Combined Transpetrosal-Transtentorial Approach for Excision of Petroclival Tumors

Petroklival Tümörlerin Çıkartılmasında Kombine Transpetrozal Transtentorial Yaklaşım

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Abstract: This report describes our experience using a combined transpetrosal-transtentorial approach to address petroclival lesions. This surgical technique provides good exposure to the cerebellopontine angle, the petroclival region, the posterior aspect of the cavernous sinus, and the upper and mid-clivus. Over a-5-year period, 16 patients with tumors in the petroclival region underwent surgery involving a combined transpetrosal-transtentorial approach. Eight of the masses were meningiomas, four were epidermoid cysts, three were trigeminal schwannomas, and one was a chordoma. Total resection of the tumor was achieved in 12 cases (75%), and subtotal resection in four cases (25%). Four patients died (25%) in the early postoperative period due to brainstem edema, hemorrhagic infarct, pulmonary embolism, and pulmonary dysfunction. The remaining 12 patients were followed for a mean of 30 months. Six patients developed additional neurological deficits postoperatively. None of the surviving 12 patients experienced tumor recurrence or symptomatic deterioration during follow-up. This technique provides the most efficient route to the petroclival region, offers good surgical exposure, allows the major cranial neurovascular structures to be preserved, minimizes temporal lobe retraction, and does not impair hearing. In light of these advantages, we believe that the combined transpetrosal-transtentorial approach is the best way to access large tumors in the petroclival area.

Key Words: Meningioma, petroclival lesion, skull base surgery, transpetrosal-transtentorial approach

Özet: Bu makalede, petroklival bölge lezyonlarına ulaşmak için kombine transpetrozal-transtentorial yaklaşım tekniği tanımlanmaktadır. Bu yaklaşımın kullanılmasıyla cerebello-pontin köşe, petroclival bölge kavernöz sinüsün posterior bölümü üst ve orta klivus alanları dahil olmak üzere geniş bir expozisyon sağlanmaktadır. Kombine transpetrosal-transtentorial yaklaşım, beş yıl içinde, petroklival bölgede tümörü bulunan 16 olguda kullanıldı. Bu olguların sekizinde meningioma, dördünde epidermoid kist, üçünde schwannoma ve birinde ise kordoma olduğu gözlendi. Olguların 12'sinde (%75) gross-total, dördünde (%25) ise subtotal tümör rezeksiyonu sağlandı. Dört hasta (%25), beyin sapı ödemi, hemorajik infarkt ve pulmoner emboli nedeniyle öldü. Geriye kalan 12 hasta ortalama olarak 30 ay boyunca takip edildi. Altı hastada post-operatif dönemde ek nörolojik defisit gözlendi. Bu hastaların hiçbirinde takipleri sırasında tümör rekürrensi veya semptomatik kötüleşme gözlenmedi. Sonuç olarak, bu teknik petroklival bölgeye ulaşmada kısa bir yolu, geniş bir ekspozisyonu, ana nörovasküler yapıların korunmasını minimal temporal lob retraksiyonuyla sağlamaktadır ve işitme korunmaktadır. Bu yüzden, kombine transpetrozal-transtentorial yaklaşım, petroklival bölgede yer alan tümörlerin çıkartılması için en uygun yöntemlerden biridir.

Anahtar Kelimeler: Kafa tabanı cerrahisi, meningioma, pertoklival lezyon, transpetrozal-transtentorial yaklaşım

INTRODUCTION

Pterional, subtemporal, and suboccipital approaches, as well as various combinations of these procedures, have been used to approach tumors in the petroclival region. Masses in this area present significant surgical challenges, and their surgical excision is associated with a high complication rate. Removal of these tumors has become safer in the last decade, with the introduction of better approaches to the lateral skull base (the combined transpetrosal-transtentorial approach, for example) and improved microsurgical technique (1-6,9,11,16,18-24).

We have used the combined transpetrosal-transtentorial approach to access and treat selected tumors in 16 patients since 1994. This report details our experience in surgically managing these cases.

