Petroclival meningiomas: is radical resection always the best option?

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Abstract

Background—The surgical management of petroclival meningiomas is, despite the invaluable technical achievements in the past decade, still burdened by a high operative morbidity. It seems doubtful whether radical surgical removal should always be the primary goal in those lesions as advocated until very recently.

Methods—A series was critically analysed and the literature discussed to elucidate criteria for a different attitude. Between 1990 and 1995 a total of 19 patients harbouring petroclival meningiomas were operated on. The following approaches were used: petrosal (n = 13), retrosigmoidal (n = 5), and subtemporal (n = 1). Thirteen lesions were removed completely and six incompletely as assessed by postoperative MRI.

Results—No recurrence or regrowth could be detected on MRI after a mean follow up of 18 months. Surgical mortality occurred in one patient (5%) and there was early postoperative dysfunction in 56%. At the time of follow up major permanent operative morbidity was present in two patients (11%).

Conclusions—In accord with recent literature subtotal resection of petroclival meningiomas should be contemplated in a subset of patients (with invasion of brain stem or cavernous sinus) to reduce the incidence of disabling deficits. Surgery should not be delayed in younger patients because surgical morbidity relates positively with tumour size.

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Published surgical series of petroclival lesions, particularly meningiomas, have undergone a remarkable and probably predictable evolution. Because the operative mortality for petroclival meningiomas has been reported to be as high as 56% before 1980, their removal was regarded as a “formidable challenge”. However, the inherent fascination of technical challenges and the potential to cure meningiomas triggered the predictable part of the development.

With the simultaneous expansion of microneurosurgery, specialised skull base centres introduced new complex approaches and surgical techniques based on extensive

anatomical studies. Subsequently reported surgical series—from the mid-1980s on—had a much lower mortality rate, ranging from 0 to 9%.^{1–19} However, temporary and permanent operative morbidity in all those reports still tended to be high. An immediate postoperative worsening was seen in virtually all patients. Permanent morbidity reached up to 50%, with severe disabilities in up to 18%. Although all authors openly reported those complication rates, the rather trite conclusion remained the same for the past 10 years: Radical tumour removal should be the primary goal in all cases, because it can be achieved by new and elegant techniques. The morbidity and mortality were simply considered acceptable by almost all authors. Only rarely were doubts expressed about this point of view.^{14 20}

Recently, some of those that had spearheaded many innovations and surgical aggressiveness in skull base surgery advocated a much more differentiated and critical attitude.^{21–23} We are encouraged to report our own series of petroclival meningiomas and review the current literature as we have simultaneously reached similar conclusions.

Patients and methods

Between 1990 and 1995 19 patients were operated on for petroclival meningiomas. Two men and 17 women with a mean age of 56 (range 31–75) years, underwent a total of 20 procedures. Preoperative symptoms were mostly mild and thus Karnofsky performance scores (KPS) were high with a median of 80 (range 70–90). Six patients exhibited no symptoms or minor headaches only, whereas in nine cases intermediate symptoms such as cranial nerve deficits or limb and gait ataxia were present. Four patients had already developed motor weakness and hemisensory loss (table).

All patients underwent preoperative MRI for evaluation of tumour size and exact anatomical correlation. Tumour size and location were classified according to Sekhar *et al.*¹⁷ Seven patients with suspected involvement of the internal carotid artery underwent additional preoperative angiography with balloon occlusion testing as a precaution in the case of arterial injury. In six patients simple standard approaches and in 13 patients so called complex skull base approaches were used (table). The technical details of the mentioned routes of access to the base of the skull are described in detail elsewhere.^{1–3 5 8 11 13 17–19 24–33}

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Clinical data of 19 patients with petroclival meningiomas

