Convexity meningiomas: study of recurrence factors with special emphasis on the cleavage plane in a series of 100 consecutive patients

Clinical article

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Object. Convexity meningiomas are expected to have a low recurrence rate given their classically “easy resectability.” Nonetheless, recurrence can occur. Factors playing a role in their recurrence are analyzed here, including the extent of resection and tumor histological type, among others, with a special emphasis on the cleavage plane.

Methods. The authors reviewed 100 cases of convexity meningiomas surgically treated between 1987 and 2001 with a median follow-up of 86 months (range 2–16 years). Preoperative and postoperative functional status, Simpson resection grade, histological type, and intraoperative surgical plane with pial vessel invasion were studied and correlated with the recurrence rate.

Results. The average tumor size was 3.6 ± 0.4 cm. The pre- and postoperative Karnofsky Performance Scale scores were 92.6 ± 4.6 and 97.9 ± 2.2, respectively. Ninety-five lesions were benign (WHO Grade I) and 5 were atypical (WHO Grade II). Ninety-one and 9 tumors were subjected to Simpson Grade 1 and 3 resections (three Grade 3a and six Grade 3b), respectively. Surgical deaths did not occur. After a mean follow-up of 7.2 years, 4 meningiomas recurred; 2 (2.2%) after Simpson Grade 1 resections and 2 after Simpson Grade 3 (3a and 3b) resections (22.2%; p = 0.0034). When just the subgroup of Simpson Grade 1/WHO Grade I was studied, the recurrence rate decreased to 1.2% (1 of 86 cases). The recurrence of WHO Grade I tumors was higher in the subpial group than in the extrapial group (p = 0.025). No difference in recurrence according to the cleavage plane was seen in the WHO Grade II subgroup (p = 0.361). As for the subpial group, no difference in recurrence was noted between the WHO Grade I and II subgroups (p = 0.608). Importantly, however, the extrapial subgroup of WHO Grade II lesions had a higher recurrence rate compared with its counterpart in the WHO Grade I subgroup (p = 0.005).

Conclusions. Pial and vascular invasion affect the recurrence rate in convexity meningioma surgery. The recurrence rate of WHO Grade I tumors was higher among those with a subpial plane of dissection than among those with an extrapial one. Histological type did not determine the degree of pial invasion in WHO Grade I and II lesions.

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Key Words • convexity meningioma • recurrence • cleavage plane • oncology

I t has been well established that the recurrence rate of meningiomas is prominently associated with the extent of tumor resection as well as with histological type. Other factors, including a male sex, a lack of calcification, a non–cranial base location, a high MIB-1 index, a loss of chromosome 1p, and an expression of vascular endothelial growth factor, have been shown to increase the likelihood of recurrence.5,15,17,19,21,24,27–29 Most of the literature on recurrence has included all topographic types of meningioma. Because of the location, a lower recurrence rate is expected of meningiomas at the convexity, as compared with those at the skull base or those in relation to the major venous sinuses. So far, there have been only a few studies dealing exclusively with convexity meningiomas.4,11,14,21 Morokoff and colleagues21 examined 163 surgically treated convexity meningiomas and reported a recurrence rate of 4.3% with a median follow-up of 28 months. On the other hand, Giombini et al.,11 after a 113-month follow-up, documented a higher recurrence rate of 12.9% among 185 convexity meningiomas subjected to Simpson Grade 1 resections.

By including in the present study only those meningiomas located at the convexity, the authors were able to analyze the role of the pial plane and its invasion on recurrence.
giomas located at the convexity, we are in a unique position to analyze the factors contributing to the recurrence rate of these so-called easily resectable meningiomas. We particularly investigated the role of the cleavage plane found at surgery, extrapial or subpial, which is essentially linked to the pial-cortical invasion by the tumor.