CLINICAL MATERIALS AND METHODS

Between 1994 and 1999, we operated on 16 patients with tumors or cysts in the petroclival region. All procedures were done in the Department of Neurosurgery at Ankara University School of Medicine. Patient age ranged from 23 to 53 years (mean, 39.1 years). The presenting symptoms were related to cranial nerve impairment, increased intracranial pressure, and brainstem or cerebellar compression. Only two of the patients had previously undergone surgery for removal of the tumor. All patients underwent computed tomography (CT), magnetic resonance imaging (MRI), and cerebral angiography (Figures 1a-d). None of the tumors were

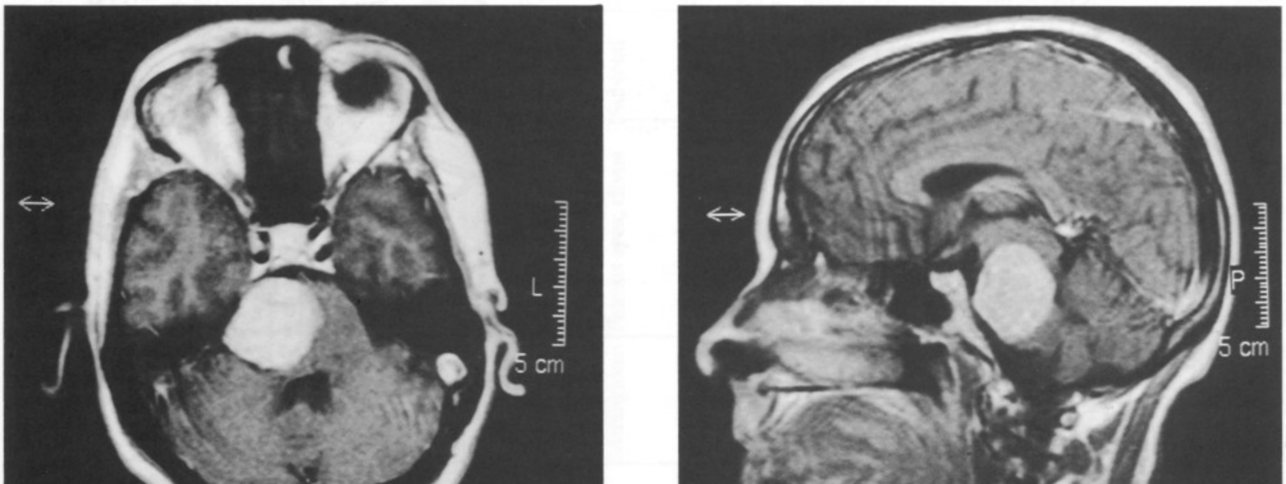

Figure 1: (Case-16 AE) (a) Preoperative axial, (b) sagittal, and (c) coronal magnetic resonance images with intravenous contrast show a petroclival meningioma. A carotid angiogram (d) confirms that blood is being supplied to the tumor by the tentorial artery.

embolized before surgery. Our series included eight meningiomas, four epidermoid cysts, three trigeminal schwannomas, and one chordoma. The pertinent clinical data are summarized in Table 1.

Surgical Technique:

Under general anesthesia, the patient is placed in semisupine or lateral park-bench position on the operating table, with the head turned laterally until the temporal surface of the skull is horizontal to the floor. The head is then secured in pin fixation with a Mayfield head-rest, and with the vertex cranii facing slightly downward. Intraoperative and perioperative antibiotic administration is recommended to protect against infection.

A question-mark skin incision is made around the temporal and retromastoid areas, as illustrated in Figure 2a, and the temporal muscle and pericranium are dissected separately, and reflected anteriorly with the scalp. The bone covering the beginning of the sigmoid sinus and the middle section of the ipsilateral transverse sinus are drilled to expose the sinus in these two areas (Figure 2b). The dura just below and above the sinus is exposed, and a craniotomy is performed using a Midas Rex high-speed drill. The craniotomy involves the temporal bone and retromastoid-suboccipital bone. A partial mastoidectomy and

