The System of the Modified Transcochlear Approaches to the Petroclival Area and the Prepontine Cistern

ABSTRACT—Between June 1986 and June 1993 46 different tumors (27 extradural and 19 intradural) located in the petroclival area and/or prepontine cistern have been operated on at The Gruppo Otologico Piacenza and the ENT Department of Bergamo, Italy, using a modification of the transcochlear approach. Total tumor removal was obtained in all cases. Complications occurred in eight patients. One patient died due to infarction of the brain stem. The system of modified transcochlear approaches conceived for the removal of various intradural and extradural tumors is presented. This approach, together with its modifications, is the major operative access to the central skull base and clivus among a series of lateral approaches described in the literature. The basilar surgical technique (type A) and its modifications (types B, C, D) are described in detail, and five different, illustrative cases are presented. Indications, limits, results, and complications related to the approach are discussed. (*Skull Base Surgery*, 6(4):237–248, 1996)

Approaches to the central skull base have progressed rapidly through continued improvements of imaging diagnosis and surgical strategies. The transcochlear approach was extended to its full range of potentialities, leading to the most direct and close access to the petrous apex and clivus, the anterior cerebellopontine angle, and the prepontine cistern. The transcochlear approach was introduced by House and Hitselberger¹ in 1976 for management of lesions in the petrous apex and clivus medial to the internal auditory canal and anterior to the brainstem. This approach was improved by overcoming the constricted operative field with the removal of the bony canal wall, as described by Jenkins and Fisch² for acoustic neuromas. A modification of the transcochlear approach has been adopted by Sekhar and Estonillo³ with the anterior mobilization of the internal carotid artery to extend the anterior limit of the dissection. Similar ap-

proaches have been reported by Pellet et al,⁴ Horn et al,⁵ Speltzer et al,⁶ and Thedinger et al.⁷

This approach has been used by us since 1986, initially for the management of petrous bone cholesteatoma. Starting in 1988, we used it for intradural, extra- and transdural lesions of the petroclival area. The present report reviews the results of 46 patients with large tumors of the petroclival area and/or prepontine cistern, managed with the modified transcochlear approach with the aim of complete tumor removal.

DEFINITION AND CLASSIFICATION

The system of modified transcochlear approaches is a versatile lateral approach to the median skull base through the petrous bone. The basilar surgical procedure

that we define as type A consists of the removal of the whole petrous bone and homolateral mid-clivus with dissection of the vertical and horizontal portions of the internal carotid artery and posterior rerouting of the facial nerve from its intracisternal portion up to the stylo-mastoid foramen. The surgical field lies between the retrosigmoid posterior fossa dura, the carotid artery, and clivus, from the tentorium to the jugular bulb, and permits the control of V up to XI CNs, the basilar artery with its branches, and the homolateral vertebral artery (Fig. 1).

The anterior extension (type B) resembles the infratemporal approach type B according to Fisch, and includes the anteroinferior dislocation of the mandible, sacrifice of the middle meningeal artery, and a section of the mandibular division of the trigeminal nerve. It widens the surgical field up to the anterior foramen lacerum and retropharyngeal spaces (Fig. 2).

The supratentorial extension (type C) consists of incision and removal of the middle fossa dura and tentorium. It widens the surgical field with minimal temporal lobe retraction and permits the control of the III and IV c.n., as well as the superior cerebellar artery and the posterior cerebral artery (Fig. 3).

The inferior extension (type D) is a petrooccipital transsigmoid approach and includes the closure of the sigmoid sinus and jugular bulb together with drilling of the lateral portion of the occipital condyle. It extends the surgical field inferiorly and allows control of the vertebro-basilar junction and of the homo- and contralateral vertebral arteries (Fig. 4).

Figure 2. Modified transcoclear approach type B: Final step of the surgical procedure. The type A has been anteriorly extended. The mandibular condyle has been displaced forward, the middle meningeal artery and the mandibular division of the trigeminal nerve sectioned. The internal carotid artery (vertical and horizontal segments) have been completely dissected up to the anterior foramen lacerum. (Abbreviations: see Figure 1.)

