Extracranial Sinonasal Tract Meningiomas

A Clinicopathologic Study of 30 Cases With a Review of the Literature

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Extracranial meningiomas of the sinonasal tract are rare tumors. These tumors are frequently misclassified, resulting in inappropriate clinical management. To date, there has been no comprehensive study to evaluate the clinicopathologic aspects of meningioma in these anatomic sites. Thirty cases of sinonasal tract meningiomas diagnosed between 1970 and 1992 were retrieved from the files of the Otorhinolaryngic Registry of the AFIP. Histologic features were reviewed, immunohistochemical studies were performed, patient follow up was obtained, and the results were statistically analyzed. The patients included 15 females and 15 males, aged 13 to 88 years (mean, 47.6 yrs). Patients presented clinically with a mass, epistaxis, sinusitis, pain, visual changes, or nasal obstruction, dependent on the anatomic site of involvement. Symptoms were present for an average of 31.1 months. The tumors affected the nasal cavity (n = 14), nasopharynx (n = 3), frontal sinus (n = 2), sphenoid sinus (n = 2), or a combination of the nasal cavity and ethmoid, frontal, sphenoid, and/or maxillary sinuses (n = 9). The tumors ranged in size from 1.0 to 8.0 cm in greatest dimension (mean, 3.5 cm). Radiographic studies demonstrated a central nervous system connection in six cases. The tumors often eroded the bones of the sinuses (n = 18) and involved the surrounding soft tissues, the orbit, and occasionally the base of the skull. Histologically, the tumors demonstrated features similar to intracranial meningiomas. The majority were of the meningothelial type (n = 23), although there were three atypical meningiomas. Immunohistochemical studies confirmed the diagnosis of meningioma with positive reactions for epithelial membrane antigen (EMA) and vimentin (all tested). The differential diagnosis includes parangangioma, carcinoma, melanoma, psammomatoid ossifying fibroma, and angiofibroma.

Surgical excision was used in all patients. Three patients died with recurrent disease (mean, 1.2 yrs), one was alive with recurrent disease (25.6 years), and the remaining 24 patients were alive or had died of unrelated causes (mean, 13.9 yrs) at the time of last follow up (two patients were lost to follow up). Extracranial sinonasal tract meningiomas are rare tumors which need to be considered in the differential diagnosis of sinonasal tumors. A whorled growth pattern and psammoma bodies, combined with positive EMA and vimentin immunohistochemical reactions, can confirm the diagnosis of meningioma. The overall prognosis is good, without a difference in outcome between benign and atypical meningiomas.

Key words: Meningioma—Sinuses—Nasal cavity—Histology—Immunohistochemistry—Prognosis—Adult.


Meningioma is a common intracranial neoplasm with a variety of histomorphologic growth patterns which are usually easily recognized. However, primary extracranial (ectopic, extracalvarial) meningiomas of the nasal cavity, paranasal sinuses, and nasopharynx (hereinafter referred to collectively as the sinonasal tract) are rare. The literature is generally limited to isolated case reports. The largest study to date is of 12 cases reported by Perzin et al. However, while a degree of controversy continues to exist around the exact origin of sinonasal tract meningiomas, it seems generally accepted that primary extracranial meningiomas do occur. Histologically, meningiomas of the sinonasal tract are identical to their intracranial counterparts, although diagnostic difficulties are frequently encountered in the differential diagnosis with carcinoma, melanoma, and olfactory neuroblastoma resulting from the rarity of meningiomas in this location. With these difficulties in mind, we thought it would be legitimate to undertake this study of 30 cases of sinonasal tract meningiomas to describe the clinical findings.
associated with these tumors, illustrate their pathologic features, document their immunophenotype, apply meningioma grading parameters, and analyze this data as it relates to patient outcome in a single comprehensive study. Our results are analyzed in comparison to a review of the English literature.

