Posterior Cranial Fossa Meningiomas*

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Abstract

This study evaluated the outcomes, complications, and recurrence rates of posterior cranial fossa meningiomas. We retrospectively reviewed our surgical experience with 64 posterior cranial fossa meningiomas. Mean age was 56 years with a female preponderance (67.2%). Headache was the most common symptom. Retrosigmoid approach was the commonest surgical procedure (23.4%). The incidence of cranial nerve related complications was 28%. Postoperatively facial nerve weakness was observed in 11%. The incidence of cerebrospinal fluid leak was 4.6%. Gross total resection was achieved in 37 patients (58%). Sixteen patients (25%) with residual tumors underwent Gamma knife radiosurgery. Recurrence or tumor progression was observed in 12 patients (18.7%). Operative mortality was 3.1%. At their last follow-up, 93% of the cases achieved Glasgow Outcome Scale scores 4 or 5. Total excision is the ideal goal which can be achieved with meningiomas located in certain location, such as lateral convexity, but for other posterior fossa meningiomas the close proximity of critical structures is a major obstacle in achieving this goal. In practicality, a balance between good functional outcome and extent of resection is important for posterior cranial fossa meningiomas in proximity to critical structures.

Keywords

- posterior fossa
- skull base
- meningiomas

Posterior cranial fossa meningiomas constitute ~9%^{1,2} of all the intracranial meningiomas. Castellano and Ruggiero² had classified posterior fossa meningiomas into cerebellar convexity, tentorium, posterior surface of the petrous bone, and clivus and foramen magnum. There are various other classification systems for posterior fossa meningiomas.³ The close proximity of critical neurovascular structures and complex anatomy of temporal bone make total surgical resection difficult with this group of meningiomas. With the advances in skull base approaches and neuroimaging techniques there is a significant reduction in mortality.^{4–6} The present study elucidates our surgical experience with 64 posterior cranial fossa meningioma patients.

Materials and Methods

A total number of 64 patients with meningiomas located in the posterior cranial fossa underwent surgical excision at Neurosurgery Department at Louisiana State University Health Sciences Center, Shreveport, LA, from 1996 to 2006. All the cases were operated by the senior author (A.N.). Information related to clinical history, surgical approach, complications, pathology, and outcomes was obtained retrospectively by review of the patient's case notes, follow-up charts, radiology, and pathology reports. Posterior fossa meningiomas were classified into groups as proposed by Castellano and Ruggiero.² All patients were investigated with contrast computed tomography scans in the immediate postoperative period and were investigated with magnetic resonance imaging (MRI) scans with contrast to assess the extent of resection following surgery. Only one patient underwent embolization prior to surgical excision. Two patients underwent prior Gamma knife radiosurgery. Patient's outcome was graded according to

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Table 1 Location of Posterior Fossa Meningiomas in Our Series

Locations	N	%
Cerebellar convexity and tentorial	10	15.6
Lateral petrous ridge and CPA	11	17.1
Petroclival	33	51.5
Foramen magnum	10	15.6

CPA, cerebellopontine angle.

Glasgow Outcome Scale (GOS) at last follow-up. SPSS software (IBM, New York, NY) was used for statistical analysis where applicable. Chi-square test was used to look for any association between the excellent outcome (GOS 5) and location of posterior fossa meningioma (petroclival versus other posterior fossa meningiomas).

Results

A total number of 64 patients underwent surgical excision of posterior fossa meningiomas. Of 64, 21 patients were males (32.8%) and 43 patients were females (67.2%). Mean age was 56 years (range, 29 to 90 years). Two patients had neurofibromatosis type 2. Multiple meningiomas were noted in two patients. One patient developed internal carotid artery aneurysm subsequently which was clipped successfully. Petroclival meningiomas accounted for majority of the cases in this series, with 33 lesions (52%) (►Table 1). Headache was the most common presenting symptom. Mean follow-up duration was 22.6 months (range, 1 to 156 months). Nine patients were lost to follow-up.

Surgical Approaches

Different surgical approaches were used to expose and remove posterior fossa meningiomas depending on the location. Retrosigmoid approach was the commonest surgical procedure used, and it was performed in 15 patients (23.4%). Surgical approaches are summarized in ►Table 2.

