



PETROCLIVAL MENINGIOMA

AN ATTEMPT TO DEFINE THE ROLE OF SKULL BASE APPROACHES IN THEIR SURGICAL MANAGEMENT

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BACKGROUND

Petroclival meningiomas represent a difficult surgical challenge. The introduction of modern techniques of skull base surgery has stimulated the interest of the neurosurgical community in the surgical management of these lesions, although very good results have been obtained by experienced neurosurgeons in cases of petroclival meningioma operated using traditional surgical approaches.

METHODS

Thirty-one cases of petroclival meningioma have been operated on during a 4-year period using two different philosophies as far as the approach. Group A patients (13 cases) have been operated on using mostly either a subtemporal transtentorial or a retrosigmoid approach. Group B patients (18 cases) have been managed using a lateral skull base approach, either the anterior transpetrosal or the presigmoid approach. Translabrynthine/transcochlear approaches have been used occasionally.

RESULTS

Tumor dissection and removal seemed to be easier in skull-base operated patients. However, operations take longer and surgical complications such as cerebrospinal fluid leak and hearing loss were increased. Radical tumor removal could be achieved in an equal percentage of cases of both groups (77% vs 83%). The early postoperative course was more favorable in group B patients. However, late permanent morbidity appeared to be similar in the two groups of patients.

CONCLUSIONS

Skull base approaches facilitate tumor dissection and removal at the expense of increased surgical complications. However, the widened surgical field and increased angle of approach that the techniques of skull base sur-

gery may offer can play a significant role in the removal of sizeable, infiltrative, and/or recurrent petroclival meningiomas.

KEY WORDS

Petroclival meningioma, surgical approach, skull base surgery, results of microsurgical management.

Meningiomas of the clivus have been traditionally considered an almost prohibitive surgical challenge [4,5,7,11,13,14]. The advent of microsurgical techniques has allowed some master surgeons to report very encouraging results of surgical management of these lesions [10,12,17,20]. However, until very recent years reports of operated patients harbouring these difficult meningiomas have appeared only occasionally in the literature, a fact that would indicate that these lesions were as a rule considered operable only by a limited number of very experienced and skillful neurosurgeons.

With the introduction of the techniques of skull base surgery, the number of reports of successfully operated cases of basal meningioma has increased significantly in the last years, as a result of widened indications for radical surgery of these difficult lesions [1,2,8,9,15,16,19].

However, a very recent study has emphasized that adequate experience with surgical management of these lesions, together with careful microsurgical techniques, can also allow very good results in the management of petroclival meningioma if traditional approaches are used [3].

The interest in microsurgical management of meningioma of the clivus started almost two decades ago in the Institute of Neurosurgery "N. N. Bur-

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1 Neurologic Signs at Admission

| | N. OF CASES | % |
|--------------------------|-------------|----|
| Ataxia | 27 | 87 |
| Nystagmus | 25 | 81 |
| Papilloedema | 24 | 77 |
| Cranial nerve deficit | | |
| III c.n. | 5 | 16 |
| IV c.n. | 8 | 26 |
| V c.n. | 20 | 64 |
| VI c.n. | 24 | 77 |
| VII c.n. | 18 | 58 |
| VIII c.n. | 19 | 61 |
| IX-X-XI c.n. | 10 | 32 |
| Motor deficit | | |
| Hemiparesis | 4 | 13 |
| Tetraparesis | 1 | 3 |
| Psychiatric disturbances | 3 | 10 |

denko," and a considerable number of cases had been operated on with reasonably good results before the 1990s [10]. The techniques of modern skull base approaches, recently introduced in our institution, have been used in the majority of our recently operated cases of upper- and mid-clival (petroclival) meningioma. In the same period, a similar number of patients harboring these tumors have been operated on according to our traditional philosophy as far as the surgical approach. The aim of the present study is to compare various aspects of the surgical treatment of these two groups of patients to define the actual role of modern skull base approaches in the management of these difficult meningiomas.

