Basal Meningioma, Diagnostic and Therapeutic Considerations

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Summary

Fifty cases of basal meningioma, consisting of olfactory groove, tuberculum sellae, middle fossa and sphenoidal ridge meningiomas, were subjected to study on operative gradings and factors influencing surgical limits. Complete resection of basal meningiomas was restricted owing to firm tumorous adhesion to the major vessels at the base of the skull. From the analysis of angiographical findings, it was found that irregular narrowing of the trunks of cerebral arteries as well as dissociation or narrowing at the distal portion of cerebral arteries constitutes convincible figures indicating complete resection as impossible.

Existence of extradural invasion of the tumor composed another cause of surgical incompleteness. Transbasal approach was available employed for removing such extradural extension. This approach can be applied not only for total removal of the lesion in focal bony invasion but also for relieving visual problems and advancing exophthalmos in cases with wide-spread osseous invasion.

Keywords: Basal meningioma, angiography, vascular narrowing, extradural invasion, computed tomography, transbasal approach

Introduction

Intracranial meningioma is regarded as usually favorable in its postoperative outcome because of the benign biological behavior. In neurological practice, however, it is found that approximately 40% of intracranial meningiomas are seated at the basal portion of the cranium and complete resection is restricted owing to tumorous adhesion to the major cerebral arteries. Further, these basal meningiomas often accompany osseous invasion at the base of the skull, which not only makes radical operation difficult but also brings serious problems due to tumor extension into the orbit, the paranasal sinuses, and the optic canals as well as into the neighboring bones. Several trials have been made to remove the tumor invading the basal portions of the skull. Recently, Derome described favorable results obtained by the application of a transbasal approach to such extradural invasion of various types of tumor.

In the present report, study of the factors influencing surgical performance in cases of basal meningioma is attempted. Primary attention is paid to the analysis of angiographic figures related to operative limits and, further, to the therapeutic significance of transbasal approaches in treating bony invasion associated with basal meningiomas.

Clinical Materials

Fifty cases of basal meningiomas were subjected to the present study, out of a series of 148 intracranial meningiomas operated on at the Nagoya University Hospital during the period from 1955 to 1978. The 50 cases include meningiomas located at the olfactory groove (14 cases), the tuberculum sellae (9 cases), the base of middle cranial fossa (3 cases) and the sphenoidal ridge (24 cases). Age distribution
ranged from 21 to 72 years old (average age: 43.5) and the sex ratio was 1:1.38 with 21 males and 29 females.

According to Simpson’s classification,20) surgical procedures were divided into following categories; complete resection of the tumor, including removal of the dural attachment and the invaded bones adjacent to the tumor (Grade I); total removal of the tumor and its visible extentions, with endotermy coagulation of its dural attachment (Grade II); macroscopically total removal of the intradural tumor, without resection or coagulation of its dural attachment, or alternatively, of its extradural extensions (Grade III); partial removal, leaving intradural tumor in situ (Grade IV); and simple decompression, with or without biopsy (Grade V). As we had only a single case of Grade V in the present series, it was included in Grade IV, and operative procedures were classified into four grades for practical purposes of the comparative study.

Results

1. Operative results
Operative results of basal meningioma in this series are summarized in Table 1. Grade I operation covers 9 cases (18%) and, even by including 15 cases (30%) of Grade II operation, total removal of the tumor in a broad sense was 48%. Surgical results improved in cases operated on from 1975 to 1978, in which the microsurgical technique was routinely employed for intentional active approach. Although the rate of total removal of Grades I and II consistently rose and reached 69% (11 out 16 cases) in a more recent series, operative cases of around 30% still remained in the category of incomplete removal of Grades III and IV. No significant correlation was noticed between the histological types of meningioma and the operative grades attained.

From the analysis of the incomplete removal cases, tumor adhesion to the major cerebral arteries and extension of bony invasion at the base of the skull were found to compose the two main factors affecting the performance of radical operation in basal meningioma.