Patient No	Age	Sex	Location	Size	Approach	Resection	Early dysfunction	Morbidity	Regrowth/recurrence	F/U	KPS pre-op	KPS F/U
1	54	F	U/M/L	Giant	Postpetrosal L*	Subtotal	Haemorrhage, CSF leak, Infection, CN IV	No	No	45	90	90
2	74	F	M/L	Large	Subocc L	Total	No	No	No	34	80	90
3	47	M	U/M	Large	Post petrosal R	Total	No	No	No	32	90	100
4	56	M	M/L	Large	Subocc L	Total	CN VI, VII, VIII	CN VII, VIII	No	28	90	90
5	37	F	U/M/L	Giant	Post petrosal L	Total	CSF leak, CN VII, VIII, altered Mental status	CN VII, VIII	No	26	90	80
6	66	F	M/L	Large	Subocc L	Total	No	No	No	23	90	90
7	61	F	U/M	Large	Post petrosal L	Total	CN VI	Incomplete CN VI	No	22	80	90
8	52	F	M/L	Large	Subocc R	Total	CSF leak, Infection	No	No	18	80	90
9	48	F	U/M	Medium	Post petrosal L	Total	No	No	No	12	90	100
10	42	F	U/M	Large	Post petrosal L	Subtotal	Hemiparesis, altered mental status	Hemiparesis	No	26	80	90
11	67	F	M	Medium	Post petrosal L	Total	No	No	No	10	90	100
12	71	F	U/M	Large	Post petrosal L	Total	Epidural haemat, CN VI	Incomplete CN VI	No	10	90	80
13	75	F	U/M	Large	Post petrosal L	Subtotal	No	No	No	10	70	70
14	44	F	U	Medium	Ant petrosal L	Total	CSF leak, altered mental status	No	No	10	70	70
15	35	F	U/M/L	Giant	Complpetrosal R	Subtotal	No	No	No	9	80	80
16	74	F	U	Medium	Subtemp L	Subtotal	CSF leak, altered mental status	No	No	9	80	80
17	60	F	L	Medium	Subocc L	Total	No	No	No	9	70	90
18	31	F	U/M/L	Giant	Post petrosal R	Subtotal	CN III, V	No	No	9	80	90
19	67	F	U/M/L	Giant	Post petrosal L	Total	Death (brainstem infarct)				80	Patient died

Location relates to involvement of clivus; U = upper clivus (above CNV); M = middle clivus (between CN V and CN IX); L = lower clivus (below CN IX). Size is graded according to Sekhar *et al*¹⁷; medium = 1–2.5 cm; large = 2.5–4.5 cm; giant = > 4.5 cm. Approaches are *subocc* = simple suboccipital retrosigmoidal; *subtemp* = simple subtemporal; *ant petrosal* = subtemporal with partial anterior petrosotomy; *post petrosal* = combined infra and supratentorial with partial posterior petrosotomy (= anterosigmoidal retrolabyrinthine); *compl petrosal* = combined infra/supratentorial with complete petrosotomy (= anterosigmoidal transcochlear). Resection is as determined by early (< 3 months after surgery) MRI. Early dysfunction defines the temporary operative morbidity including direct operative complications. Morbidity is the permanent operative morbidity at time of follow up. Regrowth/recurrence was determined by MRI at time of follow up. F/U = time of last follow up in months after surgery. KPS preop = Karnofsky performance score preoperatively. KPS F/U = Karnofsky performance score at time of last follow up.

Extent of tumour removal and recurrence or regrowth were evaluated by serial MRI. Clinical evaluations were performed during the first days after surgery and at regular follow up to establish (a) temporary operative morbidity and mortality and (b) permanent operative morbidity. Mean follow up time was 18 (range 9–45) months.

Results

The table gives tumour size and location, and approaches used. All tumours were histopathologically classified as typical meningiomas (World Health Organisation (WHO) grade I). Complete tumour removal was achieved in 13 patients (68%) as defined by postoperative MRI criteria. In the remaining six patients (32%) remnants were intentionally left either inside the cavernous sinus (n = 3), or as small rims attached to the brain stem (n = 1), or both (n = 2) (fig 1). Brain stem oedema on preoperative MRI was considered indicative of adhesion or invasion by the tumour and therefore precluded total removal.

Recurrence within the limited time of follow up could not be shown in any of the patients with completely resected tumours. In those patients with tumour remnants in the cavernous sinus or at the brainstem surface, no progression could be detected after a short follow up of around 10 months in five patients and a period of 45 months in one patient.

The table lists all complications related to surgery. One patient died on the fifth postoperative day, accounting for the surgical mortality of 5%. She developed a fulminant sepsis secondary to pneumonia while being ventilated on the intensive care unit for a severely depressed neurological status secondary to

brain stem infarction. A radical removal of her giant petroclival meningioma had been attempted despite adherence to the brain stem. In the remaining patients direct operative complications in the immediate postoperative period were seen in six instances (34%). One epidural haematoma and one intracerebral haemorrhage required reoperation with a further uneventful course in both cases. Of five patients with CSF leaks (28%), four could be treated conservatively and one required definite surgical repair. Two patients developed postoperative meningitis (11%) which resolved after antibiotic treatment without sequelae.