**Methods**

**Patient Characteristics**

For homogeneity in this study, from an overall series of 2100 patients with intracranial meningiomas surgically treated by the senior author (M.P.S.) at the University Neurological Hospital Pierre Wertheimer between 1987 and 2001, 100 consecutive cases of meningiomas located at the convexity were analyzed. Data were collected through chart review, including patient age and sex, pre- and postoperative functional status, tumor size, Simpson resection grade, histological type, and cleavage plane with pial-cortical invasion. The functional status of patients was assessed during the last visit before surgery by using the KPS. A postoperative KPS score was assigned to each patient at the 3-month postoperative outpatient visit. All patients underwent preoperative CT, MR imaging, or both, with which tumor size was determined. The Simpson grading system was used to characterize the extent of tumor removal. At the 3rd postoperative month, total gross removal (that is, the absence of tumor remnant) was checked via CT or MR imaging with contrast medium. Any death within 3 months postoperatively was considered an operative death. Neurological morbidity was defined as the aggravation of a previous neurological deficit or the appearance of a new deficit that persisted beyond the 3rd postoperative month. All patients were followed up via mail inquiry or telephone interview in August 2004. Moreover, all patients had undergone control imaging (CT or MR imaging or both) every 2 years and at least once within the year before the August 2004 inquiry.

**Operative Techniques**

All patients underwent selective bilateral external and/or internal carotid artery (and if necessary, vertebral artery) angiography using the transfemoral arterial route based on lesion location. Special attention was given to the presence or absence and extent of peritumoral edema on CT and/or T2-weighted MR imaging sequences and to the pial tumor blush on selective internal carotid artery angiograms as predictors of the surgical plane of dissection. As a matter of fact, in previous publications we showed a statistically significant correlation between the degree of peritumoral edema identified on preoperative CT or T2-weighted MR imaging sequences and tumor pial vascularization as seen on selective angiography (Fig. 1). In those publications we also showed a statistically positive correlation between these imaging features and the cleavage plane. We stressed the adverse impact on neurological outcome when an extrapial cleavage plane could not be found when working in eloquent areas (Fig. 2).

In the present study we investigated the role of pial involvement in tumor recurrence. Surgery was performed using the classic microsurgical dissection techniques: operating microscope, bipolar coagulation, microscissors, microsuction, and ultrasonic aspiration. Succinctly, the operative steps were as follows: 1) centered wide craniotomy, 2 cm around the tumor edges; 2) circumferential opening of the dura mater, 1 cm around the meningioma after bipolar coagulation of the meningeal arterial feeders; 3) intratumoral volume reduction via piecemeal removal with bipolar microcoagulation, microscissors, and microsuction, or via ultrasonic aspiration when the tumor was hard; 4) sharp dissection of the tumor from underlying cerebral cortex using high magnification with special attention to the presence or absence of a pial plane along with the presence or absence of vascular attachments (Fig. 3); 5) dural resection with at least 1 cm from dural implantation of the tumor; 6) autologous duraplasty with either fascia lata or perioisteum; and 7) inner table drilling when hyperostotic reaction was associated with the tumor or cranioplasty when the external table was compromised as well.
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Type and Degree of Resection

A modified Simpson scale was used to evaluate, with the aid of the microscope, the degree of resection at the underlying cortex level (Table 1). Although Simpson defined resection Grade 3 as gross-total intradural excision without removal or coagulation of the dural attachment or its extradural extensions, no reference was made to the presence of small tumor remnants attached to underlying cortical vascular structures—pia mater, veins, and arterial cortical branches—which require magnification to be identified or may otherwise pass unnoticed. To elucidate the role of "microscopic" remnants in tumor recurrence, we added 2 subcategories to Simpson Grade 3. Simpson Grade 3a corresponds to a very small layer of tumor tissue (visible only under the high magnification of the operative microscope) left at the cortex because of the tumor’s adhesiveness to the pia mater. Simpson Grade 3b corresponds to a small piece of tumor tissue (visible, although not quite identifiable without the magnification of the operative microscope) left because of invasion of the pial vasculature or a cortical vessel in an eloquent area (branches of the MCA or cortical central veins) and coagulated with the aid of the microscope, using fine bipolar forceps.