CLINICAL MATERIAL AND METHODS

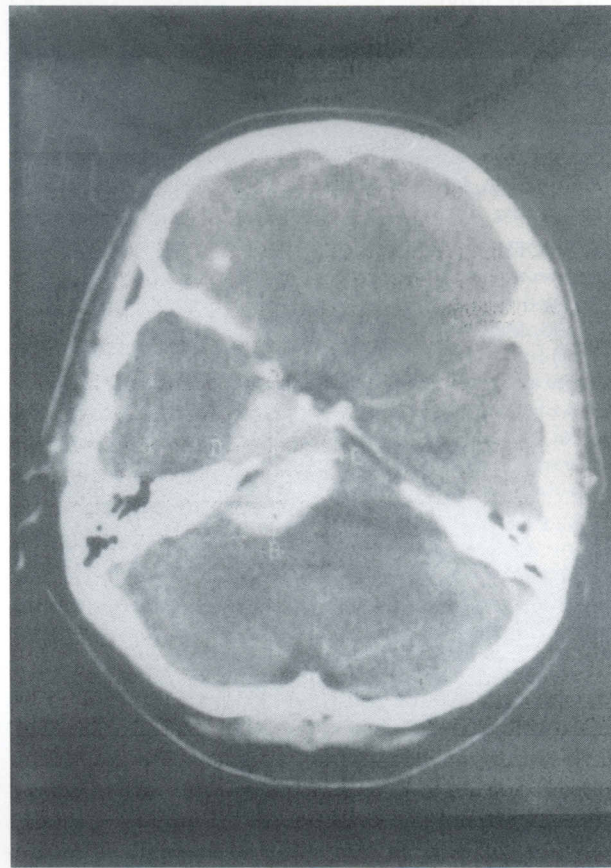
In a 4-year period from December 1990, to December 1994, 31 cases of petroclival meningioma were operated on in the Institute of Neurosurgery "N. N. Burdenko." Under this definition we included tumors located predominantly in either the upper or the mid-clivus, originating from the posterior part of the petrous pyramid anterior to the porus acusticus. These cases represented 14.9% of 208 posterior fossa meningiomas, as well as 5.3% of 585 intracranial meningiomas operated on during the same period in our institution. Six of the present patients had had previous surgeries elsewhere, usually simple exploration and/or biopsy. In only two of these cases had a partial tumor removal been accomplished at the first operation. The patients were mostly young adults (24-58 years, average 41 years) and female (22:9 F/M ratio).

CLINICAL AND RADIOLOGICAL FEATURES

The duration of the clinical history varied from 6 months to 9 years and averaged 3.2 years. Neurologic symptoms and signs were mainly ataxia, nystagmus, and cranial nerve palsy (Table 1). Papilloedema, as a rule in a mild form, was detected in the majority of the present cases, whereas significant motor weakness affected only a minority of patients.

All present cases underwent angiography and computed tomography (CT) scanning, and 23 patients also underwent magnetic resonance imaging (MRI) examination.

CT and MRI accurately predicted tumor size and actual location (see below). They also helped predict the consistency of the tumors, because a round-shaped lesion with relatively little dural attachment (Figure 1) as a rule indicated a tumor of soft consistency.



1 Post-contrast CT scanning demonstrates a lesion with sharply demarcated margin and relatively limited dural attachment. This tumor was radically removed via an anterior transpetrosal approach and found at surgery to be of relatively soft consistency.

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2 Approaches in Group A Patients

| | |
|--|---|
| Retrosigmoid | 6 |
| Subtemporal transtentorial | 4 |
| Combined subtemporal-subtentorial-retrosigmoid | 2 |
| Pterional | 1 |

STUDY GROUPS

For the purpose of the present study, the patients were divided into two groups: A—13 cases operated on using “traditional” approaches (Table 2); B—18 cases operated on using modern skull base approaches (Table 3).

Locations of the tumors (Table 4) were similar in the two groups of patients. Larger lesions were overrepresented in Group B, although the difference in the sizes of the tumors did not reach statistical significance. Eight patients (26%), three in Group A and five in Group B, respectively, showed an angiographic contribution of the vertebrobasilar system to the tumor vascularization. Seven of these cases showed features of peritumoral edema on CT and/or MRI scanning (Figure 2).