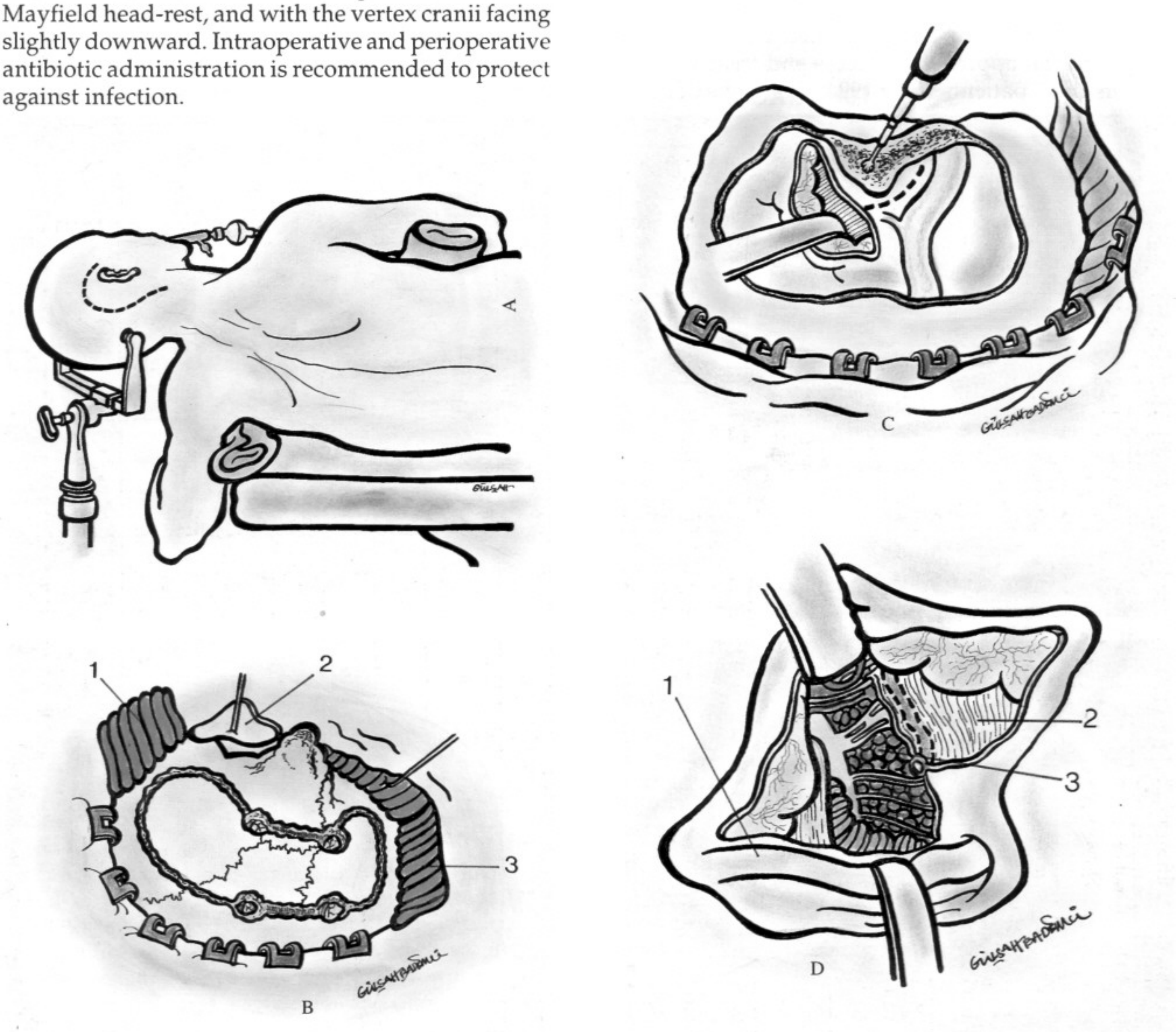

Figure 2: (a) Illustrations of the patient's position and the skin incision; (b) drilling the bone over the beginning of the sigmoid sinus and the middle section of the transverse sinus, and craniotomy (1: temporal muscle; 2: flab; 3: sternomastoid muscle); (c) partial mastoidectomy and posterior petrosectomy by drilling the bone, incising the dura on the floor of the temporal fossa, and extending the openin downward to the posterior fossa, anterior to the sigmoid sinus; (d) Transection of the superior petrosal sinus; retraction of the temporal lobe, sigmoid sinus, and cerebellum; division of the tentorium; visualization of the tumor and related neural and vascular structures (1: sigmoid sinus; 2: tentorium; 3: tumor).

Table 1: Clinical summary of 16 cases undergoing combined transpetrosal-transtentorial approach.

