

Microsurgical Resection of Posterior Petrous Meningiomas: 18 Cases

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ABSTRACT

In this study a series of 18 patients with meningiomas of the posterior petrous bone had undergone microsurgical treatment in Neurosurgical Department, Cairo University Hospitals from February 2000 to May 2005. The patient population consisted of 14 females and 4 males with a mean age 49.1 years (range 32-61 years). The main symptom on first admission was diminution of hearing in 61%, tinnitus in 38.9% and vertigo in 33%. Physical examination and audiological testing revealed hearing impairment in 66.7%, gait ataxia in 33.3% and trigeminal hyposthesia in 27.8%. All patients underwent surgical treatment via a lateral suboccipital approach. The tumour was found to be attached to the retromeatral dura in 66.7%, premeatal dura in 16.7%, suprameatal dura in 11.1% and one case (5.6%) centered on IAM with gross intrameatal growth and widening of the IAM. Tumour resection was categorized into Grade I in 27.8%, Grade II in 55.6%, Grade III in 11.1% and Grade IV in 5.6% according to the Simpson classification system. The site of displacement of the cranial nerves was predictable in most of the patients depending on the dural origin of the tumour as depicted on preoperative magnetic resonance imaging studies. However; the exact relationship of the neurovascular structures in relation to the tumour can only be fully appreciated intraoperatively. Postoperatively, all patients of Trigeminal pains (16.7%) had complete resolution. Hearing was preserved in 72% and one of them had mild improvement (5.6%). Deterioration of hearing occurred in 27.8% and permanent facial nerve palsy was observed in 11.1%. It was concluded that CPA meningiomas require special surgical management with detailed analysis of the preoperative MR Images to predict the site of displaced neurovascular structures, careful operative technique with familiarity with the anatomy, and effective intraoperative nerve monitoring to obtain an optimal functional result.
Keywords: Cerebellopontine angle, meningioma, microsurgery, suboccipital approach.

INTRODUCTION

Meningiomas represent the second most common tumour in the CPA, with a prevalence of 10 to 15% of all CPA lesions.^(3,4,14) Posterior petrous meningiomas refer to those meningiomas originating from the posterior surface of the petrous bone, the clinical manifestations, surgical difficulty and outcomes for the various posterior petrous meningiomas are clearly different because of their various locations.⁽¹⁴⁾

These tumours were classified according to their site of dural attachment in relation to the PA as demonstrated on preoperative MR

images and as revealed in the surgical record.

Five tumour groups were created: retromeatral, premeatal, suprameatal, inframeatal, and centered on the IAM.⁽¹²⁾

The clinical presentation, as for meningioma as a whole, depends on the site of origin and direction of growth. Tumours growing superior to the internal auditory meatus commonly present with trigeminal symptoms, whereas those growing alongside the meatus may present with auditory and facial nerve dysfunction, the latter being distinctly uncommon with vestibular schwannoma. Those tumours growing inferior to the meatus may present with dysfunction of the

lower cranial nerves. Symptoms and signs secondary to brain stem and cerebellar compression, owing to the slow growth rate are a late occurrence.⁽¹⁵⁾

Clinical Material and Methods

Patient population

A series of 18 patients of posterior petrous meningiomas were treated at the Neurosurgical Department of Cairo University hospitals from February 2000 to May 2005.

The patients consisted of 14 female and 4 male with a mean age 49.1 years (ranging from 32 to 61 years). All patients underwent a general neurological examination, audiological testing with pure tone audiography and speech discrimination score, and neuroimaging examinations (CT or MR imaging). Surgery was performed after general anaesthesia had been induced and the operating microscope and microsurgical instrumentation were used in all cases. In cases in which the tumour diameter was larger than approximately 2cm, an ultrasonic aspirator was used for tumour reduction. A facial nerve stimulator was used in all cases to help identify the facial nerve. Preoperative and postoperative facial nerve functions and hearing functions were examined and graded. The mean duration of hospitalization was 14.5 days.