Statistical Analysis

Statistical analysis was performed using JMP Version 6 software. The chi-square test was used to evaluate Simpson grades, recurrence rate, mortality rate, histological type, cleavage plane, and complications. One-way ANOVA and the Student t-test were applied to analyze continuous data including patient age, tumor size, and preoperative and postoperative KPS scores. The mean values were presented with 95% confidence intervals. Statistical significance was reached at a p value < 0.05.

Results

Age, Sex, Tumor Size, Tumor Location, and Operative Data

The F/M ratio was 2.4:1 with 71 women and 29 men. The mean age at surgery was 58.9 ± 2.4 years (range 20–85 years). Men were slightly younger than women: 58.3 versus 60.5 years (p = 0.4226). Tumor sizes ranged from 1 to 7 cm (mean 3.6 ± 0.4 cm). The majority of tumors were located in the frontal lobe (38 lesions). Other locations included the parietal region (19 lesions), occipital region (5 lesions), temporal region (5 lesions), and lobal junction (35 lesions; Table 2). Forty-six meningiomas were on the right side and 54 were on the left. Ninety-one lesions (91%) were subjected to a Simpson Grade 1 resection and 9 (9%) to a Grade 3 resection. The surgical plane was predominantly subpial in 19 cases and predominantly extrapial in 81 cases. Six tumors invaded the cortical MCA branches or rolandic veins, and thus a Simpson Grade 3b resection was only attempted.

Histological Type

A majority of convexity meningiomas in this series were benign (WHO Grade I, 95 lesions) with a few atypical ones (WHO Grade II, 5 lesions). The transitional type was the most common (35 lesions), followed by the

<table>
<thead>
<tr>
<th>Grade</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>macroscopically complete removal of the tumor, w/ excision of its dural attachment &amp; any abnormal bone; when the tumor arises from the wall of a dural venous sinus, such an operation necessarily entails resection of the sinus</td>
</tr>
<tr>
<td>2</td>
<td>macroscopically complete removal of the tumor &amp; its visible extensions, w/ endothermy coagulation (usually to the point of charring) of its dural attachment</td>
</tr>
<tr>
<td>3</td>
<td>macroscopically complete removal of the intradural tumor, w/o resection or coagulation of its dural attachment or, alternatively, its extradural extensions (for example, an invaded sinus or hyperostotic bone); apparently gross-total removal of intradural tumor mass</td>
</tr>
<tr>
<td>3a</td>
<td>very small layer of tumor tissue (only visible under magnification of operative microscope) left at cortex because of invasiveness to the pia mater</td>
</tr>
<tr>
<td>3b</td>
<td>small (mm³) piece of tumor tissue (hardly visible w/o magnification of operative microscope) left because of invasion of cortical vessel in an eloquent area (branches of MCA or cortical central veins), &amp; coagulated w/ bipolar forceps</td>
</tr>
<tr>
<td>4</td>
<td>partial removal, leaving intradural tumor in situ</td>
</tr>
<tr>
<td>5</td>
<td>simple decompression, w/ or w/o biopsy</td>
</tr>
</tbody>
</table>

Fig. 3. Intraoperative photograph showing a convexity meningioma (M) with both an extrapial and a subpial cleavage plane.
fibroblastic (29 lesions) and meningothelial (24 lesions). Patient sex did not predispose to one or another type (Table 3).

**Functional Status**

The tumor was primary—that is, it was not surgically treated on a previous occasion—in all patients in the series except one. Tumors were discovered based on neurological manifestations, including at least headaches, in all patients. Moreover, the majority of patients suffered from focal headaches and focal seizures (39% and 30%, respectively). Twelve percent had hemicorporeal deficit, 9% had aphasia, 6% had personality changes, and 4% had central facial paralysis.

Postoperatively, 65% of patients had complete resolution of their clinical signs or symptoms. Patient functional status was assessed using the KPS. Preoperative and postoperative KPS scores were 92.6 and 97.9, respectively. Despite the improvement in the scores, there was no statistical significance in the difference (p = 0.0775; Table 4).

**Morbidity and Mortality Rates**

There were no deaths during the follow-up period.