METHODS

Thirty cases of meningiomas were selected involving the nasal cavity, paranasal sinuses (sphenoid, maxillary, ethmoid, and frontal sinuses), or nasopharynx. The cases were retrieved from the files of the Otorhinolaryngic-Head & Neck Tumor Registry of the Armed Forces Institute of Pathology (AFIP), Washington, DC, between 1970 and 1992. These 30 cases were chosen from a review of 17,737 (0.17%) benign or malignant primary sinonasal tract tumors seen in consultation during this time. Twenty-five cases were obtained from civilian sources, including university medical centers and foreign contributors, four cases from military hospitals, and one case from a Veterans Administration Medical Center.

Materials within the files of the AFIP were supplemented by a review of the patient demographics, symptoms at presentation, medical history, radiographic studies performed, surgical pathology and operative reports, cancer registry records, and by written questionnaires or oral communication with the treating physician(s). Follow-up data tabulated included information regarding the location of the primary site, the specific treatment modalities used, and the current status of the disease and patient. Patients with primary tumors of the intracranial cavity who later developed sinonasal tract extension were excluded from this study, as were cases of psammomatoid ossifying fibroma which we think are distinct entities from meningiomas.

Hematoxylin and eosin-stained slides from all cases were reviewed to confirm that established histopathologic criteria for the diagnosis of meningioma were met. Meningiomas were classified according to subtype based on World Health Organization criteria. Lesions were considered atypical if they possessed a mitotic rate greater than four per 10 high-power fields (2.5 mm²) and/or had at least two of the following histologic features: hypercellularity, growth of tumor cells in sheets, prominent nucleoli, necrosis, and marked nuclear pleomorphism. Immunophenotypic analysis was performed in 15 cases with suitable material. The standardized avidin–biotin method of Hsu et al. was used, using 4 μm thick, formalin-fixed, paraffin-embedded sections.

Table 1 documents the pertinent, commercially available immunohistochemical antibody panel used. The analysis was performed on a single representative block in each case. When required, proteolytic antigen retrieval was performed with predigestion for 3 minutes with 0.05% Protease VIII (Sigma Chemical Co, St. Louis, MO, USA) in a 0.1 M phosphate buffer at a pH of 7.8 at 37°C. Antigen enhancement (recovery) was performed, as required, using formalin-fixed, paraffin-embedded tissue treated with a buffered citric acid solution and heated for 20 minutes in a calibrated microwave oven. Following this, the sections were allowed to cool at room temperature in a citric acid buffer solution for 45 minutes before continuing the procedure. Standard positive and negative (serum) controls were used throughout.

The antibody reactions were graded as weak (1+), moderate (2+), and strong (3+) staining, and the fraction of positive cells was determined by separating the percentage of positive cells into four groups: <10%, 10%–50%, 51%–90%, and >90%, specifically for the proliferation marker (PCNA) and for the hormone receptors (progesterone and estrogen).

A review of English journal publications (1931 to 1998) was performed, and all cases involving the nasal cavity, paranasal sinuses, and/or nasopharynx were included in the review, even if there was central nervous