Figure 1. Modified transcoclear approach type A: Final step of the surgical procedure after removal of the anterior and posterior labyrinth and posterior rerouting of the facial nerve. The carotid artery has been dissected in its vertical portion and part of the horizontal portion has been exposed. The middle clivus has been totally removed. The dura of the posterior fossa and clivus are opened. Schematic view of the cerebellopontine angle and prepontine cistern is shown (I.C.A., internal carotid artery; B.A., basilar artery; S.S., sigmoid sinus; P.I.C.A., posteroinferior cerebellar artery; A.I.C.A., anteroinferior cerebellar artery; S.C.A., superior cerebellar artery; S.P.S., superior petrosal sinus).

Figure 3. Modified transcoclear approach type C: Final step of the surgical procedure. The type A has been extended supratentorially with section of the superior petrosal sinus and gentle retraction of the temporal lobe. Control of the supratentorial compartment (third and fourth cranial nerves and posterior cerebral artery) is achieved. The tentorium has been cut and removed. (Abbreviations: see Figure 1.)

Figure 4. Modified transcochlear approach type D. Final step of the surgical procedure. The type A has been extended inferiorly to reach the lower clivus. The sigmoid sinus has been sectioned and closed and the jugular bulb dissected and pushed inferiorly. The occipital condyle (lateral portion) has been removed and the twelfth and the lower cranial nerves are exposed. Posterior rerouting of the facial nerve is done. (Abbreviations: see Figure 1; G.G., geniculate ganglion.)

The modified transcochlear approach can be used as a single procedure for purely intra- or extradural tumors, or may represent the first or second stage in combined procedures for transdural lesions.

SUMMARY OF PATIENTS

Eight hundred thirty patients underwent skull base surgery at our institutions between June 1986 and June 1993. Forty-six patients with large tumors of the petro-clival area and prepontine cistern were treated with the modified transcochlear approach during the same period of time. Forty-one of them were operated in one stage, and five were staged: a total of 51 surgical procedures.

Intradural Tumors

Thirteen of nineteen intradural tumors (10 petro-clival meningiomas, 5 clival chordomas, 2 acoustic neuromas, 1 jugular foramen neuroma, 1 glomus jugulare

tumor) were treated with the modified transcochlear approach type A. Fourteen patients underwent a single-stage procedure and 5 were staged (Table 1). Preoperative inner ear function was normal in 7 cases; sensory neural hearing loss was present in 3 cases, and the remaining 9 had a dead ear. Preoperative facial nerve function was normal in 15 cases, and 4 had facial palsy grade VI according to the House-Brackmann grading.

Extradural Tumors

Twenty-seven extradural tumors (18 petrous bone cholesteatoma, 3 cholesterol granuloma, 3 facial nerve tumors, 1 residual acoustic neuroma, 1 osteosarcoma, and 1 giant cell tumor) were treated with the modified transcochlear approach type A. Twenty-three cases had a dead ear preoperatively on the involved side, and the remaining cases showed a sensory-neural hearing loss. Facial palsy grade VI was present in 21 cases preoperatively and normal facial nerve function was present in the remaining 6 cases.

MATERIALS AND METHODS

The patient is placed in a supine position with the head rotated toward the contralateral side. A postauricular incision is made about 4 cm from the postauricular sulcus, 3 cm above the pinna, and 1 cm below the mastoid tip. The temporalis muscle, the mastoid, the zygomatic arch, and part of the temporalis squama are exposed. The external auditory canal is transected up to the tragus, and the skin is everted and the blind sac closed. The skin of the bony external auditory canal, the drum, and the ossicles are removed. An extended mastoidectomy is performed. The bone over the temporalis squama, the sigmoid sinus, and the portion 2 to 3 cm over the retrosigmoid posterior fossa dura is thinned and removed until dura of the middle cranial fossa and posterior cranial fossae can be displaced easily, superiorly and posteriorly. Skeletonization of the sigmoid sinus is continued down to the jugular bulb, and if the latter is in a high position it is completely freed from bone and then pushed down with oxidized cellulose and bone wax.⁸ The anterior bony canal wall of the external auditory canal is usually removed; the mastoid tip, as well as the tympanic bone, are removed. A complete labyrinthectomy is performed and decompression of the facial nerve from the geniculate ganglion to the stylomastoid foramen is done leaving a thin cover of bone over the nerve. The bone over the IAC superior, posterior, and inferior to it is removed. The greater superficial petrosal nerve is cut and bleeding from it is controlled with bipolar coagulation. The facial nerve is freed from bone in its second, third, and intralabyrinthine portion, then raised and displaced posteriorly. The dura of the IAC from the fundus to the porus is freed and pushed posteriorly with