Case No.	Age (yr), Sex	Duration of Symptoms	Symptom & Signs	Previous Surgery	Lesion	Location	Gross Total Removal	Operative Complications	Outcome Clinical / Tumor (follow-up)
1 AG	44, M	8 months	Hemiparesia, disesthesia	None	Meningioma	Petrous apex, tentorial notch	Complete	Brain stem edema, venous infarct & Respiratory Distress	Death from respiratory problems
2 ES	32, M	12 months	Diplopia, vertigo, disphagia	None	Epidermoid cyst	Tentorial notch, CPA	Complete	CSF leak	Good, no tumor (3 years)
3 SK	46, F	12 months	Headache, tinnitus,	None	Meningioma	Petrous bone, clivus	Complete	None	Good, no tumor (3 years)
4 HA	48, F	3 months	Headache, vertigo	None	Meningioma	Petrous bone, clivus, Cavernous sinus	Subtotal	Brain stem edema, venous infarct, CN III paresis	Death from pulmonary embolism
5 EA	23, F	2 years	CN VII, VIII paresis	Partial tumor removal through suboocipital craniectomy	Neurinoma	CPA, tentorial notch	Complete	CN VII, VIII, IX paresis	Good, no tumor (5 years)
6 TS	37, F	3 months	Headache	None	Epidermoid cyst	CPA, tentorial notch	Complete	None	Good, no tumor (2 years)
7 ED	32, M	10 days	Trigeminal neuralgia, facial hypoesthesia	Trigeminal ganglion Radiofrequency rhizotomy	Epidermoid cyst	Prepontine cystern, tentorial notch	Complete	CN III paresis	Good; no tumor (2 years)
8 DD	35, M	3 years	CN III, V paresis, Hemiparesis,	Partial tumor removal through suboocipital craniectomy	Meningioma	Petrous apex, clivus	Subtotal	CN VII, VIII, IX, X & ataxia	Moderate disability, residual tumor (4 years)
9 RK	51, F	5 years	Fasial disesthesia	None	Meningioma	Petrous apex, tentorium, clivus	Complete	None	Good; no tumor (2 years)
10 FY	51, F	7 years	Headache; trigeminal neuralgia	None	Trigeminal neurinoma	Middle cranial fossa, tentorial notch, petrous apex	Complete	Intracerebral Hematoma, brain stem edema, venous infarct	Death
11 EA	53, F	5 years	Headache, diplopia	None	Meningioma	Petrous apex, clivus	Complete	CN VI paresis, hemiparesis	Good; no tumor (2 years)
12 VS	28, M	10 years	CN III, VIII, hemiparesis, Ataxia	None	Epidermoid cyst	PCA, Tentorial notch	Complete	None	Good; no tumor (2 years)
13 ZD	45, F	2 years	Visual impairment, CN III paresis	None	Meningioma	Clivus, petrous apex, cavernous sinus, orbita	Subtotal	CN V, VII	Good; residual tumor (2 years)
14 MK	35, M	3 months	Headache	None	Cordoma	Clivus, petrous apex, cavernous sinus,	Subtotal	Brain stem edema, venous infarct & pulmonary embol.	Death
15 BB	30, M	5 months	Visual impairment, headache, vomiting, CN V, IX, X paresis	None	Neurinoma	PCA, clivus, cavernous sinus	Complete	None	Good; no tumor (2 years)
16 AE	37, F	2 months	Headache, hemihypoesthesia, dysphagia	None	Meningioma	PCA, Petrous apex, tentorial notch	Complete	None	Good; no tumor (1 year)

CN: cranial nerve; CPA: Cerebellopontine Angle posterior petrosectomy are performed by drilling under magnification (Figure 2c). The reference end-point of the extension of the petrosectomy is the prominence of the lateral semicircular canal, which is identified by its compact bone-type structure. In order to preserve hearing, it is essential that no bone be removed beyond this point.

Once the posterior petrosectomy is complete, the dura covering the inferior temporal lobe and the posterior fossa (anterior to the sigmoid sinus) is exposed. The dura on the floor of temporal fossa is opened, and the incision is extended downward to the posterior fossa, anterior to the sigmoid sinus. The cerebellum and temporal lobe are gently retracted, with care taken during retraction to preserve Labbe's vein as it enters the transverse sinus (Figure 2c). In the majority of our cases, we identified, ligated, and transected the superior petrosal sinus, but in the most recent two cases we preserved the integrity of this structure.

The dural incision is extended along the tentorium parallel to the pyramis until the tentorial notch is exposed and incised (Figure 2d). The tentorial artery is coagulated as the tentorium is incised. Usually, the surface of the tumor and cranial nerve IV are visible after the tentorial incision is completed, and the surgeon has good exposure to the structures in the petroclival region. Once the tumor is exposed, the surgeon can observe its relationships to the brainstem, cranial nerves, and major vascular structures, such as the basillar artery, posterior cerebral artery, anterior inferior cerebellar artery, and superior cerebellar artery. Intracapsular removal of some tumor bulk may be necessary if the tumor is large. The surgeon gains access to the brainstem by removing most of the mass. The capsule and remnants of the tumor can also be removed, taking care to preserve the vascular and nervous structures. In cases where the tumor is adherent to vital structures, subtotal tumor resection is recommended.