<table>
<thead>
<tr>
<th>Antigen/antibody</th>
<th>Primary antibody</th>
<th>Company</th>
<th>Dilution</th>
<th>Antigen recovery</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cytokeratin (AE1/AE3 and CK1)</td>
<td>mm</td>
<td>Boehringer Mannheim</td>
<td>1:50</td>
<td>Protease treatment</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Biochemicals, Indianapolis, IN,</td>
<td>1:200</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>and Dako, Carpinteria, CA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Epithelial membrane antigen (EMA)</td>
<td>mm</td>
<td>Dako</td>
<td>1:100</td>
<td>Protease digestion</td>
</tr>
<tr>
<td>CD34</td>
<td>mm</td>
<td>BioGenex Labs, San Ramon, CA</td>
<td>1:40</td>
<td>Microwave</td>
</tr>
<tr>
<td>Glial fibrillary acidic protein (GFAP)</td>
<td>rp</td>
<td>Dako</td>
<td>1:2000</td>
<td>Protease digestion</td>
</tr>
<tr>
<td>Vimentin</td>
<td>mm</td>
<td>BioGenex Labs</td>
<td>1:400</td>
<td>n/a</td>
</tr>
<tr>
<td>Smooth muscle actin (SMA)</td>
<td>mm</td>
<td>Sigma Chemical, St. Louis, MO</td>
<td>1:400</td>
<td>n/a</td>
</tr>
<tr>
<td>S-100 protein</td>
<td>rp</td>
<td>Neat</td>
<td>1:800</td>
<td>n/a</td>
</tr>
<tr>
<td>Neuron-specific enolase (NSE)</td>
<td>rp</td>
<td>Dako</td>
<td>1:200</td>
<td>Protease digestion</td>
</tr>
<tr>
<td>Neuroluimination protein (NFP)</td>
<td>mm</td>
<td>Dako</td>
<td>1:2000</td>
<td>Microwave</td>
</tr>
<tr>
<td>Proliferating cell nuclear antigen (PCNA)</td>
<td>mm</td>
<td>Dako</td>
<td>1:400</td>
<td>Microwave</td>
</tr>
<tr>
<td>Progesterone receptor</td>
<td>mm</td>
<td>Dako</td>
<td>1:400</td>
<td>Microwave</td>
</tr>
<tr>
<td>Estrogen receptor</td>
<td>mm</td>
<td>Dako</td>
<td>1:400</td>
<td>Microwave</td>
</tr>
</tbody>
</table>

mm, mouse monoclonal; rp, rabbit polyclonal; n/a, not applicable.
system involvement. Cases that involved only the temporal bone, middle ear, orbit, oral cavity, or soft tissues of the neck were not included. Likewise, cases of cranial cavity or spinal canal meningiomas which metastasized to distant sites were not included in the review, unless they involved the sites described above. No foreign language articles were included.

Categoric variables were analyzed using chi-square tests to compare observed and expected frequency distributions. Comparison of means between groups were made with unpaired t tests. Confidence intervals of 95% were generated for all positive findings. The alpha level was set at p < 0.05. All analyses were conducted using the computer program, Statistical Package for the Social Sciences (SPSS) 8.0 for PC (Chicago, IL, USA).

RESULTS

Clinical

The patients included 15 females and 15 males (Table 2). Their ages ranged from 13 to 88 years of age, with an overall mean age at presentation of 47.6 years (median, 46.5 yrs). The average age at presentation for men was younger than women, at 39.4 and 55.7 years, respectively, which was statistically significant (p = 0.040), although we do not have an explanation for this difference. Patients presented with a mass lesion in the nasal cavity or sinuses (n = 16), whereas epistaxis (n = 9), sinusitis (n = 7), pain (n = 4), and obstructive symptoms (n = 3) were also observed. Of interest were four patients who had visual changes, including blindness, related to the pressure effect of the mass as it expanded in size. The blindness did not resolve after the removal of the mass. The duration of symptoms ranged from 1 to 240 months, with an average of 31.1 months. The overall long duration of symptoms is most likely related to the generally nonspecific nature of the initial symptoms, which were frequently managed symptomatically without a specific diagnostic evaluation. Whereas, on average, there was a much shorter duration of symptoms for patients with tumors of the frontal sinus alone (4 mos) when compared with tumors of the nasal cavity alone (36.5 mos), nasopharynx alone (32 mos), or the nasal cavity and sinuses (31.3 mos), this difference was not statistically significant as a result of the small number of frontal sinus cases (p = 0.547).

Radiographic Studies

Roentgenographic procedures were performed in the majority of patients, and included conventional skull ra-
diographs, computer tomography, angiograms, ultrasound, and magnetic resonance imaging, with plain radiographs and computer tomography used the most frequently (Table 3). Nasal cavity or paranasal sinus opacification by a mass lesion, accompanied by bony erosion and sclerosis or hyperostosis was noted in many cases. Cross-sectional images identified a destructive mass lesion of the paranasal sinuses, frequently with soft tissue swelling. In a few cases (n = 6) bone erosion with extension of the tumor into the base of the skull and/or the orbit was noted. Six cases had roentengenographic evidence of a central nervous system (CNS) association, but the vast majority of the tumor bulk was located in the sinonasal tract.