A substantial part of early postsurgical dysfunction was caused by psycho-organic disturbances with concomitant slow recovery, related to prolonged left temporal lobe retraction in four patients (22%). Cranial neuropathies (six patients; 34%) were the most frequent focal deficits causing early deterioration. Cranial nerves III through VI were mainly involved and in two patients the nerve group VII/VIII was also impaired. One other patient exhibited a hemiparesis after surgery.

Only eight patients (44%) were not appreciably affected by one of the above complications in the early postoperative period. In these patients the postsurgical KPS dropped by only 20 points or less, whereas in the remaining 10 patients a drop of 30 or more occurred (table). Mean time resident in hospital in the neurosurgical department also differed significantly between these two groups (two weeks *v* five weeks). All patients in the five week group were referred to a rehabilitation unit and spent up to seven months there.

At the time of the last follow up five patients still exhibited deficits and thus accounted for

Gadolinium enhanced T1 weighted MRI before (A) and after (B) subtotal resection of a giant right sided petroclival meningioma in a 31 year old woman. The postoperative course was uneventful except for a transient CN III and V paresis. Note tumour remnants that were left intentionally inside the cavernous sinus and around the brain stem.

the overall permanent surgical morbidity of 28%. Of those, however, three were minor neurological impairments. The remaining two patients with moderate to severe deficits were responsible for an 11% incidence of major surgical morbidity. One has a pronounced hemiparesis which prevents her from returning to her preoperative activity, while being independent at home. The other has lost a preoperative useful hearing and facial nerve function (table).

Discussion

The extremely high hazard of operative death associated with the removal of petroclival meningiomas in the premicroscopic era of neurosurgery was successfully overcome from the mid-1980s on. All recent series show a mortality below 10%.¹⁻¹⁹ This success was based on anatomical studies and reports reflecting the dedication of specialised groups in the development and refinement of neurosurgical techniques.^{2,7,24-44} These publications, however, often focused on technique rather

than discussing details of outcome. The authors' inventiveness earns the merit of reducing mortality and morbidity dramatically. However, we found their conclusion to advocate radical tumour removal as the surgical goal with permanent morbidities in up to 50% and severe disabilities in up to 18% of patients confusing. Very rarely has this philosophy been questioned.²⁰

Recently two publications appeared that focused on outcome after the resection of petroclival meningiomas.^{21,23} The authors reviewed a large number of their own cases, most of which had been published earlier in multicentre studies and reached conclusions that "have modified the authors' present approach to these lesions". Our group was always rather unsure in thinking of radical surgical removal as the primary surgical goal in every case, although we were tempted to. In fact, until not long ago we thought that our attitude might be too conservative. Reviewing our series, however, showed us that this was not the case, as discussed in the next sections.

Surgical approaches

We have only used lateral approaches to the skull base, as we consider that anterior approaches such as transfacial, transoral, transmandibular, or extended transbasal routes^{34 35 37 39 41 44} are basically and primarily suited for extradural disease, which is in accordance with the literature. Some lateral routes such as the transcondylar^{2 24 27} or infratemporal⁷ approach are rarely used, by contrast with those around or through the petrous bone.^{1 4-6 8-13 15-19 21 23 25 28 31-33 37} Despite the confusing nomenclature, they all derive from a common denominator. In simple terms, a standard suboccipital, or subtemporal trepanation, or both are combined with a varying degree of petrous bone resection. Only with complete preoperative hearing loss is a total petrosectomy (transcochlear) indicated whereas otherwise a “tailored” pyramid resection should be performed. Most often—also in our series—a combined subtemporal/suboccipital trepanation with posterior petrosectomy is performed. While providing excellent exposure, these complex routes have an inherent risk for operative complications which contribute to early postoperative dysfunction. In particular, CSF leaks and subsequent infections were seen in 28% of our patients and caused a prolonged period of recovery, a fact that is also appreciated in the literature.^{21 23} This high rate may be lowered by meticulous dural closure and the use of rotating muscle and fascia flaps. Another problem, despite advanced anaesthesiological management of brain relaxation, is temporal lobe retraction especially on the left side. In our series 27% of cases in which a left sided approach was used had postoperative neuropsychological impairment which again prolonged the period of recovery. This dysfunction is most likely caused by impairment of venous drainage and may be avoided or alleviated by paying particular attention to the venous anatomy and by using an appropriate surgical technique. Although these early postoperative deficits improved in all patients, similar to the experience of Sekhar *et al*,²³ they must be considered as a potential cause of severe sequelae and therefore discussed in the counselling of the patients.

