Petroclival meningioma case series

2021

Retrospectively analyzed clinical data of 179 cases of PCM from Department of Neurosurgery, Xiangya Hospital, Central South University between January 2011 and November 2020. There were 28 males and 151 females with an age of(49.9±10.2) years(range: 22 to 75 years) and the tumor size of(44.8±10.3)mm(range: 15 to 80 mm). The mean duration of symptom(M(QR)) was 18.0(40.6)months(range:1 week to 320 months) and the mean preoperative Karnofsky performance scale(KPS) was 78.6±13.3(range: 40 to 100). The PCM were classified into 5 types according to the difference in the origin of dural attachment, involvement of adjacent structures and growth patterns through preoperative MRI. The surgical approaches were selected based on the proposed classification, and the clinical characteristics, surgical record, and follow-up data of each type were reviewed. Results: The PCM were divided into clivus type(CV, 4 cases), petroclival type(PC, 60 cases), petroclivosphenoidal type(PC-S, 62 cases), sphenopetroclival type with 2 subtypes(S-PC, 50 cases) and central skull base type(CSB, 3 cases). All of 176 cases were obtained microsurgical treatment except CSB type. The gross total resection reached in 124 cases(70.5%) with 112 cases of retrosigmoid approach(RSA), 27 cases of subtemporal transtentorial transpetrosal approach, 13 cases of pretemporal trancavernous anterior transpetrosal approach(PTCA), 12 cases of extended pterional transtentorial approach(EPTA) and presigmoid combined supra-infratentorial approach, respectively. The RSA could be adopted in both of CV type and PC type and most of PC-S type(71.0%). S-PC subtype Ⅰ and subtype Ⅱ were mainly underwent EPTA(40.8%) and PTCA(52.2%), respectively. Seventy-two cases(40.9%) gained new neurological dysfunctions mainly with the cranial nerve paralysis. The postoperative morbidity and complications were recovered or improved with conservative and positive symptomatic and supportive treatment. There was no intraoperative and postoperative death case. One hundred and sixty four cases(93.2%) of operative patients were followed with the duration of 24(48)months(range:3 to 108 months). Tumor recurrence and progress were identified in 14 cases(10.4%) and 14 cases(28.6%), respectively. Compared with postoperative neurological status, 89 patients(54.3%) had improved and 38 patients(23.2%) were still suffering various degrees of neurological dysfunctions during the follow-up. The recent KPS was 84.2±11.4(range: 50 to 100) without statistical difference from preoperative KPS(t=-1.356,P=0.125). As for each type, there were statistically significant differences in brain stem edema($\chi2$=3.482,P=0.038), gross total resection($\chi2$=9.127,P=0.001), surgical duration(F=8.954, P=0.013), postoperative length of stay(F=3.652, P=0.025), postoperative complications($\chi2$=1.550,P=0.024), postoperative KPS(F=2.856, P=0.042) and tumor recurrence/progress($\chi2$=4.824,P=0.013). Conclusion: The precise and comprehensive classification of PCM and specific individual treatment strategy are benefit to evaluate the diverse clinical prognosis, choose optimal surgical approaches, elevate gross total resection, diminish neurological dysfunctions and restraint tumor recurrence, so as to improve the quality of life for patients [1)].

2020

Between 2004 and 2019, 64 patients (52 patients for alternative and 12 patients for adjuvant treatment) with Petroclival meningioma underwent GKRS. The clinical and radiological factors were retrospectively analyzed. The mean radiologic follow-up duration was 58.4 months (range, 6-164 months). The mean tumor volume and diameter before GKRS were 13.4 cm^3 and 2.9 cm, respectively.

The median marginal dose was 12 Gy (range, 10-14 Gy) with a 50% median isodose line. Fractionation was used in 19 cases (29%, two fractionations in 5 cases & three fractionations in 14 cases).

Progression was noted in 7 cases (10.9%) and the progression-free survival rates were 91.1% at 5 years and 69.6% at 10 years. Although large in volume, moderate to severe peritumoral edema and male gender were somewhat related to progression, they did not reach statistical significance. Ten patients (15.6%) developed complications after GKRS. The most common complication was cranial nerve deficit (n=8), followed by hemiparesis, cognitive dysfunction, and hydrocephalus. Large size (maximal diameter ≥5 cm) [hazard ratio (HR) 0.091, 95% confidence interval (CI) 0.014-0.608; p=0.013] and multiplicity (HR 0.102, 95% CI 0.018-0.573; p=0.009) were independent factors for developing complications after GKRS.