Table 1. Modified Transcochlear Approach

Materials and Methods Types of Approaches Staged

- Cordoma → IFT Type B + T.C. Type A
- Cordoma → T.C. Type B + P.O.T.S.
- Cordoma → IFT Type B + T.C. Type A
- Meningioma → T.C. Type A + Supratent.
- Meningioma → T.C. Type A + Supratent.

its entire contents to better protect the facial nerve, which is without epineurium in this segment. At this point, the facial nerve is glued to the posterior fossa dura. A new canal can be created toward the jugular bulb to protect the nerve from further drilling. The remaining portion of bone of the Fallopian canal, the anterior wall of the IAC, and the cochlea are also removed. The vertical portion of the internal carotid artery is reached. It can be identified simply and skeletonized, leaving a thin layer of bone; or the artery may be freed from bone with a large diamond burr. This maneuver is better accomplished after anterior displacement of the mandibular condyle with the aid of a retractor. The apical portion of the petrous bone is removed with exposure of the Meckel's cave. The middle clivus is reached. Clivus bone is soft and bleeds easily, so attention should be paid to avoid excessive exposure superiorly and opening it into the sphenoid sinus. The inferior petrosal sinus can be reached and closed with oxidized cellulose. Removal of the lateral midclivus is done following dissection of its dural covering. The whole procedure is performed under continuous suction irrigation.

At this point the extradural tumor is removed. The Eustachian tube is tightly closed with a muscle plug. The cavity is obliterated with abdominal fat.

In cases of intradural tumors (petroclival meningiomas, clivus chordomas, etc.), opening of the dura is accomplished below the superior petrosal sinus and over the jugular bulb in a triangular fashion to reach the meatus. Attention should be paid when opening the dura of the area of the acoustic meatus to preserve the facial nerve. In meningioma cases, in which the nerve is frequently pushed posteriorly by tumor, once the nerve has been identified the posterior transposition of the intradural segment is accomplished. Removal of the tumor begins under continuous suction irrigation using the bipolar coagulation. The tumor capsule is dissected from the surrounding structures, and in meningiomas from the tentorium, to reduce vascular supply. It is essential to maintain the dissection within the arachnoid planes. The tumor is then debulked from inside. Bipolar cautery is always utilized for this purpose with the goal of devascularizing the tumor early, shrinking the tumor mass and debulking it piecemeal. The basilar artery is generally pushed to the opposite side, but in large tumors the artery and its branches may be encased. The removal of the tumor continues by alternating the dissection inferiorly from the lower cranial nerves, superiorly from the tentorium, and posteriorly from the cerebellum. This allows reduction of the tumor mass and dissection from the sixth and seventh cranial nerves, and the brainstem. When the tumor mass is reduced (in cases of meningioma), the tumor is dissected from the petroclival dura and the dura is removed, taking care not to damage the sixth cranial nerve. Very often a meningioma infiltrates the Meckel's cave, pushing cranial nerve V infero-anteriorly and more rarely posteriorly or superiorly. In such cases, the tumor

generally can be dissected easily from inside the cave after opening it. Care must be taken to dissect the tumor from the fibers of the trigeminal nerve. Dissection is rather easy from the above-mentioned structures and brainstem if an arachnoid sheet is present. However, it is very difficult if this sheet is absent, and sometimes incomplete removal must be accepted to avoid a high incidence of postoperative morbidity. Once the tumor has been removed, a careful bipolar coagulation of the surgical field is done. The dura is not closed because a watertight suture cannot be achieved. The Eustachian tube is closed with muscle, the cavity is filled with one large piece of abdominal fat, and the soft tissues are closed in a double layer. This is possible because soft tissues in the skull base are not dissected during the surgical approach, and thus spaces in the neck are kept separated from the dural wound.