Overall, surgical complications occurred postoperatively in 8 patients (8%). Two patients (2%) had osteomyelitis due to *Staphylococcus* organisms; both of them were successfully treated via surgical removal of the bone flap plus intravenous antibiotics. Surgically related abscesses, 1 epidural and 1 subgaleal, developed in 2 other patients (2%); they were successfully treated using surgical drainage and intravenous antibiotics. Noninfectious processes accounted for the other half of the complications. Wound dehiscence was seen in a patient after the removal of an occipital meningioma. Two extradural hematomas were uneventfully drained in a timely manner. Another patient suffered a pulmonary embolism, with a full recovery after anticoagulation treatment.

**Recurrence Rates**

The median follow-up was 86 months (range 2–16 years). Tumor recurred in 4 patients. One patient presented with partial motor seizures, one with arm weakness, and the other two with unspecific headaches. Magnetic resonance imaging confirmed the tumor recurrence. Characteristics of these patients are summarized in Table 5. The first patient was a 54-year-old woman who presented at our center for the recurrence of an angiomatous meningioma (WHO Grade I) that had been surgically treated at another institution and then was surgically retreated by us. The tumor had a subpial cleavage plane after our surgical treatment. Only a Simpson Grade 3b resection was achieved because of the lesion’s adhesiveness and invasion of the cortical branches of the MCA. The tumor recurred 39 months after our surgery. The second patient was a 47-year-old man in whom tumor recurred 50 months after an initial Simpson Grade 3b tumor excision; a small ± 1-mm³ remnant had been left behind because of infiltration of a cortical branch of the MCA. A pathology report showed a WHO Grade I lesion of the meningothelial type. The third patient was a 72-year-old man who initially underwent a Simpson Grade 1 resection of an atypical meningioma (WHO Grade II), which had a subpial cleavage plane. The tumor recurred 67 months later. The fourth patient was a 58-year-old man with a transitional meningioma (WHO Grade I) who underwent a Simpson Grade 1 resection at the first surgery; however, the tumor recurred 84 months later. A surgical specimen showed a transitional meningioma.

In all 4 cases, subsequent surgery was performed to remove the recurrent tumor. No deaths occurred during the follow-up period. No radiosurgery was performed in any of the recurrent cases after reoperation.

**Correlation With Patient Sex.** Patient sex played a role in meningioma recurrence; that is, men had a higher recurrence rate (10.3%) than did women (1.4%; p = 0.0385).

**Correlation With Histological Type.** The histological type influenced the recurrence rate. One (20%) of 5 atypical (WHO Grade II) meningiomas recurred after surgery, whereas only 3 (3.2%) of 95 benign (WHO Grade I) meningiomas recurred (p = 0.061).

**Correlation With Tumor Cleavage Plane.** Two (10.5%) of 19 tumors with a subpial cleavage plane of dissection (because pia mater invaded) recurred at 39 and 50 months.
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After surgery. In contrast, only 2 (2.4%) of 81 tumors with an extrapial cleavage plane showed signs of regrowth. Although there was a higher tendency for tumors with a subpial cleavage plane to recur regardless of WHO grade, no statistical differences were found (p = 0.106). Table 6 shows the tumor recurrence rate by histological type and cleavage plane. Among patients in the WHO Grade I subgroup, the recurrence rate was significantly higher in those with a subpial plane of dissection (2 [11.8%] of 17) than in those with an extrapial plane (1 [1.3%] of 78; p = 0.025). Moreover, among meningioma cases with an extrapial cleavage plane, the WHO Grade II type recurred at a higher rate than the WHO Grade I type (33% vs 1.3%; p = 0.005).

Correlation With Resection Grade. Only 2 (2.2%) of 91 tumors recurred after Simpson Grade 1 resection, at 67 and 84 months of follow-up. No Simpson Grade 2 resections were documented. Simpson Grade 3 (3a + 3b) resections accounted for a total of 9 cases (3 and 6 cases, respectively). No recurrences were noted in the 3a subgroup, whereas 2 recurrences were found in the 3b subgroup. Overall, Simpson Grade 3 resection was associated with a higher recurrence rate than Simpson Grade 1: 22% vs 2.2% (p = 0.0034). Individually, Simpson Grade 3b recurrence was statistically significant as compared with Simpson Grade 1 (p = 0.0002), whereas Simpson 3a was not (p = 0.79; Table 7).