Neuroimaging Studies

Magnetic resonance images including contrast-enhanced studies had been obtained in all but one patient, who had a cardiac pacemaker, and thus high resolution CT scan of the petrous bone was performed instead. High resolution CT scan was also done for the other cases. MR angiography was done for 5 cases to assess the patency of dural venous sinuses.

Surgical Procedure

The standard retrosigmoid approach with the patient in the lateral position was used in all cases to

remove the posterior petrous meningiomas.

The craniotomy was enlarged to the foramen magnum, and the cisterna magna was opened. A nerve stimulator was used in all cases to identify the facial nerve. The meningioma's dural attachment to the posterior pyramid was progressively coagulated and divided to devascularize the tumour, and this was done carefully to avoid injury to the exiting cranial nerves.

When the size of the tumour precluded safe removal the tumour capsule was opened and the tumour was centrally debulked and devascularized. The capsule was then carefully dissected from the surrounding cranial nerves, the brain stem, the superior cerebellar artery (superior and medial), the anterior inferior cerebellar artery (medial), and the posterior inferior cerebellar artery (inferior and medial).

After the tumour was removed the dural attachment was removed or coagulated. In two cases the removal of only a few millimeters of the posterior lip of the IAC was required to remove the entire intracanalicular portion of the meningioma. In one case the tumour occupied the entire IAC and a wide exposure of the IAC was required to reach the fundus.

First the dura mater over the posterior aspect of the IAC was removed and the canal drilled open using small sizes of diamond drills until the intrameatal portion was exposed.

Patients follow up

All patients underwent follow up with clinical examination and CT and or MR images 6 months and one year after surgery. Assessment of facial nerve function preoperatively and at each postoperative follow up was based on the House - Brackman grading system 21.

An otological examination was routinely conducted in the department of ENT by performing pure tone audiometry and speech discrimination testing according to the scale of Gardner and Robertson 17 before discharging the patient from the hospital.

RESULTS

Clinical data

Our series consisted of 18 patients, 14 women and 4 men with a mean age of 49.1 years (range 32-61 years).

Diminution of hearing was the main presenting complaint in 11 cases (61%) other presenting symptoms are shown in Fig (1)

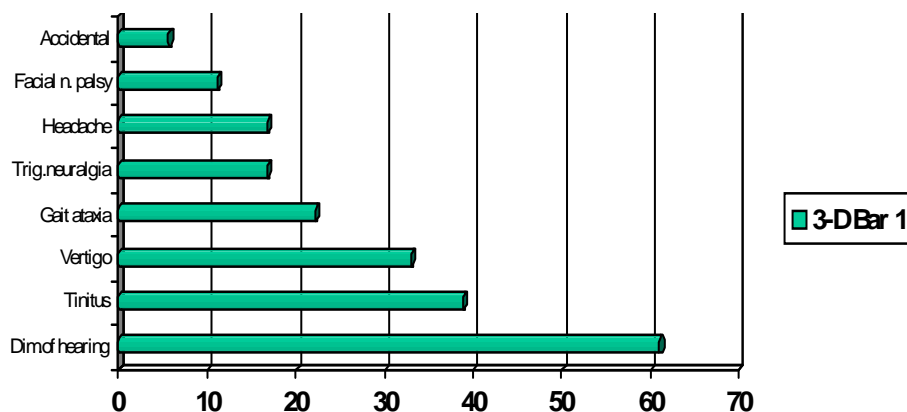


Fig.(1) Bar graph showing symptoms at time of initial evaluation.

Results of physical and audiological assessment revealed impairment of the eighth cranial nerve in 12 patients (66.7%), gait ataxia was present in 6 cases (33.3%). Facial numbness or a decreased corneal reflex indicating fifth cranial nerve impairment was present in 5 cases (27.8%). None of our patients had lower cranial nerves or long tract signs.