Group A patients were operated on mostly, but not exclusively, in the first 2 years of this study. Skull base approaches were used mostly, but not exclusively later on during the study period. Other than the individual surgeon’s preference and the obvious preference for more modern approaches in the more recent years, no definite factors significantly influenced the choice of one approach instead of the other. The demanding skull base approaches were as a rule performed by surgeons with adequate laboratory training and experience with these approaches. The main part of the operation, i.e., microsurgical tumor removal, was also always performed by neurosurgeons with great experience with microsurgical basal tumor removal.

CHOICE OF SURGICAL APPROACH

For Group A patients, tumor location dictated the choice between a subtemporal transtentorial approach, and a subtentorial retrosigmoid approach (Table 2). Very large lesions were managed using a combined subtemporal-retrosigmoid approach,

3 Skull Base Approaches in Group B Patients

| | |
|--------------------------------|---|
| Anterior transpetrosal | 5 |
| Retrolabyrinthine presigmoid | 7 |
| Retrolabyrinthine transsigmoid | 2 |
| Translabyrinthine | 3 |
| Subtotal petrosectomy | 1 |

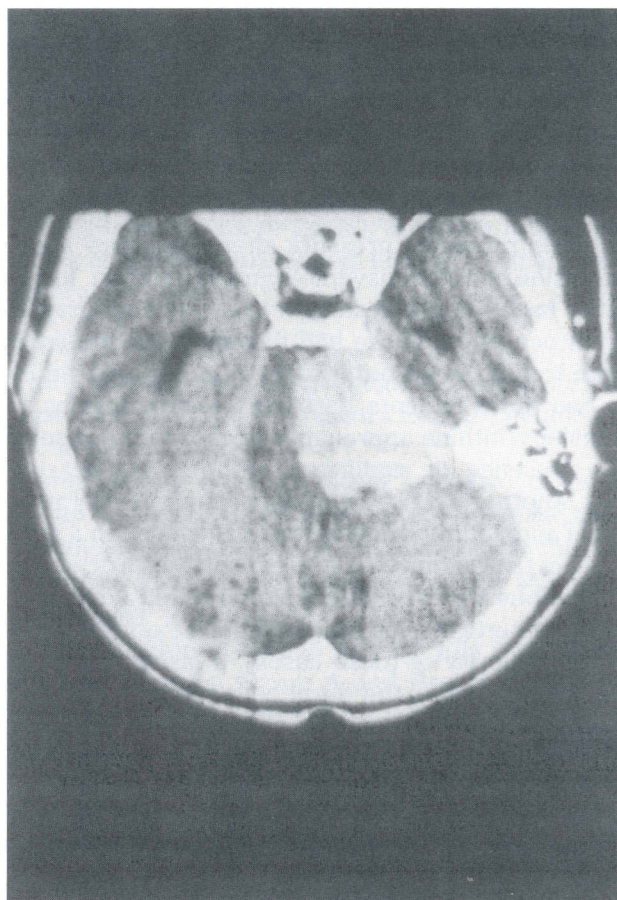
4 Location of Meningiomas

| LOCATION | NO. OF CASES | % |
|----------------------------|--------------|-----|
| Upper third of the clivus | 22 | 71 |
| Invading the CS | 4 | 13 |
| Middle third of the clivus | 9 | 29 |
| Total | 31 | 100 |