GKRS can be considered an effective and safe treatment for large-volume Petroclival meningiomas. However, for patients with large size or multiple masses, the treatment method should be determined with caution because the probability of complications after GKRS may increase [2].

2018

Adachi et al., studied 51 feeding arteries from 24 patients who had undergone operations to treat primary petroapex and petroclival meningiomas via the anterior transpetrosal approach. They measured the lower and posterior extension distances, the extension rate of the cavernous sinus and Meckel's cave, and the midline extension rate of the tumors.

They revealed that the ascending pharyngeal artery (AphA) was the predominant feeding artery responsible for tumors with lower extensions. They determined that tumors extending over the lower border of internal acoustic meatus (IAM), in cases where the feeding artery was not the AphA, can be resected using the ATP approach.

This study revealed an association between the predominant feeding artery and tumor extension area and that an evaluation of the dural attachment area based on the feeding artery is useful for selecting the appropriate surgical approach [3].

From 2014 to 2017, patients harboring large PCMs (> 3 cm) and undergoing their first resection in the Department of Neurosurgery, Neurological Institute, Taichung Veterans General Hospital.

In combination with pretemporal transcavernous and anterior transpetrosal approaches, the trans-Meckel's cave transtentorial route was created. Surgical details are described and a video demonstrating the procedure is included. Retrospective review of the medical records and imaging studies was performed.

A total of 18 patients (6 men and 12 women) were included in this study, with mean age of 53 years. The mean sizes of the preoperative and postoperative PCMs were 4.36 cm × 4.09 cm × 4.13 cm (length × width × height) and 0.83 cm × 1.08 cm × 0.75 cm, respectively. Gross-total removal was performed in 7 patients, near-total removal (> 95%) in 7 patients, and subtotal removal in 4 patients (> 90% in 3 patients and > 85% in 1 patient). There were no surgical deaths or patients with postoperative hemiplegia. Surgical complications included transient cranial nerve (CN) III palsy (all patients, resolved in 3 months), transient CN VI palsy (2 patients), CN IV palsy (3 patients, partial

recovery), hydrocephalus (3 patients), and CSF otorrhea (1 patient). Temporal lobe retraction-related neurological deficits were not observed.

A pretemporal trans-Meckel's cave transtentorial approach offers large surgical exposure and multiple trajectories to the suprasellar, interpeduncular, prepontine, and upper-half clival regions without overt traction, which is mandatory to remove large PCMs. To unlock Meckel's cave where a large PCM lies abutting the cave, pretemporal transcavernous and anterior transpetrosal approaches are prerequisites to create adequate exposure for the final trans-Meckel's cave step [4].

Sadik et al., performed a retrospective study of patients with PCM who underwent primary GKRS between 2003 and 2015 at the Gamma Knife Center of the Elisabeth-Tweesteden Hospital in Tilburg, the Netherlands. This study yields 53 patients. In this study the authors concentrate on qualitative volumetric tumor changes, local tumor control rate, and the effect of the treatment on trigeminal neuralgia (TN).

Local tumor control was 98% at 5 years and 93% at 7 years (Kaplan-Meier estimates). More than 90% of the tumors showed regression in volume during the first 5 years. The mean volumetric tumor decrease was 21.2%, 27.1%, and 31% at 1, 3, and 6 years of follow-up, respectively. Improvement in TN was achieved in 61%, 67%, and 70% of the cases at 1, 2, and 3 years of follow-up, respectively. This was associated with a mean volumetric tumor decrease of 25% at the 1-year follow-up to 32% at the 3-year follow-up.

GKRS for PCMs yields a high tumor control rate with a low incidence of neurological deficits. Many patients with TN due to PCM experienced improvement in TN after radiosurgery. GKRS achieves significant volumetric tumor decrease in the first years of follow-up and thereafter [5].

2017

Koutourousiou et al. retrospectively reviewed 32 patients with petroclival meningiomas. Eleven patients (34.4%) were managed with lateral approaches (retrosigmoid or far lateral approach), 17 (53.1%) with anterior midline approaches (endoscopic endonasal approach [EEA]), and 4 (12.5%) with a combination.