Recurrence Rate by Histological Type and Extent of Resection. The Simpson Grade 1 resection group showed a recurrence rate of 2.2% (2 of 91 cases) regardless of the WHO grade. When considering just the Simpson Grade I/WHO Grade I subgroup, the recurrence rate decreased to 1.2% (1 of 86 cases). In a comparison of WHO grades, the recurrence rate of WHO Grade II lesions among those in the Simpson Grade 1 resection subgroup was statistically higher than the recurrence rate of WHO Grade I lesions (p = 0.0052).

The Simpson Grade 3 resection subgroup exhibited a recurrence rate of 22.2% regardless of WHO grade; however, cases in the WHO I subgroup that underwent Simpson Grade 3 resection were more prone to have a recurrence (p = 0.0017; Table 8).

Discussion

It has been well recognized through several studies that the Simpson resection grade and histological type (WHO classification) are the 2 most important factors affecting the recurrence rate of meningiomas. Other factors associated with the meningioma recurrence rate are a male sex, lack of calcification, skull base location, high MIB-1 index, loss of chromosome 1p, and an expression of vascular endothelial growth factor. In our series, another variable, the pia mater invasion condition- ing the cleavage plane, was found to play a role in meningioma recurrence regardless of the lesion histological type.

Simpson Scale Modification

Although widely accepted since 1957, the Simpson scale has remained without any modifications since the development of microsurgical techniques, especially optic magnification. To have a better understanding of the different factors that may play a role in recurrence,

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**TABLE 4: Preoperative and postoperative KPS scores according to patient sex and age***

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Overall</th>
<th>Males</th>
<th>Females</th>
<th>p Value</th>
<th>&lt;65 Yrs</th>
<th>≥65 Yrs</th>
<th>p Value</th>
<th>preop</th>
<th>postop</th>
<th>p value‡</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>92.6</td>
<td>85.0</td>
<td>95.0</td>
<td>0.0577</td>
<td>96.9</td>
<td>78.8</td>
<td>0.0002†</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>97.9</td>
<td>92.5</td>
<td>98.8</td>
<td>0.0452†</td>
<td>99.2</td>
<td>91.3</td>
<td>0.0102†</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>p value‡</td>
<td>0.0775</td>
<td>0.4091</td>
<td>0.0562</td>
<td>NA</td>
<td>0.1644</td>
<td>0.1417</td>
<td>NA</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Postoperative scores in females were significantly higher than those in males (p = 0.0452). Similarly, the younger age group presented with better functional status both before and after surgery (p = 0.0002 and 0.0102, respectively). Of note, patients younger than 65 years regained most of their functional status after surgery with a mean KPS score of 99.2. Abbreviation: NA = not applicable.
† Statistically significant.
‡ Comparing pre- and postoperative KPS scores (Student t-test).

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**TABLE 5: Summary of characteristics in patients with tumor recurrence***

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Age (yrs), Sex</th>
<th>Histology</th>
<th>Tumor Location</th>
<th>Cleavage Plane</th>
<th>Modified Simpson Grade</th>
<th>Time From Surgery (mos)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>54, F</td>
<td>angiomatous</td>
<td>rt parietal</td>
<td>subpial</td>
<td>3b</td>
<td>39</td>
</tr>
<tr>
<td>2</td>
<td>47, M</td>
<td>meningothelial</td>
<td>lt parietal</td>
<td>subpial</td>
<td>3b</td>
<td>50</td>
</tr>
<tr>
<td>3</td>
<td>72, M</td>
<td>atypical</td>
<td>lt parietal</td>
<td>extrapial</td>
<td>1</td>
<td>67</td>
</tr>
<tr>
<td>4</td>
<td>58, M</td>
<td>transitional</td>
<td>rt frontal</td>
<td>extrapial</td>
<td>1</td>
<td>84</td>
</tr>
</tbody>
</table>

* The recurrence rate after Simpson Grade 1 and 3 resections was 2.5% (2 of 80) and 33.3% (2 of 6), respectively. The recurrence rate was significantly higher in men (10.3%) than in women (1.4%; p = 0.385).
especially the identification of the cleavage plane under
the microscope, we propose the addition of microscopic
evaluation at the surgical bed to establish the presence of
pial remnants and/or vascular wall invasion at the under-
lying cerebral parenchyma.