2. Angiographic features related to operative results
All angiograms were retrospectively re-examined. Angiographic features of the major cerebral arteries and their branches adjacent to, or, in the tumor were divided into following four patterns: Type 1: simple displacement of the major cerebral arteries without vascular narrowing (35 cases); Type 2: displacement of the major cerebral arteries with smooth narrowing of the lumen, including the tapered deformation (8 cases); Type 3: narrowing or occlusion of the major cerebral arteries with luminal irregularity (4 cases); and Type 4: marked dissociation and/or narrowing of the vessels at the distal portions of the cerebral arteries (3 cases).

Lysis of the vessels from the tumor tissue was possible in more than 70% of the Type 1 cases. Even in Type 2 showing smooth narrowing of the compressed or embedded vessels, half of the affected vessels could be dissected from the tumor. On the other hand, no total removal of the basal meningiomas was attained in all 4 Type 3 instances, in which an irregular narrowing of the major cerebral arteries was angiographically noticed. Fig. 1 shows an example of the meningioma seated at the base of middle cranial fossa, in which tumor removal had to be restricted only to partial resection owing to the wide-spread extension of the meningioma and the firm adhesion to the internal carotid artery. Such arterial narrowing with irregularity was

<table>
<thead>
<tr>
<th>Grades of operation</th>
<th>Olfactory groove</th>
<th>Tuberculum sellae planum sphenoidale</th>
<th>Middle fossa</th>
<th>Sphenoidal ridge</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>4</td>
<td>4</td>
<td>0</td>
<td>1</td>
<td>9(18%)</td>
</tr>
<tr>
<td>II</td>
<td>5</td>
<td>2</td>
<td>0</td>
<td>8</td>
<td>15(30%)</td>
</tr>
<tr>
<td>III</td>
<td>3</td>
<td>3</td>
<td>1</td>
<td>9</td>
<td>16(32%)</td>
</tr>
<tr>
<td>IV</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td>6</td>
<td>10(20%)</td>
</tr>
<tr>
<td></td>
<td>14</td>
<td>9</td>
<td>3</td>
<td>24</td>
<td>50</td>
</tr>
</tbody>
</table>
considered as a critical feature in indicating that complete resection was impossible. In addition to such signs of firm tumor adhesion to the trunks of cerebral arteries, marked dissociation of vessels as well as vascular narrowing, even of smooth narrowing in form, at the distal portions of the cerebral arteries or at their branches were found to compose critical features against total resection. Complete resection was not possible in all of the 3 Type 4 instances. Fig. 2 shows angiograms, showing marked dissociation of bilateral A2 portions as well as an elevation of A1 portions in a meningioma arising from the planum sphenoidale. Total resection of the meningioma was abandoned because of the difficulty in dissecting vessels and the risk of vessel-damage at the distal parts of anterior cerebral arteries. Fig. 3 shows another example of incomplete resection of a meningioma. The unilateral M1 portion is elevated to a high degree on the affected side by an expansion of a right sphenoidal ridge meningioma. At the beginning of the M2 portion, moreover, the vessel is markedly narrowed. It was impossible to make lysis at the trifurcation due to fibrous adhesion. As indicated in these findings, angiographical abnormalities at the distal parts of the cerebral arteries, such as vascular dissociation and narrowing, are also regarded to constitute critical features in evaluating the possibility of complete resection.

3. Extradural tumor invasion and operative results

Bony invasion of meningioma at the base of the skull posed another series of problems in achieving radical operation. On plain craniogram or polytomogram, hyperostotic and destructive changes of the neighboring bones were observed in 38 of the 50 cases, or 76%. Besides conventional tomography, computed axial tomography (CT) was employed for examining changes at the base of the skull in the recent series.