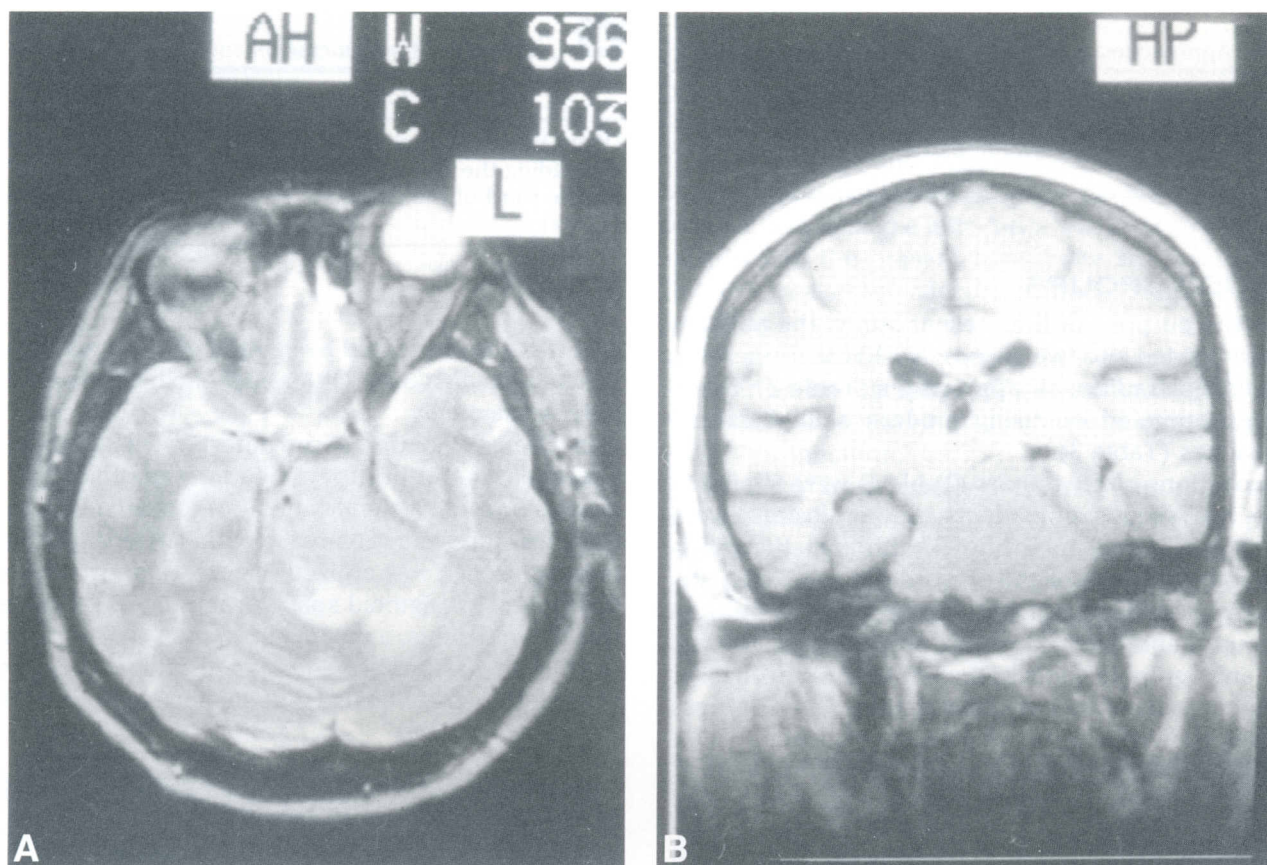
CS, cavernous sinus.

that was supplemented by ligation of the transverse sinus in one instance. Other approaches were used only occasionally.

In Group B patients, an anterior transpetrosal approach via an orbitozygomatic craniotomy [18] was preferred if a significant supratentorial component was present (Figure 3). Otherwise a presigmoid approach was utilized (Figure 4). In two cases the limited presigmoid space prompted us to ligate the sigmoid sinus, a maneuver that as a rule in our institution was performed only after intraoperative verification of the absence of significant variations



2 CT scanning of an infiltrative petroclival meningioma showing peritumoral edema. The tumor was subtotally removed via a retrosigmoid approach.



3 Axial (A) and coronal (B) MRI of a petroclival meningioma with significant supratentorial component. This tumor was operated through an anterior transpetrosal approach.

in the intraluminal pressure after temporary sinus occlusion at the transverse-sigmoid junction. In another instance, the results of this test discouraged sinus occlusion, so we had to turn down the labyrinth to gain space anteriorly to the sigmoid sinus. In two more patients harboring sizable lesions, a translabyrinthine approach was chosen because of the presence of significant preoperative hearing loss. Another case showing significant preoperative facial and auditory deficit was managed with a subtotal petrosectomy. At the end of the procedure, meticulous attention was devoted to dural closure. When watertight closure could not be obtained (as in the majority of these cases), a fascia lata graft was placed under the dural edges to which it was attached with some stitches. Small pieces (approximately 0.5×3 cm) of fat grafts were placed over the dural opening as well as in the opened air cells. Great care was taken in the reconstruction of muscular and fascial layers. Fibrin glue was never used. Cerebrospinal fluid (CSF) drainage for the first postoperative days (average, 5 days) was routine, as was peri- and early postoperative antibiotic coverage.