Permanent problems that were related to the approach did occur with respect to petrous bone drilling. In two patients (10%) there was impairment of the cranial nerves VII and VIII. This constituted a major morbidity in one of the patients. Also in the above mentioned published series inadvertent sacrifice of useful hearing or facial function that recovered only incompletely after reconstructive surgery is described in up to 16%.

Amount of resection and operative complications

The question is, whether all tumours in all patients should be radically resected or whether some patients and some tumours preclude complete removal because of an unacceptable high risk of neurological deficits. In

theory a radical excision of these “benign” lesions will best prevent recurrence. However, the natural history (for example, growth rate) and the recurrence rates after surgery—including incompletely resected lesions—are not fully understood and vary in other series between 13% and 20% after a follow up of up to 6-1 years.^{12 16 17 21-23} Whether adjuvant radiation therapy is helpful in prolonging the interval or preventing progression is still matter of debate.⁴⁵⁻⁴⁷ However, these figures alone suggest that—at least for elderly patients—subtotal removal is a valid option.^{21 23 48} We have so far experienced neither recurrence nor regrowth in our patients after an, admittedly short, follow up of 18 months on average.

On analysing our operative mortality and morbidity two facts are apparent: (1) Our sole operative death and one of our two major permanent disabilities, a hemiparesis, resulted from attempted radical tumour dissection from the brain stem, when a clear tumour/brain stem interface was not visible. Sekhar *et al*²³ and Couldwell *et al*²¹ both describe the phenomenon that some of these lesions show poor planes of dissection, with pial invasion of the brain stem parasitising its microvascular supply. They both conclude that this situation prohibits complete removal and may be predicted by the presence of brain stem oedema on preoperative MRI. (2) The incidence of only two (11%) permanent cranial neuropathies related to the cavernous sinus—both minor abducens nerve paresis—compares favourably with the other series mentioned. The reason is most probably that we did not usually attempt to completely remove tumour parts in the cavernous sinus. The figure illustrates a typical example (patient 18) for this policy, which we adapted over time. In fact, tumour extension into the cavernous sinus by itself should not generally prevent the pursuance of complete tumour removal. Particularly, tumours in the posterior cavernous sinus may be separable from cranial nerves, with good long term function. However, earlier efforts at radical removal in every case by some of the authors,⁴⁰ who proposed reconstruction of oculomotor nerves, have been rather disappointing and now a more conservative attitude with respect to cavernous sinus surgery is advocated by those authors.^{21 23} The high incidence of vascular accidents with radical cavernous sinus resection that occurs despite preoperative balloon occlusion testing etc⁴⁹ further stresses the need for a more cautious approach. In a very recent publication Larson *et al*⁵⁰ describe the previously unreported phenomenon that “benign” meningiomas sometimes infiltrate cranial nerves in the cavernous sinus. They conclude that “the hope of total removal of a meningioma may be futile and, in the long term, may provide no advantage over treatment options with lower morbidity”.

Our overall ratio of complete resections (68%), surgical mortality (5%), and permanent minor (17%) or major (11%) deficits can also be favourably compared with other published series.^{21 23} As in all other series mortality

and morbidity increases with increasing tumour size, and especially early postoperative dysfunction is naturally correlated to older age.

Conclusions

From our own experiences and failures and the recent literature, we conclude that radical resection of petroclival meningiomas is limited or even precluded by cavernous sinus involvement and brain stem adhesion, as both situations considerably increase the risk of permanent morbidity and mortality. Because morbidity and mortality are also correlated with tumour size, surgery should not be delayed in younger patients. Older patients and those with concomitant severe general disease should only be operated on when symptomatic, as the prolonged phase of recovery increases the risk of secondary fatal complications.

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