Limits of the Approach

In the presence of a high jugular bulb, the control of the lower clivus and foramen magnum is difficult. If the tumor does not extend inferiorly too far, the jugular bulb may be uncovered with a diamond burr and pushed inferiorly with oxidized cellulose and bone wax.⁸ If the tumor is large or involves the jugular bulb and the lower clivus, a petro-occipital transsigmoid transjugular approach is used in conjunction, after closure of the jugular vein in the neck with a separate skin incision (type D).

Another limitation is extension of the tumor above the trigeminal root in the upper clival area, which is the superior limit of the approach. This requires some temporal lobe retraction or combination with a supratentorial approach with transection of the superior petrosal sinus and tentorium (type C).

If a transdural tumor extends from the cerebellopontine angle to the retropharyngeal spaces (for instance, chordomas), the anterior limit of the surgical field can be overcome with anterior dislocation of the mandible and sacrifice of the middle meningeal artery and mandibular division of the trigeminal nerve. Removal of bone and dura at the same time is particularly important for chordomas that have infiltrative growth pattern.

RESULTS

All patients had total tumor removal in one or two stages as judged by intraoperative inspection and by postoperative contrast-enhanced CT or MRI. The follow-up ranged from 6 months to 7 years. One patient died from brainstem infarction 20 days after surgery for a sphenopetroclival angiomatous meningioma. Complications occurred in eight patients. One patient with an infected petrous bone cholesteatoma developed a brain abscess which was successfully drained; one patient had intra-

petrous carotid artery laceration that was repaired immediately with no sequelae; three patients had transection of the sixth cranial nerve, but in two patients the nerve was infiltrated by tumor and preoperative dysfunction was present. One patient had the fourth cranial nerve sectioned because of tumor infiltration despite normal function preoperatively. In two cases, lower cranial nerves were sectioned because of tumor involvement: only one of these patients had slight dysphagia for 1 week postoperatively.

Facial nerve function was worse postoperatively in 21 patients. The results of seventh nerve function immediately after surgery and at a minimum of 1 year or more follow-up are shown in Table 2. No cases of ataxia or lower cranial nerve palsy occurred in the present series as a consequence of surgery. All patients are independent, without need of assistance postoperatively. The Karnofsky status of patients pre- and postoperatively is summarized in Table 3.

Illustrative Cases

Case 1

A 45-year-old woman was first seen at another institution where a speno-petro-clival-meningioma was diagnosed with CT scan and MRI. The tumor was partially removed through a subtemporal approach. Following surgery, the patient experienced difficulty in swallowing, sphincter control, and could not walk. Her Karnofsky grade was between 40 and 50. When first seen by us 1 year postoperatively, this patient presented a large residual petroclival meningioma located in the prepontine cistern and compressing the pons (Fig. 5). Arteriography confirmed the diagnosis of meningioma. Facial nerve function and hearing were normal. Preoperative embolization of the feeding vessels was done 48 hours before surgery.

A modified transcochlear approach type A with posterior rerouting of the facial nerve was done in January 1991, and the tumor was completely removed in one stage (Fig. 6). The operation took 8 hours. The postoperative course was uneventful except for facial nerve palsy grade

Table 3. Modified Transcochlear Approach

Karnofsky Score	Intradural Tumors Karnofsky		
	Status	Pre-Op.	Post-Op.
<40	Poor	2	—
50–60	Fair	2	—
70–80	Good	2	2
90–100	Excellent	13	16*

*One fatality

VI and a dead ear. The patient started to move her legs and arms 15 days after surgery. One year postoperatively she has resumed her work (Karnofsky 100), and to date there is no sign of recurrence on gadolinium enhanced MRI. Facial nerve function is grade III.