The average Karnofsky Performance Score (KPS) at presentation was 73.8. The average postoperative KPS improved to 87.9 ($P < 0.001$) during short-term follow-up of 14 months (range, 1-42) and was significantly higher in primary tumors ($P = 0.013$), tumors <4 cm ($P = 0.039$), and tumors without vascular encasement ($P = 0.002$) but remained significant regardless of age, tumor size, or vascular encasement. The greatest benefit occurred with primary tumors, in young patients and in those who underwent nontotal resection ($P < 0.001$). EEA had a significantly greater potential for improved KPS ($P = 0.002$). Gross ($n = 6$) or near total ($n = 9$) resection was achieved in 15 of 32 cases (47%). Complications included new cranial nerve palsies affecting mainly the abducens nerve (18.7%). New lower cranial nerve palsies occurred in only 1 case (3.1%). Other complications included postoperative hydrocephalus (15.6%) and Cerebrospinal fluid fistula (28.1%). One patient died in the perioperative period (3.1%).

In the short-term, less aggressive cranial base approaches, including retrosigmoid exposures and the recently introduced EEA, are effective alternatives to transpetrosal approaches for debulking petroclival meningiomas with significant early clinical improvement and limited major surgical

complications [6].

Patients with surgically resected WHO grade I petroclival meningiomas were retrospectively reviewed (1999-2015). Image analysis software was utilized to perform volumetric analyses of tumor size and growth on serial MRI studies. The impact of preoperative and postoperative variables on tumor growth after subtotal resection was analyzed. An increase in tumor volume of at least 20% was defined as “tumor growth.” RESULTS:

Twenty-three patients had immediate preoperative and serial postoperative MRI studies available for review. The mean preoperative tumor volume was 20.9 cm 3 (range 0.4-54.6). The mean extent of resection was 75.5% (range 31.5%-100.0%). At a mean follow-up of 24.8 mo, 12 tumors (66.7%) exhibited radiological tumor growth, while 6 tumors did not change in size. The median annual volumetric growth rate was 2.82 cm 3 /yr (range -0.34 to 10.1). Extent of resection and immediate postoperative tumor volume were significantly correlated with the annual volumetric growth rate following resection. At last follow-up, 3 (13%) patients required further intervention. CONCLUSION:

The majority of petroclival meningiomas exhibit growth following subtotal resection. Extent of resection is strongly associated with risk for disease progression following surgery. [7].

2016

21 patients with petroclival meningiomas were reviewed retrospectively. The method, degree of tumor resection,techniques of the combining keyhole approach, Karnofsky performance score (KPS) before and after operation were also analyzed. The neuronavigation guided operation was performed in 9 cases, and 12 cases were operated in the neuroelectrophysiological monitoring.

Total excision of the tumor resection (Simpson, I-II levels) was conducted in 18 cases (85.7%, 18/21), and 3 patients underwent close resection (Simpson III level, 14.3%, 3/21). Postoperative three-dimensional CT showed good lock bone flap restoration; Postoperative pathology confirmed meningioma. Postoperative cranial nerve dysfunction or new original nerve dysfunction were aggravated in 5 cases (23.8%) , including transient trochlear nerve (3 cases), abducent nerve (1 case), and the motor branch of trigeminal nerve paralysis (1 case). Abducent nerve paralysis (1 case) appeared, with hearing impairment. After the 3-month follow-up, 11 cases had the same KPS aspreoperation, 7 cases improved, and 3 cases not improved. The KPS score was 77.14±23.12 on average, and there was no statistically significant difference compared with that before operation (P>0.05). The postoperative follow-up for half a year showed fluent speaking and writing in 19 cases (KPS 70 or higher), and general recovery in 2 cases (KPS<70). The postoperative follow-up for 3-29 months showed no tumor recurrence or progress [8].

Li and co-workers present a detailed sub-analysis of their series of petroclival meningiomas, which is the largest monocentric series published till 2016 [9] [10].

They restrict the analysis to medium and large tumours of more than 2 cm in diameter

Gross total resection was achieved in 56 % of patients; dysfunctions of the cranial nerves were the most common complication and occurred in two-thirds of the patients. Immediately following surgery,

morbidity temporarily increased and the Karnovsky Performance Scale temporarily decreased on average. The case fatality rate amounted to 2 %. Permanent surgical morbidity remained in 20 % of patients during the average long-term follow-up of almost 10 years, but significantly more patients lived independently after than before surgery (61 vs 46 %). One-fourth of patients were lost to longterm follow-up, so that the numbers regarding long-term outcome must be appreciated with sound judgment.