Residual Tumor

Gross total resection as verified with MRI scan was achieved in 37 patients (58%). Most of the residual tumors were

observed following petroclival meningioma surgery (78%). In three cases residual tumors were noted following excision of meningiomas arising from the posterior fossa dura, tentorium cerebelli and cerebellopontine (CP) angle, respectively. There were 16 patients with residual tumors who underwent Gamma knife radiosurgery and 2 patients with residual tumor underwent surgical excision. One patient with incomplete excision (tentorial meningioma) expired. Rest of the patients is under clinico-radiological follow-up.

Recurrence

Recurrence or tumor progression was observed in 12 patients (18.7%). Most of the recurrences were noted following excision of petroclival meningiomas ($n = 6$). The remaining six recurrences were noted following excision of foramen magnum ($n = 2$), tentorial ($n = 2$), lateral petrous and CP angle ($n = 1$), and convexity ($n = 1$) meningiomas. Two patients with residual tumor showed disease progression and required surgical excision. Four patients underwent surgical excision. Two patients with recurrence underwent Gamma knife radiosurgery. One patient underwent surgery followed by Gamma knife radiosurgery. For the petroclival meningiomas the time to recurrence averaged 62.3 months. For other meningiomas (nonpetroclival) the time to recurrence averaged 53.9 months.

Complications

There were three patients who died following surgery. One death was not related directly to operation. This patient died due to pulmonary infarction at 8 weeks following surgery. One patient died due to severe brain swelling following tentorial meningioma excision. Other patient

Table 2 Summary of the Surgical Approaches

Approaches	N	%
Retrosigmoid	15	23.4
Transpetrosal	13	20.3
Far lateral	10	15.6
Transcondylar	2	3.1
Suboccipital craniotomy	8	12.5
Orbitozygomatic	7	10.9
Middle fossa approach (with anterior petrosectomy)	6	9.3
Combined approach (presigmoid and retrosigmoid)	2	3.1
Infratentorial supracerebellar	1	1.5

Table 3 Summary of Complications

Complications	N
Facial weakness	7
Hemiparesis	5
Sixth paresis	4
Facial numbness	3
Third paresis	3
Fourth paresis	1
Postoperative clot (explored in one)	3
Cerebrospinal fluid leak	3
Wound leak	2
Otorrhea	1
Pseudo-meningocele	2
Respiratory failure	2
Swallowing difficulty	1
Subdural hematoma (required evacuation)	1
Meningitis	1
Wound dehiscence (after second surgery)	1
Visual loss	1
Death	3
Operative related	2
Nonoperative related	1

(CP angle meningioma) developed hydrocephalus for which external ventricular drain was put. This patient developed respiratory failure and died. Results are summarized in ►Table 3. The incidence of cranial nerve related complications was 28%. Most of these cranial nerve complications were observed following petroclival meningioma excision (94%). Postoperative facial nerve weakness was observed in 11% of the cases and it was the commonest cranial nerve that was affected. Nine patients developed hydrocephalus, all except one required ventriculoperitoneal shunting shunt. Two patients underwent subsequent revisions. One patient had visual loss following surgery which was difficult to explain. The tumor was in the posterior fossa without any extensions. Complications are summarized in ►Table 3.

Clinical Outcome

Neurological outcome was assessed according to GOS. Nine patients were lost to follow-up. At the time of last follow-up for 55 patients the outcomes were GOS 1 (3), GOS 3 (1), GOS 4 (9), and GOS 5 (42). Excellent outcome (GOS 5) was achieved in 76% of cases. Good outcome (GOS 4 and 5) was achieved in 93% of cases. In view of petroclival meningiomas being associated with distinctly higher complications when compared with other posterior fossa meningiomas, we have stratified the outcomes between the two groups (petroclival versus other posterior fossa meningiomas) (►Table 4). There was no difference in the excellent outcome (GOS 5) between petroclival group and other posterior fossa meningiomas ($p = 0.9$, chi-square)

Illustrated Cases

►Figures 1 to 5 elucidate the representative cases of petroclival, foramen magnum, tentorial, lateral petrous, and convexity meningiomas, respectively, in our series.