Case 2

A 65-year-old male was first seen in January 1992 with a history of a left sixth cranial nerve palsy that began 3 years before. He was in a wheelchair because he had great difficulty moving his legs. He was unable to write and, 3 months before consultation, he developed swallowing and alertness problems (Karnofsky less than 50). His facial nerve and hearing were normal. CT and MRI revealed a medially located large tumor of the clivus

Figure 5. CT axial scan showing a large meningioma in the prepontine cistern compressing the brain stem.

Table 2. Modified Transcochlear Approach

House Grade	Follow-up Facial Nerve Function		
	Pre-Op.	Immediately Post-Op.	1 Year Post-Op.
Grade I	23	2*	2
Grade II	—	—	1
Grade III	—	1	22
Grade IV	—	—	3
Grade V	—	—	4
		Old palsies →	7
Grade VI	23	43	F.N. absent → 6

*Facial nerve not re-routed (transotic approach)

Figure 6. Postoperative CT axial scan showing no sign of recurrence and the surgical cavity obliterated with fat.

extending intradurally for more than 4 cm and compressing the pons (Fig. 7). Arteriography showed absence of vascular pattern. A diagnosis of clival chordoma was suspected.

A modified transcochlear approach type A was done in February 1992. The tumor was located intra- and extradurally and was totally removed in one stage. The procedure took 8 hours. The postoperative course was complicated by brain edema which resolved slowly over 15 days. The patient was discharged on the twentieth day with initial recovery of leg movements. Postoperative CT and MRI 2 years after surgery show complete removal of tumor and no recurrence (Fig. 8). Facial nerve function returned to grade III. The patient has regained full movement of his limbs and has returned to work.

Case 3

This 29-year-old man presented with a longstanding history of sensory-neural hearing loss. On examination, he showed complete hearing loss in his left ear and ninth, tenth, eleventh, and twelfth cranial nerve palsy. Otoscopy was unremarkable. CT scan and MRI showed a dumbbell tumor located in the jugular foramen (Fig. 9); a lower cranial nerve tumor was suspected preoperatively.

A modified transcochlear approach type D with facial nerve rerouting was performed. Complete removal of the tumor was accomplished in a 7-hour procedure in one stage. Postoperative course was uneventful except for facial nerve palsy grade VI. The patient was discharged on the seventh day postoperatively. Follow-up at 4 years showed a grade III facial nerve palsy, and there are no signs of recurrence on CT scan (Fig. 10).

Case 4

A 47-year-old woman was seen for a right middle ear cholesteatoma. She also had a left sixth nerve paresis, trigeminal neuralgia, and tinnitus. An MRI showed a left petroclival meningioma with supratentorial extension (Fig. 11). Arteriography confirmed the diagnosis of poorly vascularized meningioma, so preoperative embolization was not performed.

The right middle ear cholesteatoma was removed with an open technique to preserve hearing. Three months later a modified transcochlear approach type C with total removal of the tumor in one stage was done on the contralateral side. The postoperative course was uneventful except for the fourth cranial nerve palsy due to nerve transection because of infiltration by tumor. The sixth cranial nerve compressed by tumor was preserved. The patient was discharged 8 days after surgery. Postoperative CT and MRI confirmed the total removal of tumor. Postoperative facial nerve function is grade III at 1 year follow-up. MRI with gadolinium enhancement shows no

Figure 7. Preoperative MRI with gadolinium enhancement showing a large chordoma originating in the mid-clivus compressing the brainstem.

Figure 8. Postoperative MRI showing complete removal of tumor and normal appearance of brainstem.

recurrence at 17 months postoperatively (Fig. 12). She no longer has major problems from fourth cranial nerve palsy.