**Pathologic Features**

**Macroscopic**

The tumors occurred in the nasal cavity alone (n = 14), nasopharynx alone (n = 3), frontal sinus alone (n = 2), sphenoid sinus alone (n = 2), and in the nasal cavity and the paranasal sinuses (n = 9), including ethmoid, frontal, sphenoid, and/or maxillary sinus (Table 3). It is curious that most of the tumors affected the left side (n = 14), although this was not statistically significant (p = 0.920), whereas five patients presented with bilateral disease. The tumors ranged in size from 1.0 to 8.0 cm, with a mean size of 3.5 cm. Macroscopically, the tumors were usually infiltrative into the bone of the sinus or nasal cavity. However, the surface epithelium was not ulcerated or penetrated (and respiratory epithelium was noted histologically in the majority of cases [n = 25]). The cut surface, when not submitted in multiple fragments, was composed of grayish white–tan to pink, gritty, firm to rubbery masses. The majority of the nasal cavity tumors were described as polypoid (n = 9). Calcifications and fragments of bone were frequently macroscopically visible.

**Microscopic**

The majority (n = 24) of these neoplasms were meningothelial (syncytial) tumors composed of lobules of neoplastic cells with indistinct borders and round to oval nuclei with delicate chromatin (Figs. 1 and 2). Two tumors had a meningothelial component as well as a spindle cell component and were classified as transitional lesions. One case was a metaplastic meningioma containing numerous lipidized cells (Fig. 3). Three cases possessed sufficient combination of loss of architectural pattern, increased mitotic activity, necrosis, and nuclear pleomorphism with prominent nucleoli to warrant a diagnosis of atypical meningioma. Psammoma bodies (Fig. 1) and intranuclear cytoplasmic pseudoinclusions were frequently identified in all subtypes. Respiratory epithelium was present in the majority of tumors (Fig. 1), and most lesions, irrespective of the type, demonstrated an infiltrative growth pattern, frequently invading adjacent soft tissue and bony structures (Fig. 4).

**TABLE 5. Immunohistochemical panel results**

<table>
<thead>
<tr>
<th>Antibody</th>
<th>No. of cases with positive reactions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cytokeratin (focal)</td>
<td>2/13</td>
</tr>
<tr>
<td>EMA</td>
<td>14/14</td>
</tr>
<tr>
<td>CD94</td>
<td>1/12 (focal)</td>
</tr>
<tr>
<td>GFAP</td>
<td>0/11</td>
</tr>
<tr>
<td>Vimentin</td>
<td>15/15</td>
</tr>
<tr>
<td>SMA</td>
<td>0/11</td>
</tr>
<tr>
<td>S-100 protein</td>
<td>1/14 (focal)</td>
</tr>
<tr>
<td>NSE</td>
<td>0/11</td>
</tr>
<tr>
<td>NFP</td>
<td>0/10</td>
</tr>
<tr>
<td>PCNA</td>
<td>3/11</td>
</tr>
<tr>
<td>&lt;10%</td>
<td>11–50%</td>
</tr>
<tr>
<td>51–90%</td>
<td>2/11</td>
</tr>
<tr>
<td>&gt;90%</td>
<td>3/11</td>
</tr>
<tr>
<td>Progesterone receptor</td>
<td>6/11</td>
</tr>
<tr>
<td>Estrogen receptor</td>
<td>3/11</td>
</tr>
</tbody>
</table>