A careful evaluation at the end of tumor removal is
crucial to precisely classify the degree of resection. We
suggest adding to the Simpson Grade 3 level the 2 sub-
types we described earlier (a and b) in which 3a means a
very small layer of tumor tissue (only visible under mag-
nification of the operative microscope) left at the cortex
because of adhesiveness to the pia mater (especially when
working in the eloquent areas), and 3b means a small
(± 1 mm³) piece of tumor tissue (hardly visible without
magnification of the operative microscope) left because
of invasion of the wall of a cortical vessel and coagulated
under the microscope using fine bipolar forceps (Table 1).

Recurrence Rate According to Resection Grade

The recurrence rates after Simpson Grade 1 and 3
(3b) resections were 2.2% and 22.2%, respectively. There
were no Grade 2 resections. Among the 6 meningiomas
subjected to Simpson Grade 3b resections, 2 recurred.
Surprisingly, no recurrences were found among Simpson
Grade 3a during the follow-up period. Note, however, that
no statistical conclusions can be drawn from this small
number of cases. In addition, the benign nature of WHO
Grade I lesions in the subgroup of Simpson Grade 3a
might have contributed to the absence of tumor recur-
rences despite subtotal removal. Factors that contribut-
ed to the seemingly high recurrence rate after Simpson
Grade 3b resection include a conservative approach to
vascular invasion and a small number of cases. On the
other hand, the low recurrence rate of meningiomas af-
after Simpson Grade 1 resection (1.2%) was probably due
to our strict policy regarding the assignment of Simpson

grades. Inasmuch, tumors with tiny remnants, such as the
ones left after the vessels were shaved off, were classified
as Simpson Grade 3 (a or b) and not as Simpson Grade 1.
The recurrence rate among Simpson Grade 3b resections
in our series was 33.3% (2 of 6 cases; Table 7). Most stud-
ies in the literature do not report on these microsurgical
nuances, which certainly are operator dependant.

The recurrence rate for meningiomas at any location
ranges from 4.3% to 15.6%. 6,9,10,12,15,18,20,22 Similar rates
have been observed for convexity meningiomas accord-
ging to authors of different studies (Table 9). 3,6–8,19,21,23
In our study, only 4 (4%) of 100 cases recurred after a mean
follow-up of 86 months.

Recurrence Rate by Histological Type and Degree of
Resection. Among the group that underwent Simpson
Grade 1 resections there was a recurrence rate of 2.2% (2
of 91 cases), regardless of WHO grade. When considering
just the WHO Grade I subgroup, the recurrence rate de-
creased to 1.2% (1 of 86 cases). The recurrence rate after
Simpson Grade 1 resection was higher among the WHO
Grade II lesions than among the WHO Grade I lesions (p
= 0.0052).

Simpson Grade 3 (3a and 3b) resections exhibited a
recurrence rate of 22.2% regardless of WHO grade; how-
ever, the WHO Grade I cases subjected to Simpson Grade
3 (3a and 3b) resections were more prone to have a recur-
rence (p = 0.0017; Table 8).

Recurrence Rate by Cleavage Plane. Independent of
histological findings, the cleavage plane also influenced
the tumor recurrence rate. Of high significance, among
WHO Grade I meningiomas, those with a subpial cleav-
age plane presented with a higher recurrence rate (11.8%)
than those with an extrapial cleavage plane (1.3%; p
= 0.025), probably because of their tendency to invade the
pia mater layer. In contrast, Table 6 shows that the re-
currence rate among those with an extrapial cleavage
plane was higher in WHO Grade II (33.3%) than in WHO
Grade I (1.3%) meningiomas (p = 0.005).