Case 5

A 57-year-old man presented with right ocular palsy starting 4 years previously, with right hearing loss and right amaurosis for 1 year. Pure tone audiometry showed a right conductive hearing loss. CT scan and MRI showed a large clival chordoma involving the retropharyngeal space, reaching the orbital fissure and extending intradurally (Figs. 13–15). An extradural removal was first done through a type C infratemporal fossa approach with muscle and fat obliteration. The postoperative course was uneventful except for slight facial nerve palsy and anaesthesia of the V3 territory (Fig. 16). Two months later a modified transcochlear approach type A with posterior

rerouting of the facial nerve was done for the removal of the intradural portion of the tumor (Fig. 17). The dura was removed and histologic examination confirmed the infiltration by tumor. The postoperative course was uneventful. At 24 months, CT scan showed complete removal of tumor and a facial nerve palsy of grade III (Fig. 18).

DISCUSSION

The prominent surgical problem with tumors that involve the petroclival area and the prepontine cistern is access. A variety of surgical routes have been proposed to remove these lesions. A system of modified transcochlear approaches is the major operative access we have used to the central skull base and clivus. They can manage extradural intraosseous lesions and intradural anterior lying

Figure 9. CT coronal section of a lower cranial nerve neuroma showing a dumbbell tumor with erosion of the petrous bone and clivus.

Figure 10. Postoperative CT axial scan showing total removal of tumor and the surgical cavity obliterated with abdominal fat.

tumors. These approaches should be considered an anterior extension of the classic transcochlear approach described by House and Hitselberger.¹

Other surgical approaches have been developed in recent years^{9-14,16} for the removal of clival and prepontine cistern tumors. Such approaches give a slightly larger anterior exposure than the classic suboccipital approach, but the exposure is still narrow and requires the temporal lobe and cerebellar retraction associated with the necessity of working between the nerves and vessels. Furthermore, the removal of dura and bone often infiltrated by meningiomas and chordomas is not possible at the same time.

Another approach to the anterior superior cerebellopontine angle has been described^{15,16}: it is an extradural subtemporal route with preservation of facial nerve and cochlear nerve function. The main disadvantage is the limited exposure of the anterior cerebellopontine angle, the necessity of temporal lobe retraction, the incomplete control of the clivus below the internal auditory canal, difficult to control bleeding from the inferior petrosal sinus. The transotic approach proposed by Fisch,¹⁷ which leaves the facial nerve in place, has the advantage of preserving the integrity of the vascular supply to the nerve and facial nerve function. It has a major disadvantage in that it provides a very narrow space between the internal carotid artery and the facial nerve, and it leaves the nerve in the surgical field, which impedes manipulation of intradural tumors. The petrous apex and the middle clivus cannot be completely removed, and the Meckel's cave is out of reach.

The modified transcochlear approach is indicated for the removal of extradural intrapetrous tumors such as apical or massive labyrinthine petrous bone cholesteatomas,¹⁸ apical cholesterol granulomas, and recurrent chemodectomas of the petrous apex. It is also suited for large intradural tumors¹⁹ (petroclival meningiomas, clival chordomas, neurinomas) extending to the anterior cerebellopontine angle, anteriorly to cranial nerve V and/or involving the prepontine cistern, and the vertebral and basilar arteries. In cases of tumors with intradural and extradural extension, such as clival chordomas, the transcochlear approach can be utilized as a first or second stage procedure for removal of the intradural portion to avoid direct connection of the subarachnoid spaces with the neck or the retropharyngeal spaces. This approach reaches primary or elective areas such as the petrous apex, the anterior C.P.A., the prepontine cistern, and the middle clivus.

Secondary intradural areas include the supratentorial region and the region below the lower cranial nerves. The

Figure 11. MRI with gadolinium enhancement showing a large petroclival meningioma with supratentorial extension with dislocation of the brainstem (frontal scan).

Figure 12. Postoperative MRI with gadolinium enhancement shows no residual tumor and cavity obliterated with abdominal fat (frontal scan).

first area can be reached following closure of the superior petrosal sinus and section of the tentorium (modified transcochlear approach type C). Access to the lower clivus requires closure of the lateral sinus and jugular bulb (modified transcochlear approach type D). Secondary extradural areas include:

- retropharyngeal spaces which can be reached after anteroinferior dislocation of the mandible (modified transcochlear approach type B);
- contralateral mid-clivus and petrosal apex which can be reached after anterior dislocation of the internal carotid artery;
- infratemporal fossa, whose access requires the association of a type B approach, according to Fisch.

