrous carotid artery has confounded surgeons for nearly a century. A variety of approaches have been developed to reach this site. The widest approach to this region is the modified transcochlear. The middle fossa transpetrous approach was developed in an effort to access this area without removal of the otic capsule. This technique has been extended recently by the addition of tentorial transection and the retrolabyrinthine approach. In properly selected cases, hearing, and labyrinthine and facial nerve function may be maintained without compromising surgical exposure.

REFERENCES

1. House WF, Hitselberger WE: The transcochlear approach to the skull base. *Arch Otolaryngol* 102:334-342, 1976
2. Fraenkel J, Hunt JR: Contribution to the surgery of neurofibroma of the acoustic nerve. *Ann Surg* 40:293-319, 1904
3. Borchardt M: Zur Operation der tumoren des Kleinhirn Bruckenwindels. *Berl Klin Wochenschr* 42:1033-1035, 1905
4. Eagleton WP: Unlocking of the petrous pyramid for localized bulbar (pontile) meningitis secondary to suppuration of the petrous apex. *Arch Otolaryngol* 386-422, 1931
5. Morrison AW, King TT: Experiences with a translabyrinthine-transtentorial approach to the cerebellopontine angle: technical note. *J Neurosurg* 38:382-390, 1973
6. Pellet W, Cannoni M, Pech A: The widened transcochlear approach to jugular foramen tumors. *J Neurosurg* 69:887-894, 1988
7. Horn KL, Hankinson HL, Erasmus MD, et al: The modified transcochlear approach to the cerebellopontine angle. *Otolaryngol Head Neck Surg* 104:37-41, 1990
8. Kawase R, Taya S, Shiobara R, et al: Transpetrosal approach for aneurysms of the lower basilar artery. *J Neurosurg* 63:857-861, 1985
9. House WF, Hitselberger WE, Horn KL: The middle fossa transpetrous approach to the anterior cerebellopontine angle. *Am J Otol* 7:1-4, 1986
10. Malis LI: Surgical resection of tumors of the skull base. In Wilkins RH, Rengachary SS (eds): *Neurosurgery*. New York: McGraw-Hill, 1985, pp 1011-1021
11. Al-Mefty O, Fox JL, Smith RR: Petrosal approach for petroclival meningiomas. *Neurosurgery* 22:510-517, 1989
12. Pensak ML, Loveren HV, Tew JM, et al: Transpetrosal access to meningiomas juxtaposing the temporal bone. *Laryngoscope* 104:814-820, 1994
13. House JW, Brackmann DE: Facial nerve grading system. *Otolaryngol Head Neck Surg* 93:146-147, 1985
14. Jackler RK, Parker DA: Radiographic differential diagnosis of petrous apex lesions. *Am J Otol* 13:561-574, 1992
15. Nassif PS, Shelton C, Arriaga M: Hearing preservation following surgical removal of meningiomas affecting the temporal bone. *Laryngoscope* 102:1357-1361, 1992

16. Hitselberger WE, Horn KL, Hankinson H, et al: The middle fossa transpetrous approach for petroclival meningiomas. *Skull Base Surg* 3:130–135, 1993
17. House WF, Hitselberger WE, Horn KL: Middle fossa transpetrous approach to the anterior-superior cerebello-pontine angle. In Smith MFW, McElveen JT (eds): *Neurological Surgery of the Ear*. St. Louis, Mosby-Year Book, 1992, pp 88–89
18. Horn KL, Hankinson H, Hitselberger WE: The middle fossa transpetrous approach for access to the petroclival region (extended middle fossa approach). In Brackmann DE, Shelton C, Arriaga MA (eds): *Otologic Surgery*. Philadelphia, W.B. Saunders, 1994, pp 659–665
19. Spetzler RF, Dasgupta CP, Pappas CT: Combined approach for lesions involving the cerebellopontine angle and skull base: experience with 30 cases. *Skull Base Surgery* 1:226–234, 1991