Transbasal approach was aimed at removing these osseous invasions in the recent series from 1975. Table 2 shows a summary of 9 cases, in which active surgical interventions for the bony invasion of basal meningioma were performed. These bony invasions were divided into two principal groups by the extent of osseous invasion; i.e., focal one (4 cases) and widespread group (5 cases). Good operative results were obtained in the focal bony invasion group. Except for a case of Grade II operation, in which postoperative cerebrospinal rhinorrhea occurred and it was repaired by a second operation, complete removal of the tumor was performed in the other 3 cases without any postoperative complications.

Serious problems in treatment were encountered in the cases where the bony invasion extended from the base of the skull and, further, widely to the orbit and the paranasal sinuses.
Fig. 2 Right carotid angiograms of a meningioma arising from the planum sphenoidale. Bilateral A₁ portions are markedly elevated. Note the dissociation of anterior cerebral arteries at the A₂ portion.

Fig. 3 Right carotid angiograms of a sphenoidal ridge meningioma. Right M₁ portion is markedly elevated. Note the narrowing at the beginning of the M₂ portion.

No instance of complete resection of Grade I was attained in the group of extensive bony invasion. There were 3 cases of Grade II and 2 cases in Grade III in operative grades. Despite such difficulty in radical operation, progression in serious complaints of patients, such as the hazard of loss of vision or advance in exophthalmos, were avoided through active transbasal approach. Two cases of extensive extradural invasion are described in the following.

K. Y. (Case 5): This 52-year-old man complained of a one year history of headache and right orbital pain. On July 29, 1970, he had undergone craniotomy for a right sphenoidal ridge meningioma and the intradural mass was totally removed. Three years later, he noticed a gradual progression of right exophthalmos and hypesthesia on the right forehead. Upon the second admission, the tumor was found to extend not only to right middle cranial fossa but also into the right orbit and sphenoidal bones. In addition to the removal of the recurrent intradural tumor, the invaded sphenoid wing and intraorbital mass were removed on November 20, 1975, which succeeded in improvement of the exophthalmos. The third admission occurred 2 years later, when the patient complained of a decrease in visual acuity of both eyes. There were no signs of reextension of the intradural tumor. The tumor extended from the base of anterior cranial fossa to the body of the clivus, involving the ethmoid cells and the sphenoidal sinus and, furthermore, bulging into the epipharynx (Fig. 4). CT revealed a large nasopharyngeal mass.
Table 2 Summary of cases with extradural invasion of basal meningioma

<table>
<thead>
<tr>
<th>Patient</th>
<th>Age</th>
<th>Sex</th>
<th>Site</th>
<th>Extent of invasion</th>
<th>Grades of operation</th>
<th>Complication</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. T.M.</td>
<td>62</td>
<td>F</td>
<td>Planum sphenoidale</td>
<td>Planum sphenoidale</td>
<td>II</td>
<td>CSF-fistula</td>
</tr>
<tr>
<td>2. T.T.</td>
<td>37</td>
<td>M</td>
<td>Olfactory groove</td>
<td>Roof of ethmoid</td>
<td>I</td>
<td>—</td>
</tr>
<tr>
<td>3. K.A.</td>
<td>64</td>
<td>F</td>
<td>Olfactory groove</td>
<td>Roof of ethmoid</td>
<td>I</td>
<td>—</td>
</tr>
<tr>
<td>4. Y.M.</td>
<td>23</td>
<td>M</td>
<td>Right sphenoidal ridge</td>
<td>Right sphenoid wing</td>
<td>I</td>
<td>—</td>
</tr>
<tr>
<td>5. K.Y.</td>
<td>52</td>
<td>M</td>
<td>Right sphenoidal ridge</td>
<td>Right sphenoid wing, tuberculum sellae, right orbit, ethmoid cells, sphenoidal sinus, epipharynx</td>
<td>III</td>
<td>Emotional disturbance</td>
</tr>
<tr>
<td>6. S.I.</td>
<td>69</td>
<td>M</td>
<td>Right sphenoidal ridge</td>
<td>Right sphenoid wing, right orbit</td>
<td>II</td>
<td>—</td>
</tr>
<tr>
<td>7. E.E.</td>
<td>55</td>
<td>M</td>
<td>Right sphenoidal ridge</td>
<td>Right sphenoid wing, right orbit</td>
<td>II</td>
<td>—</td>
</tr>
<tr>
<td>8. A.Y.</td>
<td>53</td>
<td>F</td>
<td>Left sphenoidal ridge</td>
<td>Left sphenoid wing, left orbit, sphenoidal sinus</td>
<td>III</td>
<td>—</td>
</tr>
<tr>
<td>9. K.O.</td>
<td>37</td>
<td>F</td>
<td>Left sphenoidal ridge</td>
<td>Left sphenoid wing, tuberculum sellae, left orbit, ethmoid cells, sphenoidal sinus</td>
<td>II</td>
<td>—</td>
</tr>
</tbody>
</table>

