New Grading System to Predict Resectability of Anterior Clinoid Meningiomas

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Abstract

Sixty patients with anterior clinoid meningiomas (mean age 48 years) were surgically treated. There was a slight female predominance. Headache and visual impairment were the commonest clinical symptoms at presentation. The patients were classified on the basis of extent of the visual impairment, size of the tumor, and the tumor relationship with the internal carotid artery. A grading system was designed using the total scores in these classifications on the scale of 2–10. The classifications and the grading system were assessed for planning of the operative strategy, anticipating the extent of resectability, possible difficulties in dissecting the carotid artery and optic nerve during the operation, and prognosis. Total resection was achieved in 42 cases (scores 4–8), subtotal resection in 17 cases (scores 7–10), and only partial resection in one case (score 10). Vision improved in 14 cases. Three patients died following surgery. Mean follow up was 26 months. There was one recurrence. Fifty-four patients are leading independent and active lives.

Key words: anterior clinoid meningioma, carotid artery, skull base surgery, optic nerve

Introduction

Anterior clinoid meningiomas frequently encase the carotid artery and its branches and perforators, and also involve the optic nerve, the cavernous sinus, and other critical structures in the neighborhood, thus constituting a challenging and formidable surgical problem. The tumor origin is on or around the anterior clinoid process, so the extent of dural attachment, size, and consistency vary. Various terminologies have been used to classify these meningiomas.^{1,6)} Relatively few large series have been reviewed.^{1,12,13,15,18,19)} We describe our experience with a series of 60 cases of anterior clinoid meningioma.

Materials and Methods

Sixty patients with anterior clinoid meningiomas, 28 males and 32 females aged 15 to 76 years, were treated in the neurosurgery department at King Edward Memorial Hospital and Seth Gordhandas Sunderdas Medical College, Bombay between 1993 and October 1999 (Table 1). The principal symptoms and signs at presentation are elaborated in Table 2.

Table 1 Age distribution of the patients

Age (years)	No. of cases
< 20	2
21–30	5
31–40	17
41–50	16
51–60	10
61–70	6
> 70	4

Table 2 Symptoms and signs at presentation

Clinical findings	No. of cases
Visual complaints	55
Headache	42
Abnormal behavior	3
Seizures	4
Limb weakness	7
Speech involvement	5
Third cranial nerve involvement	4
Proptosis	5
Impaired consciousness	2

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Fig. 1 Computed tomography scan with contrast medium showing a large anterior clinoid meningioma with hyperostosis of the anterior clinoid process.

Fig. 2 Computed tomography scan with contrast medium showing an anterior clinoid meningioma. The lesion has score 1 according to classification 2.

Duration of the complaints varied from 1 month to 5 years (mean 14 months). Radiological investigations included computed tomography (CT) and magnetic resonance (MR) imaging in all cases. Angiography was performed in 14 cases. The main blood supply to the tumor was from the external carotid artery in all cases, and blood supply was also observed from the branches of the cavernous sinus segment of the internal carotid artery in two cases. Embolization of the tumor was not performed in any patient. Hyperostosis of the bone was seen in 14 patients (Fig. 1). Three classifications were used for each case based on the extent of visual impairment, size

Fig. 3 Computed tomography scan with contrast medium showing a meningioma with score 2 according to classification 2.

Fig. 4 Computed tomography scan with contrast medium showing a meningioma with score 3 according to classification 2.

of the tumor (Fig. 2-4), and the relationship to the internal carotid artery (Fig. 5) as shown in Tables 3-5. The score in each classification was added for each patient to provide a final grading system from 2 to 10. The number of patients in each grade is shown in Table 6.

The patient was placed in supine position with the head turned to the contralateral side. A basal frontotemporal craniotomy was performed which included resection of the lesser wing of the sphenoid ridge and the posterior third of the roof and lateral wall of orbit. Orbitozygomatic osteotomy was performed in the initial three cases, but not in subsequent cases. The resection of the lesser wing of the sphenoid was continued medially either to include the anterior clinoid process or to remain as close to the anterior clinoid process as possible. Resection

Fig. 5 Schematic drawings showing the relationship of the internal carotid artery with the tumor (classification 3). **A:** Score 1: Internal carotid artery is displaced by the tumor. **B:** Score 2: Internal carotid artery is encased by the tumor, but the lumen is not narrowed. **C:** Score 3: Internal carotid artery is encased within the tumor and the lumen is narrowed. **D:** Score 4: The tumor extends to the contralateral side and displaces the contralateral carotid artery as well.