Neuroradiological investigation

Typical neuroimaging features of meningiomas were seen on preoperative MR images or CT scans obtained with or without contrast enhancement. The presence of dural tail was noticed in 2 cases (11%), hyperostosis of the petrous bone in 4 cases (22%), calcification within the

tumour in 5 cases (27.8%) and an en plaque appearance of the tumour in one case (5.6%).

Hydrocephalus was not present in any of our cases, and one case (5.6%) had gross intrameatal tumour growth, with widening of the IAM noted on the lesion side when compared with the other side.

The mean diameter of the tumours on MR images was 3.2 cm (range 1.2-5.1 cm). One meningioma (5.6%) was centred on the IAM, 12 tumours were attached to the dura posterior to the IAM (retromeatal 66.7%), 3 tumours originated from the dura anterior to the IAM (premeatal 16.7%) and 2 tumours (11.1%) were in the suprameatal portion. Table (1)

Table (1): Size comparison for four types of posterior petrous meningiomas

	<3 cm	3-4 cm	>4 cm
Retromeatal	2	6	4
Premeatal	2	1	-
Suprameatal	1	1	-
Centered over theIAM	-	-	1

The differentiation between this tumour and vestibular schwannoma was not obvious in all cases, although less common, typical neuroimaging manifestations of a vestibular schwannoma, such as widening of the IAM due to bone erosion, (one case) cystic degeneration of the tumour (2 cases) or a purely globoid shape of the tumour without dural attachment (one case) has been seen in our cases of CPA meningiomas.

Surgical considerations

The direction of displacement of the trigeminal, facial, vestibulocochlear, and lower cranial nerves was predictable, depending on the dural origin of the tumour as demonstrated on preoperative MR imaging studies, however the exact locations of the neurovascular

structures in relation to the tumour were only evident during surgery. table (2).

The facial and vestibulocochlear nerves were present as solid nerve bundles and were separated from the tumour by an arachnoid sheath in 13 patients (72%). In these cases the nerves could be clearly identified and protected.

In 5 patients, (27.8%) the facial nerve was incorporated into the capsule of the tumour and could be identified with the aid of a nerve stimulating electrode. The nerve was anatomically preserved in 3 of these cases (16.7%). In two patients (11.1%) with tumours of hard consistency, however, preservation of the facial nerve was not anatomically possible.

Table (2) Relationship of cranial nerves to the tumours in different locations

Tumour site	V	V11 & V111	IX, X & XI
Retromeatal	unrelated 8 Ant-superior 4	Anterior 11 Inferior 1	Inferior 6 Unrelated 6
Premeatal	Anterior 3	Posterior 2 Inferior 1	Unrelated 2 Inferior 1
Suprameatal	Anterior 2	Inferior 2	Unrelated 2
Centered over the IAM	Anterior 1	Anterior 1	Inferior 1

The extent of tumour resection according to the Simpson classification was Grade 1 in 5 patients (27.8 %), Grade 11 in 10 patients (55.6 %), Grade 111 in 2 (11.1%) and G 1V in one (5.6%).

A tumour remnant (Simpson Grade 111) was left in one patient with frank infiltration of the petrous bone and another patient with infiltration of the seventh-eighth nerve complex. The patient of Grade 1V had a premeatal

meningioma and tumour extension into the Meckel Cave.

All patients with trigeminal pains (16.7%) had complete resolution of their symptoms postoperatively. The preoperative hearing level was preserved in 13 patients (72%) and one of them (5.6%) showed mild improvement of hearing functions after surgery while 5 patients (25.8%) showed deterioration of hearing functions.

Postoperative Complications

The main complication in this study was related to facial and auditory nerve functions. Deterioration of hearing functions was observed in 5 patients (27.8%) which was progressive after surgery and irreversible. Four cases had preoperative hearing impairment, and one had no preoperative hearing deficit. These cases were unrelated to the tumour size or location.