Once complete hemostasis is confirmed, the tissues are reapproximated anatomically and the wound is closed layer by layer, in standard fashion. Watertight dural closure is essential, and this is achieved using a periosteal or dural graft. The defect created in the petrous ridge should be filled with autologous muscle and fat that is held in place with fibrin glue. Postoperative lumbar drainage may be used to prevent cerebrospinal fluid (CSF) leakage. Patients should be transferred to the intensive care unit for monitoring and care in the early postoperative period. Special attention must be given to airway protection and to maintaining correct fluid and electrolyte balance. Rehabilitation therapy can be started when the patient's neurological and vital signs are stable.

RESULTS

Table-1 summarizes our results in 16 patients with tumors in the petroclival region whose masses were excised via the combined transpetrosal-transtentorial approach. We achieved gross-total resection in 12 cases (75%) (Figure 3a and 3b), and subtotal resection in four cases (25%). As mentioned above, postoperative pathological examination confirmed that eight of the tumors were meningiomas, four were epidermoid cysts, three were trigeminal schwannomas, and one was a chordoma. Four patients died (25%) in the early postoperative period due to brainstem edema, venous-hemorrhagic infarct, pulmonary embolism, and pulmonary dysfunction. The 12 surviving patients were followed for a mean of 30 months (range, 12 to 60 months). One patient developed CSF leakage postoperatively, and this resolved with lumbar drainage. Six patients developed additional neurological deficits postoperatively (Table 1); however, at the end of follow-up, only one of the six was affected by mild ataxia during daily activity. None of the survivors experienced tumor recurrence or symptomatic deterioration.

DISCUSSION

Lesions in the cavernous sinus, clivus, petrous apex, and jugular foramen were once considered inoperable, but are now surgically removable through various skull base approaches that have been introduced over the past two decades (1-6,8-11,16-24). These new approaches provide better exposure than earlier methods, and allow the surgeon to perform microsurgery with minimal retraction of the surrounding brain tissue. The major benefits provided by these skull base techniques can be summarized as follows: (1) surgical access to deep lesions of the skull base; (2) adequate exposure for safe microsurgery; (3) better ventral and anterior views of the basal brain; (4) better exposure, isolation, and protection of major cranial arteries, cerebral veins, and cranial nerves; (5) more comfortable reconstruction of neurovascular structures (16,17).

Several surgical procedures for accessing the petroclival area have been described, including the frontotemporal pterional, temporopolar posterior transcavernous, subtemporal transtentorial,