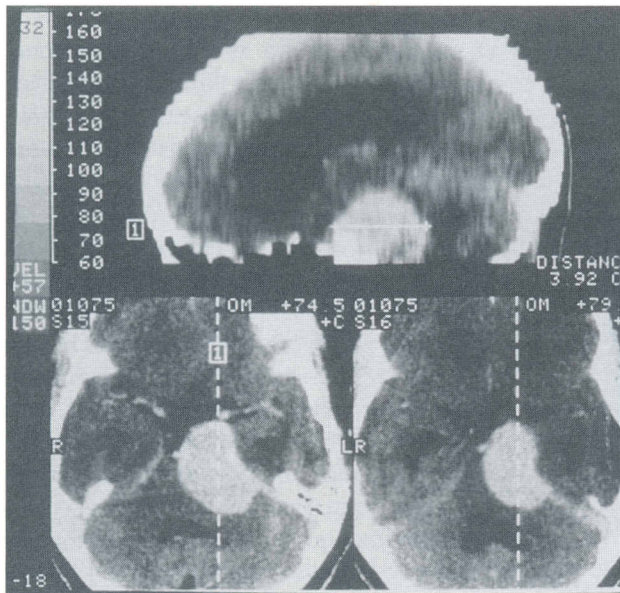
DATA EVALUATION

For the comparison of the two groups of present patients, the following data were considered: duration of operation; intraoperative blood loss; intraoperative injuries of vessels and nerves; degree of tumor removal; reasons for incomplete removal; histology; postoperative mortality; duration of stay in intensive care unit (ICU) after surgery; early postoperative morbidity; CSF leak; postoperative infections; pre-, early, and late postoperative Karnofsky score variations. In the present cases, follow-up ranged from 18 months to 5.5 years and averaged 2.8 years. For the reasons explained before, follow-up was longer in Group A patients (mean, 3.2 vs. 2 years), although the difference did not reach statistical significance.

RESULTS

PRE- AND INTRAOPERATIVE FEATURES

Duration of surgery was, as expected, longer in Group B patients (5 ± 2.3 vs 7 ± 2.9 hours). Intra-



4 Post-contrast CT scanning of a huge, predominantly subtentorial petroclival tumor that was eradicated using a presigmoid approach.

operative blood loss did not vary significantly between the two groups (360 ± 90 vs 400 ± 100 ml).

Intraoperative anatomical interruption of cranial nerves occurred in two cases in each group (difference not significant). In two cases the lesion concerned the VI nerve, while the facial nerve was involved in the remaining two cases.

Intraoperative injury of major intracranial vessels did not occur in any of the present cases.

DEGREE OF TUMOR REMOVAL

Early postoperative CT scanning was routinely performed in these cases. The results of this examination as a rule matched the impression of the operating surgeon as far as tumor removal.

Total removal could be accomplished in 10 cases in Group A and 15 cases in Group B (difference not significant). The reasons for incomplete removal in the remaining six cases, three in each group (in all of which the tumors were of significant size), included infiltrative character with invasion of the brainstem in all, invasion of the cavernous sinus in four of them, extensive dural attachment, and hard consistency ("en plaque" meningioma) in four cases.

HISTOLOGY

Twelve cases were classified as fibroblastic meningiomas, whereas the remaining 19 were either endotheliomatous (13 cases) or transitional (six cases) meningiomas. These latter histological sub-

types as a rule had a softer consistency than the former ones. Groups A and B did not show a significant difference as far as the incidence of the histological subtypes of the tumors. Fibroblastic meningiomas represented the vast majority of the "en plaque" lesions in the present series (five out of the total 6 cases). This group of tumors represented a particularly difficult surgical task, and total removal could be achieved in only two instances (33%).