Fig. 4 Case 5. Lateral tomogram on midline and lateral view of right carotid angiogram. The recurrent sphenoidal ridge meningioma erodes bony structures of the anterior fossa, sellar region and body of the clivus, further bulging into the nasal cavity and epipharynx (left). This tumor spread mainly extradural being fed by the internal maxillary artery (right).

(Fig. 5). At surgery visual acuity of the patient was reduced to 0.07 and 0.08 on right and left, respectively. On November 17, 1977, the third surgery was performed with the main purpose of relieving his visual problem. Together with partial removal of the tumor involving the skull base, decompression of both optic canals as well as wider orbital unroofing with removal of postero-lateral walls of the orbit was carried out through the transbasal approach. After freeing both optic nerves, the dura was repaired with the fascia lata and the cranial periosteum. Five weeks later, tumor tissues remaining in the maxillary sinus and the sphenoidal sinus
were removed by means of transnasal approach. No postoperative cerebrospinal fluid leakage was noted. Visual acuity of this patient has been well preserved until today, 1 1/2 years following the operation.

K. O. (Case 9): This previously healthy 37-year-old woman started having left-side blurred vision 1 year before the first admission. On February 12, 1974, she was craniostomised and a left sphenoidal ridge meningioma was removed. Half year after the surgery, she noted progression of exophthalmos and reduction in visual acuity on the lesion side. On the second admission in 1976, the patient showed a marked exophthalmos caused by intraorbital invasion of the tumor (Fig. 6). On December 14, 1976, together with the intradurally recurring tumor, the orbital mass was removed through orbital unroofing, and postoperatively she showed considerable improvement of the exophthalmos. The patient then received a course of irradiation with a total dose of 5,100 rads. One and a half years later, however, her exophthalmos progressed again. The extent of the extradural tumor was found to have spread more widely from the base of the left middle cranial fossa to the left sphenoid wing, involving the ethmoid.

Fig. 5 Case 5. Tumor extent shown on CT. The meningioma involves right sphenoideal bones, the posterior ethmoid and the sphenoidal sinus (left), and it extends into the nasopharyngeal region, forming a huge mass on the side of the lesion (right).

Fig. 6 Case 9. Unilateral exophthalmos caused by orbital invasion of left sphenoidal ridge meningioma.
cells and the sphenoidal sinus as well as the left orbit (Fig. 7). There was a fear of bilateral visual loss. On September 25, 1978, more extensive transbasal surgery with orbital exenteration was performed to remove the intraorbital mass, the invaded periorbital structures, and the sphenoidal bones. The planum sphenoidale involved was also opened and tumors in the ethmoid cells and the sphenoidal sinus were extirpated. The cavities were packed with fragments of the iliac bone and covered with the fascia lata. The postoperative course was satisfactory without leakage and infection. Visual acuity contralateral to the side of lesion has been kept normal and no sign of recurring tumor has been noticed till today.

Discussion

Total resection in basal meningiomas was limited to a considerably low rate, being less than 50% in the present series, or, around 70% even in the more recently treated cases. This shows a clear contrast to the high rate of total removal (87%) in the meningiomas located adjacent to the cranial vault, including convexity, parasagittal and falcine meningiomas.8) As described in the present results, difficulties in surgical resection of basal meningiomas are, primarily, based on the immediate adhesion of the basal tumor to the cerebral arteries and their main branches.