**TABLE 6. Patient outcome for 30 sinonasal tract meningiomas (mean years of follow up)**

<table>
<thead>
<tr>
<th>All patients*</th>
<th>D, WD</th>
<th>A, WD</th>
<th>D, NED</th>
<th>A, NED</th>
</tr>
</thead>
<tbody>
<tr>
<td>All patients with follow up</td>
<td>28 (13.7 yr)</td>
<td>3 (1.2 yr)</td>
<td>1 (25.6 yr)</td>
<td>9 (13.8 yr)</td>
</tr>
<tr>
<td>Follow-up range</td>
<td>1 mo–30.1 yr</td>
<td>1 mo–3.5 yr</td>
<td>25.6 yr</td>
<td>1 mo–30.1 yr</td>
</tr>
<tr>
<td>Histologic type</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Atypical meningiomas</td>
<td>3 (6.9 yr)</td>
<td>1 (1 mo)</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Benign meningiomas</td>
<td>25 (14.6 yr)</td>
<td>2 (1.8 yr)</td>
<td>1 (25.6 yr)</td>
<td>9 (13.8 yr)</td>
</tr>
<tr>
<td>Patients with recurrence</td>
<td>6 (16.8 yr)</td>
<td>2 (1.8 yr)</td>
<td>1 (25.6 yr)</td>
<td>2 (20.4 yr)</td>
</tr>
<tr>
<td>Anatomic site</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nasal cavity alone</td>
<td>13</td>
<td>1 (3.5 yr)</td>
<td>n/a</td>
<td>4 (10.6 yr)</td>
</tr>
<tr>
<td>Frontal sinus alone</td>
<td>2</td>
<td>1 (0.1 yr)</td>
<td>n/a</td>
<td>1 (16.5 yr)</td>
</tr>
<tr>
<td>Sphenoid sinus alone</td>
<td>2</td>
<td>n/a</td>
<td>n/a</td>
<td>1 (5.9 yr)</td>
</tr>
<tr>
<td>Nasopharynx alone</td>
<td>3</td>
<td>1 (25.6 yr)</td>
<td>n/a</td>
<td>2 (19.3 yr)</td>
</tr>
<tr>
<td>Nasal cavity and sinuses (NOS)</td>
<td>8</td>
<td>1 (0.1 yr)</td>
<td>n/a</td>
<td>3 (19.8 yr)</td>
</tr>
</tbody>
</table>

D, WD, dead, with disease; A, WD, alive, with disease; D, NED, dead, no evidence of disease; A, NED, alive, no evidence of disease; n/a, not applicable; NOS, not otherwise specified.

* Two patients were lost to follow up.
Immunohistochemical Results

All lesions tested reacted with epithelial membrane antigen, although often weakly and focally (Fig. 5) and with vimentin (Table 5). Rare lesions also exhibited focal immunoreactivity with keratin, CD34, and S-100 protein, although most were negative with these markers (Table 5). PCNA was positive to a variable degree and intensity in all cases tested (Fig. 6). Immunoreactivity was noted for progesterone receptors (n = 6) more frequently than for estrogen receptors (n = 3). There was no reactivity for glial fibrillary acidic protein and smooth muscle actin.

Treatment and Follow Up

All patients were treated by partial or complete surgical excision; complete surgical removal of the tumor was not always possible as a result of the complex anatomy of the nasal cavity and paranasal sinuses. Two patients received adjuvant radiation therapy (both were without disease at last follow up). The overall survival for sino-nasal tract meningiomas was excellent (Table 6). Follow-up data was available in 28 patients; two cases were contributed from foreign countries and were lost to additional follow up. Of these 28 patients, three had died with local disease (mean, 1.2 yrs). One female patient had a frontal sinus tumor with atypical histology and died within 1 month of sepsis. The remaining two female patients, both with nasal cavity tumors, one with sinus involvement, died with local disease as a result of sepsis, and both because of an inability to completely excise the tumor. One female patient was alive with residual disease 25.6 years after the initial presentation with the tumor involving the base of the skull region where complete surgical eradication of the tumor was complicated by the anatomic confines of the region. The remaining 24 patients were alive (n = 15, mean u 15.4 yrs) or had died of unrelated causes (n = 9, mean u 13.8 yrs) without evidence of disease (range, 0.1-30.1 yrs). This yielded a raw 5-year survival rate of 85.7%, a 5-year disease-free survival rate of 82.1%, and 10-year disease-free survival rate of 78.6%.