The system of the modified transcochlear approaches herein described has many advantages if compared to the

other routes. It allows a better access and the most lateral access to the petroclival area and to all the anterior anatomy of the prepontine region nerves and vessels. This route provides a good exposure of the middle clival structures and ipsilateral brainstem without any brain retraction and with the preservation of the integrity of the vein of Labbe. In addition, it gives a very flat angle of approach to the mid clivus and permits better visualization of the dissection plane between the brainstem and the tumor. In meningiomas it permits an early disconnection of the vascular supply from the petroclival dura and the tentorium.

The surgical field may be enlarged anteriorly, superiorly, and inferiorly to overcome the limits of the approach. It may be used alone or in combination with other lateral approaches for the excision of large extradural tumors such as petrous bone cholesteatomas or chor-

Figure 13. MRI with gadolinium enhancement shows a large clival chordoma that extends beyond the midline and extends into the retropharyngeal spaces and compresses the temporal lobe (coronal scan).

Figure 14. Axial CT scan of the same patient showing massive erosion of the petrous apex and clivus, the greater wing of the sphenoid and the posterior wall of the maxillary sinus.

domas. It may be used for intra- and transdural lesions such as jugular foramen neurinomas, chemodectomas, clival chordomas, etc. The exposure allows visualization of cranial nerves V to XI along with the basilar and vertebral arteries. It allows early identification of the facial nerve in the internal auditory canal prior to its involvement by tumor. The nerves are outside the surgical field, beyond the tumor, so that there is no need to work between the nerves and vessels during tumor removal. Thus, this approach avoids any cerebellar or brainstem retraction and related complications because the field is obtained at the expense of the temporal bone. A safe reconstruction of the surgical wound is always possible with abdominal fat and closure of the Eustachian tube and external auditory canal. The risks and complications of

this approach are the same as those of the classic trans-labyrinthine route for acoustic neuroma. No CSF leaks occurred in our series.

The main disadvantage is total ipsilateral deafness in all operated cases. However, the majority of these cases have some degree of sensory-neural hearing loss or total deafness preoperatively. In our series, only 7 out of 46 patients had normal inner ear function preoperatively. Furthermore, all patients with intradural tumors had large lesions, which are not candidates for preservation of hearing. As stated by Thedinger et al⁷ "what is gained in safety by generous, more direct access to the tumor and surrounding important neurovascular structures is a worthwhile exchange for the loss of hearing."

The other disadvantage is temporary facial nerve

Figure 15. CT coronal section shows intra- and extradural extension of the tumor which erodes the middle fossa plate, clivus, pterigoid process and extends to the pharynx.

Figure 16. CT axial scan after the first stage operation (infratemporal approach type B + C) showing the planned subtotal removal of tumor. The intradural portion is left attached to the basilar artery. The cavity is partially obliterated with abdominal fat and pedicled temporalis muscle. The horizontal portion of the internal carotid artery is clearly seen surrounded by abdominal fat.

paralysis grade VI according to the House grading system—in all cases due to posterior rerouting of the facial nerve trunk. The possibility of facial nerve transection during the dissection should be considered for the inexperienced surgeon. Proper technique and the use of intraoperative facial nerve monitoring should reduce the above mentioned risks. Another disadvantage is the time required to develop the approach which, in experienced hands, gener-

ally takes about 3 hours but may require several more hours or even a two-staged procedure (Sekkar).

In our hands, results with the system of the modified transcochlear approaches were extremely encouraging. It should be stressed that total tumor removal has been accomplished in all cases. The postoperative absence of palsy in the lower cranial nerves should be emphasized when comparing this with other approaches.¹³⁻²⁰

Figure 17. MRI after second-stage surgery (transcochlear approach) which shows total removal of tumor and abdominal fat occupying the cavity.

Figure 18. CT postoperatively clearly demonstrates the removal of the petrous bone and clivus and the cavity obliterated with temporalis muscle anteriorly and abdominal fat posteriorly.

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