2015

From 2005-2013, 29 patients with a petroclival meningioma underwent tumor removal through a Posterior intradural petrous apicectomy approach.

Patients consisted of 7 men and 22 women; the mean age of patients was 52.7 years. In 24 patients, surgery was performed with the patient in a semisitting position; in 5 patients, surgery was performed with the patient in a supine position. A total resection was achieved in 19 patients (66%). A Karnofsky performance scale score >60% was recorded in 27 patients (93%), with surgical complications that involved a Cerebrospinal fluid fistula in 3 patients, bleeding in the surgical cavity in 2 patients, and pneumocephalus in 1 patient. The most frequent postoperative neurologic deficit was facial palsy (34%), which disappeared or improved consistently in all but 1 patient, who required a cranial nerve VII-cranial nerve XII anastomosis.

For petroclival meningiomas extending into the middle fossa, the endoscopic-assisted PIPA approach is safe and straightforward. The principal advantages of the PIPA approach are familiarity with the retrosigmoid route; the absence of temporal lobe retraction; and early control of the cranial nerves, vessels, and brainstem. However, careful patient selection regarding tumor extension is fundamental to obtaining optimal outcomes [11)].

Between January 1990 and December 2009, Morisako et al. used a combined transpetrosal approach to treat 60 patients with benign (WHO Grade I) petroclival meningiomas. In this retrospective study, all 60 cases were analyzed in detail with regard to tumor volume, extent of resection (EOR), long-term tumor control, neurological outcome, and the patient condition. In addition, patients were divided into 2 groups according to the period during which the surgery was performed: the early group, from 1990 to 1999, and the late group, from 2000 to 2009. A new scoring system, the petroclival meningioma impairment scale (PCMIS), was created for quantitative assessment of 8 categories of neurological functions, with scores assigned in each category according to the level of disability and its impact on the patient. The PCMIS was used preoperatively, at 3 months after surgery, and at the time of the last follow-up examination, and the results for the 2 groups were compared.

There were 24 cases in the early group (1990-1999), and the mean duration of follow-up was 149.3 months. The mean EOR was 96.1%, and good long-term tumor control was obtained in 22 patients (91.7%). One of patients died because of a postoperative complication in the perioperative period. The PCMIS improved in 3 patients (12.5%), remained stable in 1 (4.2%), and worsened in 20 (83.3%). There were 36 cases in the late group (2000-2009), and the mean duration of follow-up was 77.9 months. The mean EOR was 92.7%, and good long-term tumor control was obtained in 34 patients (94.4%). The PCMIS score improved in 23 patients (63.9%), remained stable in 5 (13.9%), and worsened in 8 (22.2%).

The combined transpetrosal approach has provided satisfactory functional improvements and

excellent tumor control for patients with petroclival meningiomas. The PCMIS provides a specific tool for quantitative assessment of the patient's state [12].

2011

Fifty patients underwent surgical treatment for petroclival meningiomas. The majority of the patients were women (72%). The authors retrospectively reviewed the patients' medical records, imaging studies, and pathology reports to analyze presentation, surgical approach, neurological outcomes, complications, and recurrence rates. RESULTS:

Headache was the most common presentation (58%). The most commonly used approach was the transpetrous approach (in 16 patients), followed by the orbitozygomatic approach (in 13). Gross-total resection was performed in 14 patients (28%), and in the remaining patients there was residual tumor (72%). Eighteen patients with tumor remnants were treated with Gamma Knife surgery. New postoperative cranial neuropathies were noted in 22 patients (44%). The most common cranial nerve (CN) deficit following surgery was CN III dysfunction (in 11 patients) and facial weakness (in 10). In 9 patients, the CN dysfunction was transient (41%), and 7 patients had permanent dysfunction (32%). Eight patients developed hydrocephalus and all required placement of a ventriculoperitoneal shunt. A Cerebrospinal fluid fistula was noted in only 2 patients (4%), and wound dehiscence was noted in 1. The Cerebrospinal fluid fistulas and the wound dehiscence occurred in patients who were undergoing reoperations. Adequate radiographic follow-up (minimum 6 months) was available for 31 patients (62%). The mean follow-up was 22.1 months. In 6 patients, tumor progression or recurrences were noted. The median time to recurrence was 84 months. At the time of discharge from the hospital, 92% of the patients had good outcomes (Glasgow Outcome Scale Scores 4 and 5). Three patients died of causes not directly related to the surgery.