Discussion

Majority of the tumors in our series are petroclival meningiomas (51.5%). In the series published by Roberti et al,⁷ petroclival meningiomas constituted 68.3%. In the series published by Cudip et al,⁸ tentorial meningiomas constituted the majority of cases (48%).

Surgical approach varies according to the location of the meningioma, surgeons' experience, and the aim of resection. The relationship of cranial nerves and important major vessels and dural venous sinuses makes surgical excision of posterior cranial fossa meningiomas challenging. Certain locations are more challenging than the others. Tumors located medial to the internal acoustic meatus displaces the cranial nerves posterior thus the intervening cranial nerves between the surgeon and the tumor make this group of meningiomas more difficult. Preoperative neurological condition (hearing status) also dictates the choice of approach.

In our series, retrosigmoid approach was the commonest. It was performed in 23.4% of the patients. This approach was not only suited for tumors along the lateral petrous ridge and CP angle, but also some petroclival tumors can be removed with this approach. In our series with this approach four petroclival meningiomas were safely removed. Goel and Mazumdar had used this approach to excise 28 petroclival meningiomas.⁹ All the CP angle meningiomas were managed

Table 4 Outcome Stratified According to Location Based on Two Groups (Petroclival and Other Posterior Fossa Meningiomas)

Location	GOS 5	GOS 4	GOS 3	GOS 2	GOS 1	N
Petroclival meningioma	20	4	0	0	2	26
Other posterior fossa meningioma	22	5	1	0	1	29
	42	9	1	0	3	55*

*Nine patients were last to follow-up. GOS was estimated for the remaining 55 cases at last follow-up.
GOS, Glasgow Outcome Scale.

Figure 1 Axial T2-weighted magnetic resonance images (A, B) showing a large left-sided petroclival meningioma. Axial postcontrast magnetic resonance images (C, D) showing gross total excision.

with this approach except one, which required transpetrosal resection.

For petroclival meningiomas, posterior transpetrosal approach (retrolabyrinthine) was the commonest approach. It was used in 10 patients. In seven patients, orbitozygomatic approach was used. The choice of approach depends on the location, extensions of the tumor, age of the patient, and hearing status. The retrosigmoid approach is indicated for patients with functional hearing and inferiorly situated meningiomas. Transmastoid translabyrinthine approach is useful in older patients with unilateral loss of hearing with medium size tumors confined to the CA angle involving the internal auditory canal. For large tumors crossing the midline, the translabyrinthine approach can be extended to transcochlear with total petrosectomy. The retrosigmoid exposure can be combined with a transcondylar approach to increase the exposure in front of the medulla and pons.¹⁰ In the

present article three patients underwent far lateral approach for increased exposure.

Treatment of small petroclival meningiomas (<3 cm) is controversial. Radiosurgery is a frequently used treatment modality for small benign lesions at the cranial base. It is being considered a good first-line treatment for patients with small (<3 cm) tumors or elderly patients who may not tolerate surgery due to medical comorbidity. Ramina et al¹¹ present their series of patients with small petroclival meningiomas (diameter ≤ 2.8 cm) treated with radical surgical removal. Total resection (Simpson Grade 1) was possible with minimal morbidity and no mortality.¹¹

The common approaches for foramen magnum meningiomas are suboccipital, far lateral, and transcondylar approaches. Far lateral approach includes inferolateral bone removal of the rim of foramen magnum toward the condylar fossa and posterolateral removal of the arch of atlas toward

Figure 2 Axial (A) and sagittal (B) T1-weighted postcontrast magnetic resonance images showing a large foramen magnum meningioma. Axial postcontrast magnetic resonance (C) and sagittal postcontrast magnetic resonance (D) images showing gross total excision.

the exposed vertebral artery.^{12,13} Transcondylar approach involves resection of a part or all of the occipital condyle.¹³ Drilling out the condyle is necessary to treat difficult to reach tumors that lie anterior to the brainstem and without large lateral extension¹⁴ and the authors suggest that resection of the occipital condyle should be tailored to individual cases and should not be considered a technical imperative. Yasargil¹⁵ reported 100% total removal rate with excellent clinical outcomes in seven patients with foramen magnum meningiomas using lateral suboccipital approach.