was discontinued in cases with extensive or discomforting bleeding in the medial part of the lesser

wing, and the dura was opened. The attachment of the tumor to the dura was progressively coagulated, directing the initial attack towards the anterior clinoid process. Space for coagulation of the tumor attachment was obtained by simultaneous tumoral debulking, avoiding the region of the involved internal carotid artery and its branches. Whenever felt necessary, the residual portion of the anterior clinoid process was drilled either intradurally or extradurally, primarily to identify the location of internal carotid artery. The internal carotid artery dissection and isolation was then continued distally in a subarachnoid plane with simultaneous removal of the tumor. Total and radical removal of all tumors was attempted, but if dissection of the tumor from the internal carotid artery, its branches, or any cranial nerve could entail risk of damage, the dissection was discontinued and that portion of the tumor was left behind (Fig. 6). Tumor involving the dura was resected. No special attempt was made to remove the bony hyperostosis. The neck was prepared for exposure of the carotid artery for proximal control in higher grade tumors.

The optic nerve was compressed to varying degrees and generally displaced superomedially. The optic nerve was almost completely disrupted by the tumor in two cases and was not even possible to clearly identify in another two cases. The optic nerve was not sectioned to enhance the tumor exposure in any case. The optic nerve was mobilized after opening the optic bone and the dural canal early in the operation to minimize injury related to stretching. The tumor extended into the optic canal in four patients. The cranial nerves entering the cavernous sinus were displaced with an intact arachnoid barrier and were preserved in all cases. The tumor extended within the dural walls of the third cranial nerve in three cases. The pituitary stalk was in close proximity to the tumor and was markedly displaced in some cases but was never encased.

Table 3 Classification 1 based on visual involvement and extent of tumor excision

Score	Vision	No. of cases	Excision		
			Total	Subtotal	Partial
0	No visual loss	5	5	0	0
1	Partial visual loss	34	24	10	0
2	Blindness of ipsilateral eye	14	8	6	0
3	Partial/complete involvement of both eyes	7	5	1	1

Table 4 Classification 2 based on tumor size and extent of tumor excision

Score	Tumor size	No. of cases	Excision		
			Total	Subtotal	Partial
1	< 3 cm	9	9	0	0
2	3–5 cm	29	22	7	0
3	> 5 cm	22	11	10	1

Table 5 Classification 3 based on the relationship with the internal carotid artery (ICA) and extent of tumor excision

Score	Relationship with the ICA	No. of cases	Excision		
			Total	Subtotal	Partial
1	Displacement of ipsilateral ICA	39	34	5	0
2	ICA encased but not narrowed	9	8	1	0
3	ICA encased and narrowed	3	0	3	0
4	Contralateral ICA/basilar artery displacement	9	0	8	1

Table 6 Grading of the tumor and the extent of tumor excision

Total score*	No. of cases	Excision		
		Total	Subtotal	Partial
10	5	0	4	1
9	6	0	6	0
8	7	2	5	0
7	7	5	2	0
6	13	13	0	0
5	10	10	0	0
4	12	12	0	0

*Total score is total of individual scores in the three classifications.

Results

The extent of surgical excision was correlated with the three classifications (Tables 3–5) and the grading system (Table 6). Total tumor resection was achieved in 42 cases and confirmed by postoperative radiology. Subtotal tumor resection with less than 10% of the tumor left behind was achieved in 17 cases. Only partial excision of the tumor could be achieved in one case due to intraoperative brain swelling. Total excision was achieved in all 35 cases in grades 4 to 6, in five cases in grade 7, and in two cases in grade 8 (Table 6). Total excision was not possible in any case in grades 9 and 10.

Fig. 6 left: Computed tomography scan showing a massive anterior clinoid meningioma (score 3 in classification 2). center: Magnetic resonance image showing the large tumor completely encasing and narrowing the internal carotid artery. right: Postoperative computed tomography scan showing a small residual tumor and the relationship to the internal carotid artery.

Most patients (38 patients) showed no improvement in vision following surgery. Twelve patients with partial vision loss (score 1) showed at least some recovery in visual acuity. Two patients with preoperative blindness showed partial recovery of vision. Three patients suffered deterioration of vision following surgery. Four patients had postoperative hemiplegia, and three of these patients subsequently died.

Follow up ranged from 1 month to 6 years with a mean follow up of 26 months. One patient with partial tumor resection had recurrence required reoperation 3 years after the first surgery. Subtotal excision was performed in the second stage as part of the tumor encasing the carotid artery could not be adequately dissected. Fifty-four patients were asymptomatic and returned to normal life. Three patients were independent only for household activities.