Six patients developed local disease recurrence ranging from a few weeks to 21 years after the initial presentation. Two of these patients had nasal cavity and nasopharyngeal tumors which invaded the base of the skull bone, making surgical extirpation difficult. It is our opinion that these two cases probably represented re-

![FIG. 1. Typical meningotheliomatous meningioma with a whorled syncytial architecture immediately below the respiratory epithelium. Psammoma bodies are identified.](image)
residual disease, because the tumors were present within a few weeks of the initial resection. These two patients died with disease at 3.5 and 0.1 years, respectively, after the initial presentation. Mastoiditis developed, seeding the peripheral blood to cause systemic sepsis, which resulted in their death. The remaining patients developed recurrences from 1 to 21 years after the initial surgery, all at the same site of the previous tumor, although usually more infiltrative in the recurrence specimen. One of these patients is alive with residual disease (25.6 yrs after presentation), two have died (10.7 and 30.1 yrs, respectively) without evidence of disease at the time of death, and one patient is alive without evidence of disease (14.0 yrs).

Clinicopathologic Correlations

Statistically, none of the clinical or pathologic features evaluated, including age (p = 0.327), gender (p = 0.277), symptoms at presentation (p = 0.789), radiographic evidence of bone erosion (p = 0.709), anatomic site (p = 0.347), macroscopic size (p = 0.244), benign or atypical overall histology (p = 0.481), microscopic evidence of bone invasion (p = 0.460), presence of an infiltrative growth pattern (p = 0.951), degree of cellular density (p = 0.446), loss of architecture (p = 0.818), degree of nuclear atypia (p = 0.518), presence of intranuclear pseudoinclusions (p = 0.577), degree of mitotic activity (p = 0.428), presence of psammoma bodies (p = 0.837), or number of PCNA-positive cells (p = 0.865), were significantly correlated to overall patient outcome or to risk of recurrence. While there were too few cases to analyze statistically, three cases with progesterone reactivity developed recurrent disease or died with evidence of disease, whereas only one case with estrogen receptor reactivity died with disease.

DISCUSSION

Arachnoid cells (arachnoid granulations, meningiocytes, meningothelial cells, pacchionian bodies) are thought to arise from neural crest and are therefore ectodermal or neuroectodermal in origin. They normally line the inner aspect of the arachnoid membrane and fill the cores of the arachnoid villi that project into the lumens of dural veins and venous sinuses. Furthermore,
increasing evidence supports the development of all meningiomas from neural crest tissues, whether intracranial or extracranial, even though there are a number of different mechanisms to suggest how extracranial meningiomas arise, including:

1. Arachnoidal cells are present in the sheaths of nerve or vessels where they emerge through the skull foramina.

2. Displaced pacchionian bodies become detached, pinched off, or entrapped during embryologic development in an extracranial location.

3. A traumatic event or cerebral hypertension that displaces arachnoid islets.

4. An origin from an undifferentiated or multipotential mesenchymal cells, such as fibroblasts, Schwann cells, or a combination of these, perhaps explaining the diverse pathologic spectrum found in meningiomas.

Consequently, by one mechanism or another, arachnoid cells are identified outside the neuraxis and give rise to meningiomas in the sinonasal tract.

Clinicopathologically, sinonasal tract meningiomas are usually divided into four groups (modified from the original publications), based on suggested etiologies proposed for the development of extracranial meningiomas.

1. Direct extension of a primary intracranial meningioma through pressure necrosis/absorption of the bone, or through an iatrogenic or natural opening (including the cribiform plate).

2. Extracranial metastasis from an intracranial meningioma.

3. Extracranial meningioma originating from arachnoid cell clusters in the sheaths of the cranial nerves (or vessels) as they exit through the foramina or suture lines of the skull, including the cribiform plate.

4. Extracranial meningioma without any apparent demonstrable connection with foramina, cranial nerves, or cranial primaries.

All of these mechanisms have been supported by reports in the literature, whereas we think all of our cases are covered by category three and four.