Conclusions

When WHO Grade I convexity meningiomas with-
out pial vascular attachments are subjected to a Simpson
Grade 1 resection, the recurrence rate after an average
follow-up period of 7.2 years is as low as 1.2%.

The presence of pial-cortical vessel invasion affects

TABLE 6: Recurrence according to cleavage plane and WHO grade*

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Subpial Plane</th>
<th>Extrapial Plane</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No Recurrence</td>
<td>Recurrence (%)</td>
</tr>
<tr>
<td>WHO Grade</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>15</td>
<td>2 (11.80)</td>
</tr>
<tr>
<td>II</td>
<td>2</td>
<td>0 (0)</td>
</tr>
</tbody>
</table>

* Regarding the subpial group, no differences in recurrence were seen between the WHO Grade I and II subgroups (p = 0.608).
Regarding the extrapial group, a higher recurrence rate was seen in the WHO Grade II subgroup compared with the WHO Grade I group (p = 0.005).

TABLE 7: Tumor recurrence rate according to Simpson grade

<table>
<thead>
<tr>
<th>Simpson Grade</th>
<th>No. of Surgical Cases</th>
<th>No. of Recurrence Cases</th>
<th>% Recurrence Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>91</td>
<td>2</td>
<td>2.2</td>
</tr>
<tr>
<td>3 (a and b)</td>
<td>9</td>
<td>2</td>
<td>22.2</td>
</tr>
<tr>
<td>3a</td>
<td>3</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>3b</td>
<td>6</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>total</td>
<td>100</td>
<td>4</td>
<td></td>
</tr>
</tbody>
</table>
TABLE 8: Tumor recurrence according to WHO and Simpson grades

<table>
<thead>
<tr>
<th>Parameter</th>
<th>WHO Grade</th>
<th>No Recurrence</th>
<th>Recurrence (%)</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simpson grade</td>
<td>I</td>
<td>1</td>
<td>85</td>
<td>1 (1.2)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>7</td>
<td>2 (22.2)</td>
</tr>
<tr>
<td>No Recurrence</td>
<td>Recurrence (%)</td>
<td>p Value</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>4</td>
<td>1 (20)</td>
<td>0.0052</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

TABLE 9: Recurrence rate of surgically treated convexity meningiomas*

<table>
<thead>
<tr>
<th>Authors &amp; Year</th>
<th>No. of Cases</th>
<th>Recurrence Rate (%)</th>
<th>Median Follow-Up (mos)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yamashita et al., 1980</td>
<td>47</td>
<td>14.9</td>
<td>—</td>
</tr>
<tr>
<td>Giombini et al., 1984</td>
<td>185</td>
<td>12.9</td>
<td>113</td>
</tr>
<tr>
<td>Chan &amp; Thompson, 1984</td>
<td>53</td>
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<td>Borovich et al., 1986</td>
<td>62</td>
<td>11.3</td>
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<tr>
<td>Baird &amp; Gallagher, 1989</td>
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<td>Morokoff et al., 2008</td>
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<tr>
<td>present study</td>
<td>100</td>
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</table>

* Only studies with convexity meningiomas specified were reviewed. Abbreviation: — = not specified.

Discussion

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

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The recurrence rate in convexity meningioma surgery. The recurrence rate of WHO Grade I tumors that have a subpial plane of dissection is higher than those with an extrapial one (p = 0.025).

Histological type does not determine the degree of pial invasion in WHO Grade I and II meningiomas.

Evaluation of the tumor bed under the operative microscope must be part of applying the Simpson grading system. Meningiomas with pial involvement and/or vascular attachments behave differently despite apparently complete tumor removal. Therefore we propose within the Simpson Grade 3 category to take into account these kinds of intraoperative findings, which might otherwise mistakenly lead to classification as a Simpson Grade 1..

Disclosure

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Author contributions to the study and manuscript preparation include the following. Conception and design: Alvernia, Sindou. Acquisition of data: Alvernia. Analysis and interpretation of data: all authors. Drafting the article: Alvernia. Critically revising the article: Alvernia, Sindou. Reviewed submitted version of manuscript: all authors. Statistical analysis: Dang. Study supervision: Sindou.

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