Vascular changes associated with meningioma have been noticed as a sign of its direct involvement.4,11,15,19,22) Among the various types of brain tumor, meningioma is regarded as the most common tumor that brings vascular deformation, such as narrowing and occlusion of the vessels. According to Momose and New,17) narrowing or occlusion of the major cerebral arteries was noticed in 5.3% of their total cases of intracranial meningioma. Such vascular alteration likely appears more frequently in meningiomas seated at the base of the skull. Bradac1) mentioned that direct involvement of the vessel wall observed on angiograms appeared in 30% of all brain tumors seated at the base of the anterior and middle cranial fossae and that these vascular abnormalities were found most commonly in basal meningioma, occurring in 7 out of 13 cases. Among these reports in the literature, however, little attention has been paid to angiographic features relating to the criterion of operative limits. As stated in this report, irregular narrowing of the major cerebral arteries on angiogram appears to be a convincible criteria indicating that complete resection of the tumor is impossible. Such irregular deformation of the larger arteries might be caused by advanced adhesion or immediate invasion of meningioma upon the vessels. Moreover, narrowing and dissociation of vessels at the distal portions of the cerebral arteries
were found also to compose critical features indicating tremendous difficulties in total resection. Under the situation of marked vascular alteration at the distal portions, it is convincing that practical procedures of vessel dissection will inevitably face much difficulty owing to the thinner walls of these distal vessels with the subsequent risk of vessel damage.

Extradural extension of basal meningioma constitutes another principal cause of therapeutic difficulty. Intraosseous invasion of basal meningioma has been noted as difficult to cure when it spreads widely. With regard to bone changes associated with basal meningioma, a considerably high incidence of roentgenological abnormalities ranging from 50 to 85% has been mentioned in the literature. In the present series, hyperostotic and destructive bone changes in the vicinity of the tumors reached 76%. As mentioned in our previous paper, such abnormal bones were found usually to be invaded by tumor cells which play an important role in recurrences.

Recently CT has been utilized as a diagnostic aid for these bone changes. A new generation of CT scanners makes the study of the structures at the base of the skull possible, though there are still some limitations. Fine details of bone structure and its pathology were better or only observable by conventional tomography. On the other hand, soft tissue detail is more clearly visible by CT than by conventional tomography. This property of CT offers a great advantage in determining the spread of tumors into the orbit and the paranasal sinuses, the information on which was absolutely needed for surgery. We feel that the special value of CT lies in the visualization of the exact extent of tumor invasion at the skull base and the relations between intra- and extradural mass.

Transbasal approach described by Derome was applied for the treatment of these extradural invasions. Total removal of the osseous invasion, together with the resection of intradural tumor, was made in all instances of focal bony invasion. When the base of skull and the facial bones were widely involved, complete removal still remained difficult depending on the spread of the accompanied extradural invasion. Even in such cases of wide-spread invasion, however, serious symptoms, such as marked exophthalmos and visual disturbances, could be improved. The great advantage of this approach consists in its extensive reach during operation. The entire anterior fossa and the major part of the middle fossa can be resected, including procedures of freeing vessels and nerves and removing tumors in the paranasal sinuses and the orbit. The most important complication is considered as possible communication between the subarachnoid spaces and the paranasal sinuses. With caution, leaks can be prevented by packing the cavity with bone fragments and repairing the dural defect with homologous grafts. If there is considerable risk of leakage, it is recommended that a two-step operation is performed. It is our conclusion that, even though complete resection of tumor tissue might be regarded as impossible in cases of extensive bony invasion of the tumor, active surgical intervention should be applied in order to prevent further aggravation of functional outcome. We also emphasize that, if there is any hazard of failing vision, the surgery should be aimed, overall, at preventing loss of vision consequent to optic atrophy.

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References