Up to 20% of intracranial meningiomas may have extracranial/extraspinal extension, including the orbit, middle ear, soft tissues, and skin of the head and neck, and upper airway involvement (nasal cavity, para-
nasal sinus, nasopharynx). However, when the orbit, middle ear, and soft tissues are excluded, the incidence decreases to less than 1%. Most of the reported cases involving the upper airway represent secondary extension from an intracranial lesion. Extracranial meningiomas arising from the sinonasal tract without any evidence of an association with an intracranial tumor (also called heterotopic, ectopic, or extracalvarial) are rare (Table 7). In our series, 30 sinonasal tract meningiomas made up only 0.17% of the benign or malignant primary sinonasal tract tumors seen in consultation at the AFIP. These findings support the rare nature of this neoplasm in the sinonasal tract.

In our series, sinonasal tract meningiomas were equally common in males and females, although the literature supports a slight female predominance, 1:1.2 (Table 7), or approximately 55%. In contrast to intracranial meningiomas in which male patients have a worse prognosis, all of the patients who died with sinonasal tract meningiomas in which male patients have a worse prognosis, whereas pressure necrosis may result in spread from one sinus to another.

The roentgenographic findings were usually nonspecific and included clouding or opacification of the sinuses, bony sclerosis, and focal destruction of the surrounding sinusoidal or nasal cavity bony tissues. Meningiomas often show a proclivity for local permeation of crevices, suture lines, and foramina of the skull, whereas pressure necrosis may result in spread from one sinus to another.

It may be difficult to demonstrate an intracranial component to the meningioma especially if there is a clinically silent (asymptomatic) or a radiographically obscure plaque growth, which creates a small dural or intracranial component, while the bulk of the tumor grows beyond the cranial vault. While six of our cases demonstrated an intracranial component, either radiographically at surgery or in postoperative work-up (type 1 or type 3, as outlined above), 24 cases were diagnosed as primary ectopic meningiomas of the sinonasal tract based on a lack of clinical, radiographic, operative, or follow-up data to support an intracranial lesion (type 4). It is simply impossible to accurately determine the point of origin of these cases (our series or the ones reported in the literature), and therefore we think two principle mechanisms account for sinonasal tract meningiomas which have a CNS connection: (1) the meningiomas may have arisen primarily in an extracranial position and extended secondarily into the cranial cavity, or (2) the meningiomas may have started intracranially and penetrated through the foramina and fissures so that the extracranial (sinonasal tract) extensions may be the first manifestation of the intracranial tumor. Based on our findings and the cases in the literature, primary extracranial meningiomas without any intracra-
nial component certainly exist, although none of our cases or those reported in the literature were confirmed to be ectopic meningiomas by postmortem examination of the skull.13,19,30,46,49