Only two patients in this study had mild facial nerve paresis preoperatively, in those patients the facial nerve was adherent to the capsule of hard tumours and was not preserved, and they had permanent worsening of facial nerve functions.

Another 2 patients had temporary facial nerve paresis which resolved completely within months post surgery. A new or an aggravated postoperative gait ataxia was observed in 5 patients (27.8%), and it has completely resolved in all of them after variable period post surgery.

A CSF leak from the wound site in 2 cases (11.1%) which was treated using lumbar drainage in one patient and VP shunt placement in the other, whose postoperative CT scan showed hydrocephalus.

Wound infection was observed in one case (5.6%) without signs of meningitis, which was treated with antibiotics. Table (3)

Table 3: Postoperative complications in 18 patients with posterior petrous meningiomas

Complication	No of cases	%
Deteriorated auditory functions	5	27.8%
Deteriorated facial nerve functions	4	22.2%
Ataxia	5	27.8%
CSF leak	2	11.1%
Wound infection	1	5.6%



Fig. (2): (A) Axial contrast-enhanced MR image showing a tumour medial to the IAC and compressing the brainstem. (B) Follow up MR image obtained one month after surgery, demonstrating complete tumour resection.

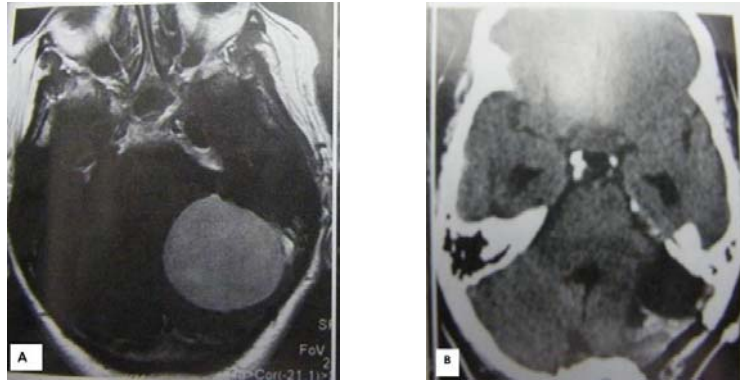


Fig. (3): (A) preoperative T1 contrast-enhanced MR image revealing a postmeatal meningioma. (B) postoperative CT scan demonstrating complete tumour resection via a retrosigmoid approach.

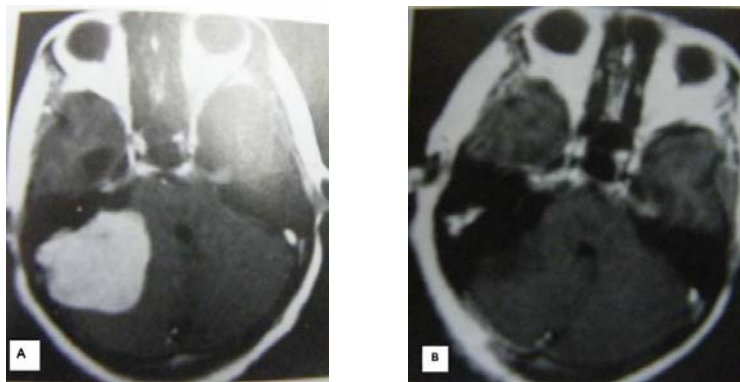


Fig. (4): (A) T1-enhanced MR image demonstrating a tumour lateral to the IAC. (B) Follow up T1 enhanced MR image revealing total resection of the tumour.