POSTOPERATIVE RESULTS

MORTALITY

One Group A patient died after incomplete removal of a large infiltrative meningioma in which a suboccipital approach was used. Another patient died in a nursing home 5 months after subtotal removal of a large recurrent lesion using a combined subtemporal-retrosigmoid approach. His Karnofsky scale score had decreased from 70 preoperative to 40 postoperative, and he never showed a significant improvement thereafter (Figure 5). No mortality occurred in group B patients.

POSTOPERATIVE COMPLICATIONS

Significant deep wound infections did not occur in the present cases. Not unexpectedly, postoperative CSF leak occurred more frequently in Group B patients ($3/18$ vs $1/13$, $p < 0.05$); however, it resolved in all cases with prolonged lumbar drainage and bed rest.

CLINICAL RESULTS

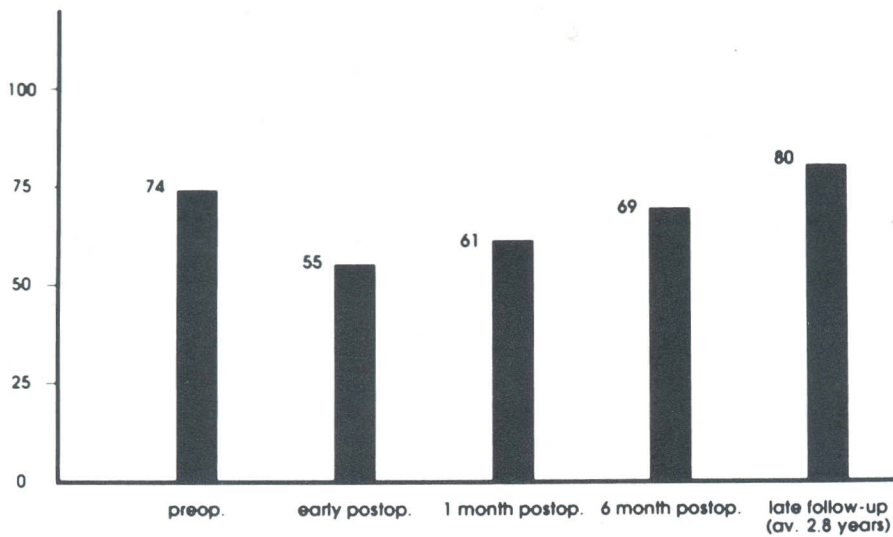
The characteristics of neurologic deficits occurring postoperatively in the present cases are detailed in Table 5.

Immediately after operation only two cases in Group A and six in Group B did not decrease their neurologic performances as compared with the preoperative level. The difference reaches statistical significance ($p < 0.005$).

The duration of stay in the ICU was statistically different between Group A and Group B patients, and shorter in the latter (2.2 ± 0.8 days vs 5.6 ± 1.8 days, $p < 0.005$).

However at the late follow-up permanent postoperative deficits appeared to be present in six cases in both groups (difference not significant). Figure 5 summarizes the changes in the Karnofsky scale scores in the present patients.

Symptomatic recurrences were not observed during the admittedly limited follow-up period.



5 Dynamics of Karnofsky scale score in present patients.

0 - 100: average Karnofsky scale

DISCUSSION

SURGICAL APPROACH FOR PETROCLIVAL MENINGIOMAS

The results of surgical management of petroclival meningioma were disastrous before 1970 [5]. The advent of microsurgical techniques has rendered these difficult lesions fairly operable in very experienced hands [8,10,12,20]. However, it was only after the introduction of modern approaches to the lateral skull base that the neurosurgical community has deemed these lesions operable with reasonably good results. However, also recently, recognized authorities have stressed that petroclival meningiomas can be operated on successfully with tradi-

tional (mostly retromastoid) surgical approaches [3]. Therefore, the advantages of the skull base approaches—widened surgical field and shortened working distance—should be balanced against their obvious shortcomings: long operative time, morbidity of the approach itself, and the need for extensive supplementary training in the laboratory.