Petroclival meningiomas still pose a formidable challenge to neurosurgeons. In their series, the authors used multiple skull base approaches and careful microneurosurgical technique to achieve a good functional outcome (Glasgow Outcome Scale Score 4 or 5) in 92% of patients, although the extent of gross-total resection was only 28%. The authors' primary surgical goal was to achieve maximal tumor resection while maintaining or improving neurological function. The authors favor the treatment of residual tumor or recurrent tumor with stereotactic radiosurgery [13].

2008

Ninety-one patients with petroclival meningioma underwent surgery via the anterior transpetrosal approach. The Meckel's cave was routinely opened. Tumour origin was classified into four subtypes according to the main attachment and trigeminal nerve deviation into, upper clivus (UC), cavernous sinus (CS), tentorium (TE), and petrous apex (PA). Their characteristic clinical symptoms and anatomical features were investigated.

The characteristic symptom was ataxia in the UC type (37.5%), abducens nerve palsy in the CS type (64.3%) and trigeminal neuropathy, mainly neuralgia in the PA type (80.0%) with a higher statistical difference from other subtypes. The rate of tumour invasion into Meckel's cave reached 70.3% in average, with the lowest rate in the PA type (25.0%). The rate of middle fossa extension was the highest in the TE type (59.5%). The middle fossa approach was considered to be ideal for UC and TE types because of easier access to the Meckel's cave. Radical dissection without complications was difficult in the CS type. Both the anterior transpetrosal approach and the lateral suboccipital approach

could be indicated in the PA type due to the rare invasion of Meckel's cave and middle fossa, and frequent extension into the internal auditory meatus.

This classification is useful to predict the relation between the tumour and the cranial nerves based on symptoms and images. The anterior transpetrosal approach could be used for all four subtypes and with an absolute indication in the UC and TE types showing middle fossa extension [14].

2005

137 meningiomas arising from the petroclival region resected between June 1993 and October 2002. There were 38 male and 99 female patients with a mean age of 53 years.

GTR was achieved in 40% of patients, and near total resection (NTR) was achieved in 40% of patients. One operative death occurred. Twenty-six percent of patients experienced new postoperative cranial nerve deficits, paresis, or ataxia when assessed at a mean follow-up of 8.3 months. The risk of cranial nerve deficits increased with prior resection ($P < 0.001$), preoperative cranial nerve deficit ($P = 0.005$), tumor adherence to neurovascular structures ($P = 0.046$), and fibrous tumor consistency ($P = 0.005$). The risk of paresis or ataxia increased with prior resection ($P = 0.001$) and tumor adherence ($P = 0.045$). Selective NTR rather than GTR in patients with adherent or fibrous tumors significantly reduced the rate of neurological deficits. Radiographic recurrence or progression occurred in 17.6% of patients at a mean follow-up of 29.8 months. Tumor recurrence rates after GTR and NTR did not differ significantly ($P = 0.111$).

Intraoperatively defined tumor characteristics played a critical role in identifying the subset of patients with an increased risk of postoperative deficits. By selectively pursuing an NTR rather than a GTR, neurological morbidity was reduced significantly without significantly increasing the rate of tumor recurrence.

1992

Thirty-six patients with petroclival meningiomas underwent surgery between 1978 and 1990. The tumours accounted for 13% of a total of 284 skull base meningiomas operated upon during the same time period. The most frequent neurological signs related to cranial nerve deficits, mainly of the 8th, 5th, and 7th nerves respectively. The approaches to the petroclival region were: retromastoid, pterional, subtemporal, and combined retromastoid-subtemporal. In 12 patients they used a modification of the retromastoid-subtemporal approach with preservation of the sigmoid and transverse sinus (presigmoid approach). “Total” tumour removal was achieved in 27 cases (75%). There was no postoperative death, and in 83% of cases no severe morbidity. With careful pre-operative evaluation, improved operative approaches and microsurgical techniques the treatment of petroclival meningiomas has been considerably improved [15].