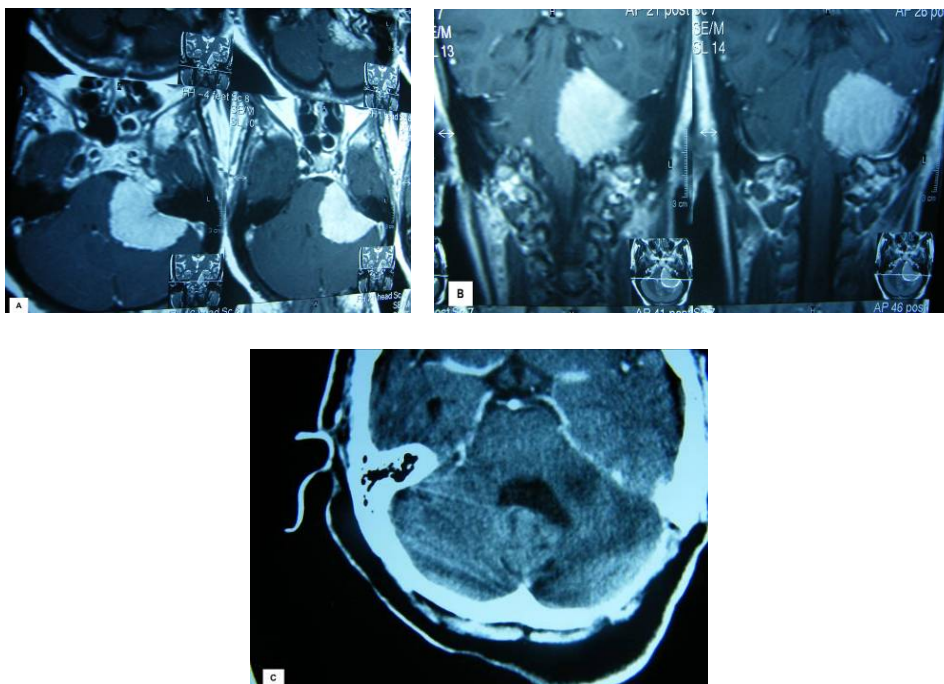


Fig. (5): Axial (A) and coronal (B) T1 MR images showing a tumour with an extensive base located at the posterior surface of the petrous bone. (C) Follow up contrast enhanced CT scan of the same case.

DISCUSSION

Meningiomas are the second most common tumour occupying the CPA angle.⁽¹³⁾

Five to eight percent of all intracranial meningiomas occur in the CPA, of these CPA tumours, acoustic neuromas comprise 70 to 80%, meningiomas 10 to 15%, and epidermoid tumours 4 to 5 %. The remainder are composed of diverse other lesions.^(18,22,26)

Most published series about meningiomas of the CPA have focused on tumours originating from the dura mater of the petrous bone, the tentorium, the clivus, and the jugular foramen.^(4,8,19,24,26,27,28)

It has been shown that petroclival meningiomas constitute a separate entity. These lesions are less frequently excised totally and are associated with higher surgical morbidity and mortality rates than tumours solely attached to the posterior petrous dura.^(6,10,26,27)

In the microsurgical era, morbidity and mortality rates in patients with petroclival meningioma have ranged between 31 and 50 % and between 0 and 17 %, respectively.^(6,10,20)

Partial resections are common with meningiomas in this location whereas the rate of total removal ranges from 25 to 85%.⁽¹⁶⁾

In Bassiouni et al series total removal defined as Simpson Grade 1 and 11 resection and no visible tumour remnant on follow up MR imaging was achieved in 84.3 % of patients harboring meningiomas whose dural attachment was restricted to the posterior surface of the petrous bone.

The reasons for performing a subtotal resection in their series included invasion of the petrous bone, infiltration of functioning cranial nerves, and tumour extension into the Meckel Cave.

Hearing impairment was the main presenting complaint and neurological sign in many series^(9,12,24,25-28)

Hearing loss has been reported to be present in 60 to 75 % of patients with meningiomas of the CPA. In our study, hearing impairment was detected in 66.7 % of patients. Headache was the main symptom and gait ataxia was the predominant neurological sign in some series,⁽¹²⁾ in patients with meningiomas of the jugular fossa, neuropathies of the lower cranial nerves occurred in 50 % in another series.⁽⁷⁾ In our study, gait ataxia was the presenting complaint in 22.2%, while headache was present in 16.7%, and none of our patients had neuropathies of the lower cranial nerves because we had no inframeatal tumours.