Like their intracranial counterparts, sinonasal tract meningiomas may exhibit a variety of different histologic patterns. However, most cases in this series were typical meningotheliomatous meningiomas composed of lobules of cells with indistinct borders and possessing generally bland nuclei with delicate chromatin. As in intracranial meningiomas, intranuclear pseudoinclusions and psammoma bodies were typical findings. Interestingly, features associated with an increased rate of recurrence in central nervous system meningiomas, including mitotic activity greater than four per 10 high-power fields, loss of architectural pattern, hypervascularity, necrosis, spindle cell formation, nuclear pleomorphism, and prominent nucleoli,8,9,45 were uncommon in sinonasal tract lesions and, when present, did not portend a worse prognosis. Moreover, an infiltrative growth pattern, as assessed both radiographically and histologically, identified in nearly all of our cases, did not have a bearing on overall patient outcome, whether using recurrence or death with disease as the end point. We did not identify any malignant meningiomas in our study, and, to our knowledge, found only a single case of sinonasal tract malignant meningioma.21 Despite their claims, based on their illustrations, we think the description of an angiofibroma, a lesion frequently misdiagnosed with proptosis. Both lesions have abundant psammoma bodies, but meningiomas lack associated osteoclasts and osteoblasts. Furthermore, the background stromal pattern of growth is storiform and more compact than a meningioma and does not have the same immunophenotypic characteristics as a meningioma. Carcinomas and melanomas generally exhibit unequivocal features of malignancy, which are distinctly uncommon in sinonasal tract meningiomas. However, in difficult cases, immunohistochemistry for cytokeratins, S-100 protein, and HMB45, respectively, should allow a distinction from meningioma. Olfactory neuroblastoma occurs in predominantly adolescent males, in a specific anatomic location, and is characterized by a collagenized background, haphazardly arranged vascular spaces, and stellate stromal cells. Paragangliomas are exceedingly rare in the sinonasal tract, and have a more organoid growth pattern with clear to basophilic cytoplasm surrounding hyperchromatic nuclei. Although occasionally paragangliomas may resemble meningiomas histologically, their immunophenotype (chromogranin-positive paraganglia cells and S-100 protein-positive sustentacular cells, EMA-negative) is distinctive and different from meningioma. Olfactory neuroblastoma occurs in the nasal vault and cribiform plate region, usually maintains a lobular growth pattern of small to intermediate cells with scant cytoplasm, has a fibrillary background, exhibits rosette and/or pseudorosette formations, and displays characteristic histochemical, immunohistochemical, and/or ultrastructural features that are easy to separate from meningiomas. An aggressive psammomatoind ossifying fibroma (formally called psammom-osteoid fibroma) is an uncommon lesion62 which may be confused with meningioma because both lesions occur in young to middle-aged patients and may be associated with proptosis. Both lesions have abundant psammoma bodies, but meningiomas lack associated osteoclasts and osteoblasts. Furthermore, the background stromal pattern of growth is storiform and more compact than a meningioma and does not have the same immunophenotypic characteristics as a meningioma. Carcinomas and melanomas generally exhibit unequivocal features of malignancy, which are distinctly uncommon in sinonasal tract meningiomas. However, in difficult cases, immunohistochemistry for cytokeratins, S-100 protein, and HMB45, respectively, should allow a distinction from meningiomas, which fail to stain with these markers.

In general, the prognosis of primary meningioma of the sinonasal tract appears to be excellent.19 In our study, there was little difference between the 5-year and 10-year disease-free survival rates (82.1% versus 78.6%, respectively), indicating that once the patients survived disease free for 5 years, they were unlikely to die with
tumor. Only a single patient was alive with disease at last follow up, and this patient had lived 25.6 years after the initial diagnosis with residual/recurrent tumor. This finding supports the slow, indolent growth of sinonasal tract meningiomas. Therefore, surgical extirpation of primary sinonasal tract meningiomas is the treatment of choice, without the necessity of adjuvant therapy. In our cases, and in those of the literature, when recurrences developed they usually arise in the same anatomic site as the primary lesion and probably represent residual disease rather than recurrent tumor. Additional surgery, if clinically feasible, is advisable, because radiation therapy does not always result in a clinical response. Metastatic disease did not occur in any of our patients nor did we find any convincing cases in the literature. Based on our series and a review of the literature, none of the clinical, radiographic, or pathologic features correlated with patient outcome, although female patients did tend to develop recurrent disease more frequently. If death with tumor does result, it is usually the result of involvement of the vital structures of the midfacial region or complications of the surgery rather than the aggressive nature of the tumor.

In summary, sinonasal tract meningiomas are uncommon lesions. The clinical and radiographic features of these tumors are nonspecific, and consequently an accurate diagnosis requires histologic evaluation. Histologically and immunohistochemically, sinonasal tract meningiomas are indistinguishable from their intracranial counterparts. An awareness of these characteristic pathologic and immunohistochemical features should allow distinction of these neoplasms from other sinonasal tract tumors. The clinical manifestations, radiographic findings, and histologic features do not accurately predict the clinical outcome, even though, with complete surgical extirpation, sinonasal tract meningiomas have an overall good prognosis.

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REFERENCES