PHILOSOPHY AND METHODOLOGY OF THE PRESENT STUDY

In the limited number of papers devoted to this subject that have appeared in the literature, a comparison between patients operated on for the pathology in point using different approaches has never been made. Several reasons can explain this;

5 Postoperative Deficits

| DEFICIT | GROUP A | | GROUP B | | STATISTICAL DIFFERENCE |
|----------------|--------------------|---------------------|--------------------|---------------------|------------------------|
| | TOTAL NO. OF CASES | TEMPORARY WORSENING | TOTAL NO. OF CASES | TEMPORARY WORSENING | |
| c.n. IV | 2 | 2 | 4 | 4 | NS |
| c.n. V | 6 | 6 | 3 | 3 | $p < 0.05$ |
| c.n. VI | 3* | 2 | 6* | 5 | NS |
| c.n. VII | 6* | 3 | 10* | 7 | NS |
| c.n. VIII | 3 | 2 | 9** | 5 | $p < 0.05$ |
| c.n. IX, X, XI | 3 | — | — | — | |
| Hemiparesis | 1 | 0 | 2 | 1 | NS |
| Ataxia | 7 | 5 | 0 | 0 | $p < 0.001$ |

c.n., cranial nerve.

*. Intraoperative section in one case of each subgroup.

**., In four cases a permanent postoperative deficit resulted from the approach chosen. Hearing was either absent or reduced in three of them.

NS, not significant.

mostly the rarity of these lesions and the consequent small number of individual surgical series limits the possibility of a comparative study.

We have already mentioned that the longtime interest in surgical management of petroclival meningioma, as well as the peculiar referral pattern of the "Burdenko" Institute, enabled us to collect a significant number of these cases in a relatively short period.

In the first part of this period, some patients were treated using widened skull base approaches, usually an extension of the retromastoid approach: presigmoid, translabyrinthine, transcochlear. The presence of already compromised cochlear-vestibular function was the usual reason for this choice. Unavoidably, skull base approaches were used more extensively in the more recent cases, when experience with the approach itself had significantly decreased the risk of complications. This fact has undoubtedly created a bias in the present study. However, other key prognostic factors, such as size, consistency, and vascularity of the lesions and incidence of infiltrative tumors [17], were equally distributed in both groups of patients, and surgical tactics and the experience of the operating surgeons did not differ except, obviously, for the approach itself.

INTRAOPERATIVE OBSERVATIONS AND POSTOPERATIVE RESULTS

As expected, skull base procedures required a longer operative time. However, patients operated on using these approaches had a shorter stay in the ICU after surgery, and exhibited a generally more favorable early postoperative course.

Interestingly, we observed a significantly increased incidence of postoperative, mostly temporary, trigeminal loss in traditionally operated patients, for which we have no clear explanation. Perhaps the tentorial cut required for removing petroclival meningioma using the subtemporal approach, which we perform close to the trigeminal porus, and the required manipulations of the nerve during the dissection of the tumor, may have been the cause. However, we did not observe instances of intraoperative lesions of the V nerve, a fact that explains the recovery of postoperative deficit that usually occurred in the present cases.

A widened approach did not increase the radicality of tumor removal, which was ultimately related to the character—whether infiltrative or not—of the lesions. Infiltrative lesions oc-

with brainstem invasion and/or cranial nerve encasement, to invasion of the cavernous sinus, and to intraoperative difficulties, did not appear to have been influenced by the type of approach.

CHOICE OF APPROACH FOR PETROCLIVAL MENINGIOMA

Small tumors do not seem to require a skull-base approach. Medium- and large-sized petroclival meningiomas probably do, although the present study failed to show any significant difference in the results other than a more favorable early postoperative course. Large "en plaque" petroclival meningiomas might benefit from a wider approach; however, total removal would remain a formidable task anyway. Couldwell et al [6] have recently stressed that the age of the patients should be a major factor of consideration in deciding if, when, and how to operate on a petroclival meningioma. The mean age of our patients seemed to be somewhat lower than other series [6,12,17,20]. However we have no reservations in operating on elderly patients harbouring symptomatic skull base meningiomas, provided that their general clinical condition does not contraindicate a major neurosurgical procedure.

CONCLUSIONS

Skull base approaches have improved early but late postoperative results in our experience. Microsurgical dissection seemed to be easier in patients in whom a skull-base approach was used, at expense of longer operative time and increased surgical complications such as CSF leak and postoperative hearing loss.

Permanent morbidity and radicality of tumor removal did not appear to be related to the type of approach.