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33 consecutive cases of petroclival meningioma treated surgically at our institution over the last 10 years; there were 21 women and 12 men between the ages of 27 and 68 (mean age, 52). All patients were assessed by computed tomographic scans including coronal sections and bone algorithm studies; in most cases, digital subtraction angiography and magnetic resonance imaging were also done. The largest tumor diameter was between 2 and 3.5 cm in 14 cases, 3.5 to 6 cm in 15 cases, and over 6 cm in 4 cases. Dural attachment predominantly involved the clivus and apical petrous bone on

one side only; in 14 cases, however, the tumor grew over the clivus midline or crossed the tentorial notch. Cranial nerve deficit was extant in all cases and was commensurate with tumor size. Cerebellar signs and somatic motor deficits were present in 60 and 30% of cases, respectively. The surgical approaches used were the retromastoid-retrosigmoid in 23 cases, subtemporal in 5 cases, and combined retromastoid subtemporal presigmoid in the remaining 5. Total removal was achieved in 26 cases (79%); incomplete removal occurred in 7 cases (21%). The extent of tumor removal and operative morbidity were not significantly related to tumor size. Brain stem indentation, arterial and cranial nerve encasement, and epidural invasion were the main factors that prevented total tumor removal and influenced operative morbidity. There was no intraoperative mortality, but three patients (9%) died perioperatively. In the postoperative period, most patients went through momentary neurological deterioration, chiefly due to new cranial nerve deficits. The average follow-up was 4.3 years in 27 patients; of these 17 were unchanged and 10 were improved. Before surgery, only 13 patients were self-sufficient; at long-term follow-up, another 6 had achieved independence. Our experience suggests that, even though real petroclival meningiomas still represent a formidable surgical challenge, such tumors can in most cases be removed completely with low attendant mortality and acceptable morbidity [16].

1989

Twenty-four patients with petroclival meningiomas were operated upon at the neurosurgical clinic of the City Hospital of Hannover between 1978 and 1987. Seventeen were women and seven men; the mean age was 45 years. Symptoms were usually present for more than 2 years before the diagnosis was made. The most common symptom was disturbance of gait; the most common preoperative sign was cranial nerve deficit, mainly of the 7th and 8th nerves. Preoperative neuroradiological evaluation included computed tomography and four-vessel cerebral angiography. Fifteen patients (62%) had a tumor larger than 2.5 cm in its major diameter. The surgical approaches used were the retromastoid, pterional, subtemporal, and combined retromastoid-subtemporal. We developed a modification of the retromastoid-subtemporal approach with preservation of the transverse sinus and used this in the last 2 patients. There was no postoperative death; 11 patients (46%) suffered postoperative complications, mainly in the form of cranial nerve deficits, often reversible. “Total” tumor removal was achieved in 17 patients (71%). Twenty patients (83%) were independent at the time of discharge from the hospital. With accurate neuroradiological evaluation, careful choice of the surgical approach, and sound application of microsurgical techniques, petroclival meningiomas may be “totally” and safely resected in a significant number of patients [17].

1988

Nine patients with tumours located at the petro-clival region were operated upon from June 1985 to June 1988 using a combined supra- and infratentorial approach anterior to the sigmoid sinus. Two patients had petroclival meningiomas. 4 foramen jugulare neurinomas and 3 glomus jugulare tumours. There was no mortality. Total tumour removal was accomplished in all the patients. All patients remained independent postoperatively. The surgical approach used involves a temporal craniotomy, a suboccipital craniectomy, an extensive mastoidectomy and petrous pyramid drilling without entering the bony labyrinth, the middle ear or the Fallopian canal. The dura is incised supratentorially over the posterior temporal lobe and infratentorially in front of the sigmoid sinus. The temporal lobe is retracted superiorly and the cerebellum and the sigmoid sinus medially. This approach makes use of a very short distance to the petroclival area, offers a multiangled exposure,

preserves the dural sinuses, does not iatrogenically impair hearing and minimizes temporal lobe retraction. This exposure is particularly useful in large tumours [18].

Al-Mefty et al., report thirteen patients harboring large petroclival meningiomas, there was no mortality, and total removal was achieved in all but two patients. Morbidity included cranial nerve deficit, pulmonary embolism, and hemiparesis [19].

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