The incidence of cranial nerve related complications was 28% in this series. Most of these cranial nerve complications were observed following petroclival meningioma excision. Postoperative facial nerve weakness was observed in 11% of

the cases and it was the commonest cranial nerve that was affected. Roberti et al⁷ reported 20% incidence of facial nerve weakness. The incidence of facial nerve weakness following posterior fossa meningioma surgery varies from 10.5 to 30%.^{4,5,16} We observed CSF leaks in only three patients (4.6%). The incidence of CSF leak following posterior fossa meningioma excision varied between 2.5 and 13.6%.^{7,17-19}

Complete resection is the ideal goal but may not be always feasible. In the present series we could achieve gross total resection in only 58% of the cases. This figure is low due to high number of petroclival meningiomas. ► **Table 5** compares the extent of gross total resection in different series in the literature. In series where the extent of gross total resection is very high, petroclival meningiomas constituted less than 25%

Figure 3 Axial (A) and coronal (B) T1-weighted postcontrast magnetic resonance images showing a large central tentorial meningioma. Axial postcontrast magnetic resonance (C) and coronal postcontrast magnetic resonance (D) images showing gross total excision.

of the total number. The factors that may prevent total resection are cavernous sinus involvement (petroclival meningiomas), elderly patients, medical problems, vascular involvement, and pial-invasion of the brainstem.⁸ Surgery can lead to complications because these lesions are difficult to approach and can involve cranial nerves and arteries.

Adachi et al²⁰ proposed a scoring system to evaluate the relative risks and benefits of surgical treatment of skull base meningiomas. The following five items that predicted surgical risk were identified: (1) tumor attachment size; (2) arterial involvement; (3) brainstem contact; (4) central cavity location (the space encircled by the dural entry of CN II–XII); and (5) cranial nerve group involvement. The authors named their scoring system the ABC Surgical Risk Scale, after the initial letters of these items. Each factor was assigned a score of 0 to 2 points, and an additional point was added for previous surgical treatment or for radiation, giving a possible total score of 12 points. On average, the scoring system allocated 2 points for gross total resections, 6.1 points for near-total resections, and 9 points for subtotal resections, with signifi-

cant differences between groups. For cases scoring ≥ 8 points, the percentage of cases showing neurological deterioration postoperatively exceeded the percentage showing improvement.

With the advent of Gamma knife radiosurgery, any small residual left over can be safely treated. In the case of residual tumors we discuss with the patients the treatment options including observation and regular MRI scans. Patient's wishes are taken into consideration in the management of residual tumor. The decision to treat a residual is based on the patient wishes plus on the fact that surgery did not achieve gross total resection. In the present series, recurrence or disease progression after gross total resection is seen in 18.7%. In the nonpetroclival group (six recurrences) the mean time to recurrence was 53.9 months and in the petroclival group (six recurrences) was 62.3 months. Longer follow-up period is required to know the exact incidence of the recurrence rate. Roberti et al⁷ reported a recurrence rate of 14.2%. Among patients with subtotal resection only 7.4% showed disease progression. Sekhar et al²¹ reported that male sex,

Figure 4 Axial postcontrast magnetic resonance images (A, B) showing a large left-sided lateral petrous meningioma. Axial postcontrast magnetic resonance images (C, D) showing gross total excision.

diminished Karnofsky Performance Scale score, size greater than 2.5 cm, brainstem edema, vascular encasement, and basilar artery blood supply, each had an impact on postoperative function. Lefkowitz et al²² studied the prognostic variables in surgery for skull base meningiomas. The result of the study suggests that prognostic factors for skull base meningioma recurrence may be unique in part due to their location and their propensity to invade muscle, bone, nerve, and the major blood vessels.