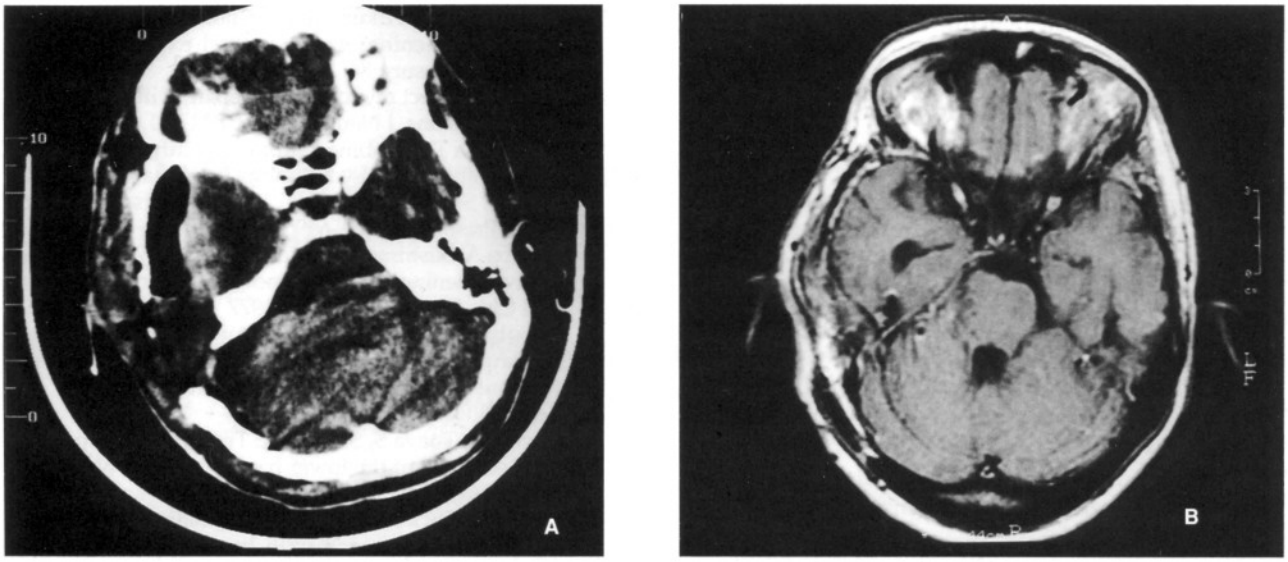

Figure 3: (a) Postoperative axial CT shows the extent of the petrosectomy; (b) Axial MRI confirms complete tumor removal (Case-16 AE).

retromastoid suboccipital, combined subtemporal and suboccipital, and petrosal approaches (9). After Hakuba et al. introduced a technique that incorporated suboccipital and subtemporal craniotomy with partial petrosectomy (10,11), the majority of neurosurgeons embraced the combined approach to the petroclival area as the best procedure for this purpose.

When combined with craniotomy, petrous bone resection helps to expand exposure of the cerebellopontine angle (CPA), the clivus, the anterior brainstem, and the basilar artery. Unfortunately, in the past, confusing labels have been applied to many of the procedures. Miller et al. attempted to rename the procedures and reduce the confusion (15) by dividing these techniques into two main groups, as follows: (1) anterior petrosectomy for lesions of the petrous apex; (2) posterior petrosectomy for lesions of the CPA and the petroclival area. The further described procedures that were combined with petrosectomy in four categories of approach, as follows: (1) subtemporal craniotomy and anterior petrosectomy (12,14); (2) subtemporal craniotomy and posterior petrosectomy (18); (3) subtemporal craniotomy, suboccipital craniotomy, zygomatic osteotomy, and posterior petrosectomy (11); and (4) subtemporal craniotomy, suboccipital craniotomy and posterior petrosectomy (9). According to this system, our technique fits into the fourth group.

Surgical treatment of petroclival tumors has been associated with high mortality and morbidity (7). Permanent postoperative cranial neuropathies are the most common complications after this type of surgery; however, complications due to venous stasis are the most serious causes of neurological deterioration postoperatively. For the most part, the continuity of the transverse sinus, sigmoid sinus, and large veins in the lateral aspect of the temporal lobe (Labbe's vein, for example) is protected throughout the procedure. Any interruption of venous flow can lead to cerebral swelling, ischemia, and hemorrhagic infarction (16,17,19). Preserving the integrity of the superior petrosal sinus may help prevent venous stasis, though most neurosurgeons currently ligate this structure in the combined approach. In terms of other types of complications, Sekhar et al. demonstrated that tumor-to-brainstem interaction is one of the major determinants of postoperative outcome (22,23). They recommended that subtotal tumor resection be done in cases where the tumor is adherent to vital structures. We achieved good neurological outcome in 11 of our 16 cases, and attribute this to our success in avoiding major vascular injury and preserving the pial membrane during tumor dissection. In our two most recent cases, we did not ligate the superior petrosal sinus but maintained the integrity of this structure. We noted better outcomes with regard to brain edema in these patients.

Hearing may be sacrificed in procedures that involve excessive petrous bone resection. In principle, the size of the petrosectomy depends on the extent of the lesion. However, the conservative retrolabyrinthine approach, which is our choice, usually provides adequate exposure of lesions in the petroclival area, and hearing can be preserved if a partial posterior petrosectomy is performed by drilling the posterior section of the labyrinthine structures (13). We encountered no postoperative hearing loss in our patients.

Hakuba et al. and Yasargil et al. reported operative mortality rates of 17% and 15%, respectively, in the series of petroclival meningioma excisions (10,25). However, other authors have more recently reported less than 10% mortality, and they attribute this success to better combined skull base approaches and improved microsurgical technique (1,7,20). The four deaths in our series were related to postoperative complications that occurred secondary to depressed neurological status induced by hemorrhagic (venous) infarction and/or brainstem edema.

In conclusion, we have had good success using a combined (retrolabyrinthine) transpetrosal-transtentorial approach to treat lesions in the petroclival area. We have found that this approach provides good exposure to this region, and that it allows lesions to be extirpated, a result that is not possible with conventional craniotomies. This superior exposure permits excellent visualization of, and access to, the upper clivus and related neural and vascular structures. This approach also minimizes cranial nerve deficits and temporal lobe retraction.

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