In general, this study would suggest the choice of the type of approach should be left to the individual surgeon, who should take into consideration his versatility and experience with microsurgical skull-base tumor dissection and removal, as well as with lateral skull-base approaches. The choice should ultimately follow his personal preference.

Nevertheless, we believe that skull-base approaches are definitely indicated for sizable tumors, especially for recurrent and/or infiltrative

Dr. Spallone was visiting Professor at the Institute "N. N. Burdenko", in the years 1993-1994, when the present study was conceived and started.

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COMMENTARY

This is an excellent report by Spallone et al in which they have compared the results of the so-called "traditional" approaches with those of skull base approaches in the resection of petroclival meningiomas. In a retrospective study like this, there is bound to be selection bias. They show that the long-term results as far as degree of resection and patient function are the same in both groups. The cases done via skull base approaches took longer and had a slightly higher incidence of postoperative CSF leaks, but none required re-exploration.

The main advantages of using the skull base approaches for such deep-seated tumors are:

1. The access is wider, which definitely facilitates tumor removal, especially in larger tumors when working on the far end of the tumor at great depth;
2. The amount of cerebellar and temporal lobe retraction is greatly reduced, which makes the immediate postoperative course smoother and avoids retraction-related complications;
3. The angle of visualization of the tumor/brain-stem interface is better because of the more lateral perspective, which facilitates the most important part of the dissection—from the brain-stem and the vessels.

It is rightfully pointed out that the skull base approach is only a means of getting to the tumor. Nevertheless, it is an important tool in the management of these difficult tumors. Exquisite microsurgical skills and judgement are required for their successful resection and a good outcome. The surgeon's experience and degree of comfort with the procedure will dictate the selection of an approach and the results he obtains.

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I think this article is an interesting contribution to the management strategy for this risky tumor group. These benign tumors were considered inoperable, at least in regard to total removal with satisfactory outcome, until the introduction of microsurgical techniques and the description of microsurgical anatomy. We all know from our own experience in skull base surgery that we have become more aggressive, with less risk, with the increasing knowledge of the specific anatomy of the posterior fossa, the tentorial notch, and the cavernous sinus over the last 20 years. Neuroradiologic techniques for preoperative diagnosis improved, as did neurosurgical anaesthesiology, enabling us to introduce new or modified approaches to the petroclival region, as well as to change the strategy according to personal preference. We learned from each other, like Dr. Spallone and his colleagues at the Burdenko Institute. Therefore, their analysis of their strategy and early results in the remarkably large number (31) of patients operated on over 4 years is interesting.

The cases discussed in this report represent 14.9% of 208 posterior fossa meningiomas and 5.3% of 585 intracranial meningiomas operated in that 4-year period. Samii and Tatagiba reported 36 cases that were operated within 12 years [1], representing 30% of a total of the 284 skull base meningiomas operated during that period. Spallone et al discuss their results with respect to the different approaches they used; the preservation of adjacent cranial nerves and vascular structures and tumor infiltration of the pia mater at the brain stem are important limitations.

From my own experience in this field, going back to my time with Madjid Samii, I believe these dangerous tumours demand the most experienced and skillful neurosurgeon on the team in order to obtain

the best results in regard to degree of tumor removal, perioperative morbidity, final outcome, and quality of life. Dr. Spallone's neurosurgery division and the N. N. Burdenko Institute of Neurosurgery are well-known departments with highly qualified neurosurgeons. However, it seems worthy to note that there have been some (how many?) neurosurgeons at Burdenko who performed the operations using different approaches within the same time period, but there is no explanation in the paper for their different operative strategies or the philosophy behind them. The authors did not make it clear why they decided on this or that approach in Groups A and B, which I would have related to the location and size of the meningioma and the adjacent structures. Therefore, I cannot understand why they chose a skull base approach, sacrificing the cochlear nerve, in three cases that had preserved hearing preoperatively.

Because some interesting papers on this topic have been reported in the last few years, with increasing numbers of patients and improvements in microsurgical techniques and operative results, the authors should draw their final conclusions from their own management of petroclival meningiomas, on the basis of their very good early results in this difficult-to-manage group of tumors.

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