Discussion

I. Philosophy of management

The difficulty in surgically excising anterior clinoid meningioma stems from its relationship to the ipsilateral internal carotid artery and its branches which are frequently encased and/or displaced. The major concern during surgery is preservation of these vessels as severe hemispheric deficits or even death may result, which would otherwise not occur in the natural course of the tumor growth or at least take several more years.¹⁰⁾ The usual presentation shows that most of these tumors are slow growing. Any surgical endeavor must therefore consider both the natural history of these tumors and personal operative experience. The extent of the surgical resection of the tumor will determine the ultimate outcome of the patient, tumor recurrence, and regrowth.^{24,25)}

II. Clinical presentation

Preponderance of anterior clinoid meningioma in females has been uniformly observed.²⁷⁾ As in most other skull basal lesions, the tumors arising from the anterior clinoid process have a relatively innocuous clinical presentation despite the commonly encountered large size. This feature was also seen in our series. The presentation of the tumor was primarily varying degrees of visual diminution in the ipsilateral eye. Involvement of extraocular nerves is seen only as a rare feature. In our series, third cranial nerve involvement was seen in four cases. The pituitary function was not affected in any case, and has been reported infrequently.²⁷⁾ Symptoms secondary to raised intracranial pressure were not

predominant. Progressive hemiparesis as a presenting symptom has also been reported,¹⁸⁾ and was observed in seven cases in our series.

III. Investigations

MR imaging was essential to clearly define the relationship of the tumor to major blood vessels, especially encasement and displacement, and to understand the exact tumor-artery relationship. Angiography was helpful to delineate the extent of arterial compression and displacement, vascularity of the tumor, and the collateral circulation. CT was useful to delineate the extent of bone involvement. Despite the large sizes of the tumor and their close relationship to the superior and lateral wall of the cavernous sinus, invasion was infrequent and was identified to be only a tail-like extension via the dural cave of the third cranial nerve and along the carotid artery. Gross invasion of the cavernous sinus was not encountered and appears to be rare, probably due to the barrier provided by the thick dura of the lateral wall. There was no invasion of the skull base and craniofacial cavities in any patient.

The importance of the criteria used to classify these tumors has been discussed before.^{8,9,22)} The size of the tumor is important in determining the possible problems during surgery. Larger tumors cause more severe stretching of the adjoining nerves and vessels and consequently the resection is more difficult. The extent and duration of visual deficit helps to determine the consistency of the tumor, its growth characteristics, and the relationship to the internal carotid artery.

Our observation was that more severe visual deficits are usually associated with firmer tumor. This relationship of visual loss to difficulty during surgery was also observed previously.²⁰⁾ The tumor was more firm when the artery was displaced rather than encased. Arterial compression appeared to be related to the consistency of the surrounding tumor, rather than invasion into the arachnoidal planes. The inclusion of all parameters used in the three classifications helped to formulate a suitable grading system which assisted in determining the consistency, growth characteristics, and relationship to critical neural and vascular structures. All these features can be used to determine the need for proximal control of the carotid artery, extent of possible resection, and the prognosis.

IV. Surgical considerations

No special anesthetic cerebral protection was utilized during the operative procedures. However, such measures could be of use in some situations. The exposure for approach of these tumors allows

the entire tumor to be removed in one single operative field. Basal exposures used in early cases included orbitozygomatic osteotomy, removal of the roof and the lateral wall of the orbit, and resection of the lesser wing of the sphenoid bone up to the clinoid process in addition to the frontotemporal pterion-based craniotomy. However, we found that the orbitozygomatic osteotomy could be avoided in the later cases in our series. Alternative approaches have been described.^{2,6,11,15,16)} No resection of any part of the frontal or the temporal lobe was necessary in our series. Before extensive usage of the skull base approaches, temporal polar¹⁴⁾ or inferolateral frontal lobe resection was recommended for safe tumor removal.¹⁷⁾

A small or a limited tumor excision appears to have no significant effect on the long-term prognosis.⁴⁾ Based on reported series, we thought that planning of the operation must be for radical excision of the lesion with adequate preparation for management of the involved arteries. We observed that if the arterial isolation is inadequate, very limited resection is possible due to the constant fear of approaching the vessel. The initial surgical attack should be directed towards the anterior clinoid process, aiming to expose the internal carotid artery trunk and then to further dissection. We found that once this artery was free, rapid and relatively safe excision of the tumor could be achieved. Some surgeons have advised tracing of the internal carotid artery from distally (its middle cerebral artery branches) to its trunk,^{1,18,21)} but we found that this procedure was difficult and carried the risk of retraction injury to the brain and to the stretched artery. The artery was exposed in the clinoidal area, so there was no need to open the compressed sylvian fissure as previously advocated.¹⁾ While proceeding towards the anterior clinoid process, the tumor was dissected free from its basal dural attachments and devascularized in the process. This dissection from the base and along the site of attachment of the tumor to the dura was relatively safe and, as in any other meningioma, an important preparatory step of the operation.²⁷⁾ Drilling of the lesser wing of the sphenoid bone also helped to some extent in tumor devascularization. Sacrifice of branches of middle cerebral artery led to severe hemispheric deficit and later death in three patients. We think that immediate reanastomosis or a bypass could have helped the situation in these cases. On the basis of our experience, sacrifice of a large branch of middle cerebral artery cannot be done. There was no carotid arterial tear in any of our cases. However, arterial injury (carotid or middle cerebral artery) may occur during the course of