Endoscopic approaches to the skull base meningiomas is still a work in progress and the published literature shows that these approaches are more commonly used to resect anterior cranial base meningiomas.^{23–29} Numerous cadaveric studies had shown the practicality of endoscopic endonasal approaches to the clival region.^{30–40} Kassam et al had described five modular approaches that provide access to several areas such as clivus, petrous bone, middle cranial

fossa, inferior and superior portions of the cavernous sinus, and medial portion of the infratemporal fossa.⁴¹ Endoscopic approaches to the petrous apex was studied by Zanation et al.⁴² In their retrospective study 20 patients were included of which none were meningiomas. There are only few case reports documenting the usefulness for the resection of clival/petrous meningiomas. Kassam et al⁴³ had used endoscopic endonasal transdorsum sellae approach to provide optic apparatus decompression in case of two petroclival meningiomas. In another series,⁴⁴ 17 patients underwent endoscopic endonasal minimal access approach to clivus of which only one case was meningioma (petroclival). In this one case authors could achieve 95% resection of the tumor. Alexander et al⁴⁵ documented another case of a midclival meningioma resected by a endoscopic transphenoidal approach. In another small series (six cases) by Solares et al only one case was a clival meningioma.⁴⁶ One of the concerns with endoscopic

Figure 5 Axial postcontrast magnetic resonance image (A) showing a large cerebellar convexity meningioma. Axial postcontrast computed tomography scan image (D) showing gross total excision.

approaches to skull base meningiomas was high incidence of CSF leak and low rate of gross total resection.^{24,29} The use of pedicle nasoseptal flap had reduced the incidence of CSF leak considerably.⁴⁷ According to a recent position paper endoscopic endonasal surgery for skull base meningiomas is still a work in progress and long-term follow studies are needed to look into tumor recurrence rates.⁴⁸

Refinements in surgical techniques and electrophysiological monitoring of the facial nerve had greatly helped surgeons in preserving facial nerve function. Caution should be exercised when using bipolar close proximity to facial nerve. The use of electrophysiological monitoring techniques such as facial electromyography may be a useful adjunct. Electrical stimulation can be used to locate the nerve even when it is out of direct view and the threshold for stimulation provides a measure of facial nerve integrity.⁴⁹ Similarly for hearing preservation monitoring of brainstem auditory evoked potentials, electrocochleography, and cochlear nerve action potentials are useful strategies.

In a prospective nonrandomized study Adeolu and Sutherland⁵⁰ studied whether the use of intraoperative MRI improves surgical resection of meningiomas and postoperative outcome in series of 39 surgeries. In their study unexpected residual lesion was found in only one patient. Intraoperative MRI was helpful for surgical planning, incision placement, and providing anatomical relationships between the tumor and adjacent structures. We feel that intraoperative MRI may be a useful adjunct in the resection of petroclival meningiomas; however, in these tumors residual is left behind to avoid cranial nerve dysfunction or vascular injury, as the strategy is aimed at functional preservation.

We feel that microsurgery remains the main strategy for the resection of posterior cranial fossa meningiomas. As the strategy is shifting toward to more of functional preservation rather than radical excision, stereotactic radiosurgery continues to play an adjunctive role in the management of residual lesions and small recurrent tumors. Endoscopic approaches to posterior cranial fossa meningiomas are still

Table 5 Comparison of GTR Rates in Large Series of Posterior Cranial Fossa Meningiomas

Series	N	Petroclival (%)	GTR %
Shen et al ¹⁷	71	23	94
Saleh et al ²⁰	40	22.5	92
Cudlip et al ¹⁹	52	19	88
Lobato et al ¹⁸	80	56.25	63
Roberti et al ⁷	161	68.3	57
Present series	64	51.5	58

GTR, gross total resection.

a work in progress and currently there are no large series to understand the complication and recurrence rates.

Conclusion

Total excision is the ideal goal which can be achieved with meningiomas located in certain location such as lateral convexity but for other posterior fossa meningiomas the close proximity of critical structures is a major obstacle in achieving this goal. In practicality, a balance between good functional outcome and extent of resection is important for posterior cranial fossa meningiomas in proximity to critical structures.

Notes

We presented the results of our study at the American Association of Neurological Surgeons Conference, Philadelphia, 2010.

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