Trigeminal neuralgia affected 18 % of the patients in Bassiouni et al series,⁽¹²⁾ while it affected 16.7 % of our cases. Postoperative resolution of this symptom was observed in all but one patient in Bassiouni et al. series,⁽¹²⁾ while Sekhar and Jannetta⁽²⁶⁾ reported resolution of trigeminal neuralgia after surgery in all eight patients in their series. Also we had complete resolution of trigeminal pains in all 3 patients in our series (16.7%).

Magnetic resonance imaging is the diagnostic tool of choice to delineate the dural origin of the tumour preoperatively and to detect tumour extending into the IAM, the jugular foramen or the Meckel cave. However, bone window high-resolution CT scanning is more sensitive than MR in demonstrating bone changes, such as expansion and erosion of the IAM, in cases with gross intrameatal tumour extension. Patency of the venous sinuses can be depicted accurately on preoperative MR imaging or MR angiography. Because these tumours usually receive their major arterial blood supply from branches of the

meningohypophysial trunk, preoperative embolization of the tumour was not possible, nor was it believed to be an important adjunct to surgery,¹² in most patients, preoperative MR imaging study results allow for accurate classification of a tumour in relation to the PA, nonetheless, there are several limitations, the exact dural origin of the tumour or en plaque extensions may become visible only during surgery in some cases. Even on MR imaging studies it's usually not possible to demonstrate intimately involved neurovascular structures directly or to determine their position in relation to the tumour preoperatively. Tumour consistency and the relationship between arachnoid membranes and tumour surface are important determinants for functional preservation of neurovascular structures and are recognized only during surgery. With these limitations in mind, preoperative classification of these tumours according to their dural attachment in relation to the IAM gives the surgeon valuable information about the most probable dislocation of the fifth through 11th cranial nerves.⁽¹²⁾

In the series of Bassiouni et al¹² the facial-vestibulocochlear nerve complex was consistently found on the ventral aspect of retromeatal tumours (84 %) and on the caudal surface of supra meatal tumours (70 %). Similar observations have been described by other investigators.^(2,26)

Schaller et al.⁽⁴⁾ found the seventh-eighth nerve complex on the lateral (posterior) aspect of 57 % of premeatal tumour. These nerves were separated from the tumour in 59% of retromeatal meningiomas and were never found on the medial (anterior) aspect of the tumour.

In our study the seventh-eighth nerve complex was found anterior in 91.6% of retromeatal tumours, and

inferior in 8.4% of them, while these nerves were found posterior in 66.7% of premeatal tumours and inferior in 33.3% of them. In suprameatal tumours the seventh-eighth complex was found inferior in all cases.

Bao Wu et al⁽¹⁴⁾ advocated another classification system for CPA meningiomas, according to imaging manifestations and intraoperative observations. Type 1 posterior petrous meningiomas were located lateral to the IAC (34 %) type 11 located medially to the IAC, which might extend to the cavernous sinus, (39 %) and type 111, extensive attachment to the posterior surface of the petrous bone which might envelop the seventh and eighth nerves and extend to the clivus and supra tentorium (27%).

Samii⁽²⁾ classified posterior petrous meningiomas into two types: those anterior to the IAC and those posterior to the IAC, and most investigators hold the same view.^(1,3,5)

Yasargil et al.⁽⁶⁾ asserted that meningiomas in this region should be classified into anterior petroclival meningiomas and posterior CPA meningiomas.

Schaller, et al.⁽⁴⁾ reported on 31 CPA meningiomas and divided them into premeatal and retro-meatal meningiomas.