dissection, so preparation must be made for immediate arterial repair and reconstruction of the vessel. If local reconstruction of the vessel is not possible, then either superficial temporal artery-middle cerebral artery bypass or a long saphenous graft from the external carotid artery to the middle cerebral trunk are possibilities.^{16,23,25,26)}

The optic nerve was compressed to varying degrees. Well-defined arachnoid sheath was found between the tumor and the optic nerve. The cranial nerves entering the cavernous sinus were displaced inferiorly in all cases, with an intact arachnoid cover. The pituitary stalk was in close proximity to the tumor and markedly displaced in some cases but was never encased. None of the patients developed postoperative pituitary dysfunction.

Occasional reports have found visual improvement in a blind eye following surgery,²⁰⁾ but no recovery of vision is a more frequent observation.^{7,10)} Visual recovery was observed in a blind eye in two of our cases. The duration of preoperative visual symptoms had a strong influence on visual outcome.²⁰⁾

V. Radiotherapy

We do not favor irradiation of the residual tumors due to poor response of the tumors, despite previous recommendations.^{3,5,7,14)} Gamma knife radiation has also been advocated for small residual tumor,¹⁴⁾ but was avoided in this series.

VI. Conclusions

Skull basal approaches with adequate isolation and protection of the internal carotid artery early in the operation can lead to safe and radical resection of anterior clinoidal meningiomas. The advantages of the classifications and grading system proposed require evaluation in a larger series.

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Commentary

A series of sixty patients with anterior clinoid process meningiomas is a rather large series to be dealt with. The classification of the meningiomas in this region, as well as in any other region, is welcome provided that it is simple, logical and objective, and last, but not at least, that it be such that it can be easily repeated. The main aim of authors is to anticipate the extent of resectability, the possible difficulties in dissecting the ICA and the optic nerve. The resectability of a meningioma anywhere — and hence also at the region of the anterior clinoid process — is the most important question, and this is actually what the surgical treatment is all about. One would appreciate very much a precise description of the involvement of the structures around the anterior clinoid process, then on the basis of the anatomy in comparison with the pathological anatomy one could predict to some extent (only) the possible conflicts and the difficulties in surgical resection of the meningioma. Unfortunately, one cannot find this kind of description in the report. The description of the surgical procedure

hence cannot be clear, since it is not based on the normal anatomy, changed due to pathology, but is based on the pathology only. The size of the tumor is far from being the leading factor in resectability of the tumor. What counts are other characteristics, including also the histological type of the tumor, since it dictates, among other factors, the relationship with the incased and/or stretched and displaced vascular and/or neural structures. The authors are discussing what could be done, if such and such thing were to happen during surgery, rather than describing what has been done or has not been done, and why so. The reader also misses also the description of the reason(s) why partial excision of the meningioma is performed in this region. If the correct surgical approach is used, then the bleeding from the tumor cannot be the cause for stopping the surgical procedure, except in case that the rupture of the ICA occurred during resection of the tumor. However, by an appropriate approach to these tumors and by the conduct of surgery, the rupture of the ICA can be prevented. The reader is also surprised that the preoperative and postoperative images are not coupled.

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Meningiomas originating from the medial sphenoid wing commonly affect or involve the carotid artery and the optic nerve, and the radicality depends on the adhesiveness to those structures. The authors introduce a new grading system scored by three factors, patient's visual function, the tumor size and degree of the carotid involvement, based on the analysis of a large number of their surgical experiences. This system will be beneficial to the neurosurgeons to assess the resectability. I want to add a particular characteristic of this tumor, by pointing out its high recurrence rate, with invasion into the basal skull and the cavernous sinus at the time of recurrence. Presence or absence of the tumor extension into the optic canal is influential on the tumor radicality as well. Therefore, removal of the anterior clinoid process including opening the optic canal is important to remove the dural attachment and the tumor in the optic canal. Careful mobilization of the optic nerve is important to spare overstretching of the nerve, and to widen the surgical window between the optic nerve and the carotid artery.

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