In meningiomas of the posterior petrosal surface a lateral suboccipital approach suffices even when the tumour is located ventral to the seventh-eighth nerve complex, all tumours in this series were successfully removed using this approach. Early drainage of the lateral cerebellomedullary cistern allowed gentle retraction of the cerebellum and direct visualization of the tumour. This approach has been used successfully by other investigators of CPA meningioma.^(2,6,11,26)

Preoperative facial nerve paresis is a rare sign (11% in our study) even in

patients with large tumours or lesions with gross intrameatal extension. Intraoperatively, the facial nerve can usually be preserved because it's separated from the tumour surface by the arachnoid membrane. Once the nerve is identified, the arachnoid is stripped away by using it as a protective sheath for the nerve during further resection. This was observed in the majority of our patients, and facial nerve function was preserved in these cases (72%). When the arachnoid membrane has undergone regressive changes and is firmly adherent to the tumour or when the facial nerve courses through the tumour the nerve can be detected using a stimulating electrode. Usually anatomical preservation using meticulous microsurgical preparation technique is possible in these cases provided that the nerve is identified as a single strand. In two of our patients (11.1%) harboring large tumours of hard consistency, the nerve was splayed over the tumour surface and thus could not be preserved. Permanent deterioration of facial nerve function has been reported to be between 7 and 30% in the literature^(6,12,23,24,26,27) and was observed in 2 patients in our study (11%).

The preoperative hearing level was preserved in 72.2% of patients in this study, one of them showed mild improvement (5.6%) while 5 patients (27.8%) showed deterioration of hearing functions which was unrelated to the tumour size or location. Matties et al.⁽²⁴⁾ reported on a series of 134 meningiomas involving the CPA, the retrosigmoid approach had been used in the majority of their patients and hearing was preserved in 82% and improved in 6%. Bassiouni et al.⁽¹²⁾ reported hearing preservation in (69%) of their patients. The rate of hearing preservation was highest in patients in the suprameatal and retrameatal

subgroups and lowest in those in the premeatal subgroup. They also reported postoperative hearing improvement in 8% of their patients. The analysis of the data in their study allowed no prediction in regard to postoperative hearing function to be made in an individual case and every effort should be made to preserve normal anatomical structures subserving auditory functions.

Wu Bao et al.⁽¹⁴⁾ reported deterioration of hearing functions in 33% and improvement in 18% of their patients. Regarding the extent of tumour resection, we had residual tumour in 3 patients (16.7%) meaning Simpson Grade III and IV a tumour remnant was left in cases of frank infiltration of the petrous bone, infiltration of the seventh-eighth nerve complex and extension into the Meckel Cave. Schaller et al.⁽⁴⁾ analysed meningiomas in the CPA and subtotal resection was performed in 30% of their cases, followed by radiotherapy. Wu Bao et al.⁽¹⁴⁾ reported residual tumour in 17% of their patients to preserve vital vascular and central nervous system structures. The residual tumours left were in the cavernous sinus, brain stem, vessels or nerves and they recommended gamma knife therapy after surgery.

Bassiouni et al.⁽¹²⁾ did not find any recurrent tumours from known tumour remnants on infiltrated cranial nerves along 5.4 years follow up period. They concluded that although complete removal of a tumour including its dural origin should always be the goal of surgery, preservation of infiltrated functioning cranial nerves should have the priority, because there are no data published showing an increased risk of recurrence from tumour traces on infiltrated nerves.

CONCLUSIONS

Meningiomas of the CPA require special surgical management. Analysis of preoperative MR Images meaning the exact dural origin of the tumour in relation to the PA gives valuable information about the most probable site of displaced cranial nerves. The exact relationship of critical neurovascular structures in relating to the tumour can only be fully appreciated intraoperatively. Hence, a careful operative technique with familiarity with the anatomy and effective intraoperative nerve monitoring are prerequisites to obtain an optimal functional result. It's wise to leave a trace of tumour on infiltrated but functioning nerves because no recurrence has been observed from these tumour remnants.

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