Primary Malignant Melanoma of the Sinonasal Cavity: MR Imaging Evaluation

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To evaluate the magnetic resonance (MR) imaging characteristics of primary malignant melanoma of the sinonasal cavity, T1- and T2-weighted MR images of 12 patients with primary sinonasal melanoma were retrospectively reviewed. Gadolinium-enhanced imaging was performed in seven cases. The MR images were compared with histopathologic results. There were seven melanotic melanomas and five amelanotic melanomas; hemorrhage was present in three melanotic and two amelanotic melanomas. The seven melanotic melanomas were hyperintense to gray matter on T1-weighted images (whether hemorrhage was present or not), consistent with the paramagnetic effect of melanin. Four of the five amelanotic melanomas had intermediate signal intensity on T1-weighted images; one was not detected. On T2-weighted images, all of the melanomas detected had intermediate though variable signal intensity compared with that of gray matter. On gadolinium-enhanced images, all cases demonstrated mild to moderate enhancement. The signal intensity of sinonasal melanoma appears to vary according to the histopathologic components of the tumor. High signal intensity within the lesion on T1-weighted images suggests the presence of melanin.

Abbreviation: TR = repetition time

Index terms: Gadolinium, 25.12143, 261.12143 • Melanoma, 23.371, 261.371 • Nose, neoplasms, 261.371
Paranasal sinuses, neoplasms, 23.471

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Table 1
Signal Intensity Characteristics of 11 Sinonasal Cavity Melanomas*

<table>
<thead>
<tr>
<th>Image and Tumor Type</th>
<th>Relative Signal Intensity†</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Versus That of Fat</td>
</tr>
<tr>
<td>T1-weighted</td>
<td></td>
</tr>
<tr>
<td>All types (n = 11)</td>
<td>&gt;</td>
</tr>
<tr>
<td>Melanotic (n = 7)</td>
<td>0</td>
</tr>
<tr>
<td>Nonhemorrhagic and</td>
<td>0</td>
</tr>
<tr>
<td>melanotic (n = 4)</td>
<td>4</td>
</tr>
<tr>
<td>T2-weighted</td>
<td></td>
</tr>
<tr>
<td>All types (n = 11)</td>
<td>1</td>
</tr>
<tr>
<td>Melanotic (n = 7)</td>
<td>1</td>
</tr>
<tr>
<td>Nonhemorrhagic and</td>
<td>0</td>
</tr>
<tr>
<td>melanotic (n = 4)</td>
<td>4</td>
</tr>
</tbody>
</table>

*One tumor (an amelanotic melanoma) was not visualized.
† > indicates greater than, < indicates less than, = indicates equal to.

INTRODUCTION

Malignant melanoma arising from the mucosa of the nasal cavity and paranasal sinuses is rare, constituting less than 4% of sinonasal neoplasms and accounting for only approximately 1% of all malignant melanomas (1). The epithelium of the sinonasal cavity is ectodermally derived, which could explain the origin of primary (extracutaneous) malignant melanoma in this location (1,2). Melanocytes migrating from the neural crest may account for the presence of melanoma in the sinonasal cavity.

Early detection, diagnosis, and treatment of sinonasal melanoma is beneficial for longer patient survival (1). When imaging can suggest the pathologic nature of a sinonasal lesion, delays in diagnosis can be avoided. Often, the imaging algorithm for a sinonasal mass leads to magnetic resonance (MR) imaging. To evaluate the MR imaging characteristics of primary malignant melanoma of the sinonasal cavity, the MR imaging findings in 12 cases of this tumor were compared with histopathologic results and results of clinical staging.

MATERIALS AND METHODS

During the past 4 years, 12 cases of histologically proved primary malignant melanoma of the sinonasal cavity were evaluated with MR imaging at four institutions. The patients were seven men and five women aged 49-81 years (mean age, 68.4 years). They presented most commonly with epistaxis (n = 7) or nasal fullness or congestion (n = 6).

All MR images were obtained on a 1.5-T imager (Signa; GE Medical Systems, Milwaukee, Wis) with a quadrature head coil or an anterior-posterior volume neck coil (Medical Advances, Milwaukee, Wis). T1-weighted images (repetition time [TR] msec/echo time msec = 500-800/11-30; one or two signals averaged) were obtained in the axial, coronal, and sagittal planes. Long TR fast spin-echo images (2,500-3,500/18-30, 70-108) were obtained in the axial and coronal planes. In seven cases, gadopentetate dimeglumine (Berlex Industries, Wayne, NJ) was administered at a dose of 0.1 mmol/kg and T1-weighted images were obtained immediately after administration. All MR images were obtained with a 256 × 192 matrix, 5-mm-thick sections, and inferior saturation pulses. Intersection gaps of 2-2.5 mm were standard for long TR images; the short TR images were obtained with no intersection gaps.

We used a modification of a classification system suggested by Freedman et al in 1973 (3). This modified classification system is as follows: A stage T1 tumor is limited to one site in the nasal cavity. A stage T2 tumor spreads into other nasal structures or the palate. A stage T3 tumor extends beyond the ipsilateral nasal cavity into the maxillary or ethmoid sinus, contralateral nasal cavity, or skin. A stage T4 lesion extends to the orbit, pterygopalatine fossa, brain, or sphenoid sinus.
Table 2
Clinical and Histopathologic Data on 12 Patients with Sinonasal Cavity Melanoma

<table>
<thead>
<tr>
<th>Patient/ Age (y)/ Sex</th>
<th>Presentation</th>
<th>Primary Tumor Location</th>
<th>Tumor Cell Type*</th>
<th>Melanin</th>
<th>Hemorrhage</th>
<th>Necrosis</th>
<th>Tumor Stage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/66/M</td>
<td>Epistaxis</td>
<td>Right anterior nasal vestibule</td>
<td>Epithelioid</td>
<td>Present</td>
<td>Present</td>
<td>Present</td>
<td>T1</td>
</tr>
<tr>
<td>2/70/M</td>
<td>Epistaxis</td>
<td>Left upper nasal cavity</td>
<td>Epithelioid</td>
<td>Present</td>
<td>Present</td>
<td>Absent</td>
<td>T3</td>
</tr>
<tr>
<td>3/49/M</td>
<td>Blurry vision on left side for 2 mo</td>
<td>Left upper nasal cavity</td>
<td>Large pleomorphic epithelioid</td>
<td>Absent</td>
<td>Present</td>
<td>Absent</td>
<td>T4</td>
</tr>
<tr>
<td>4/61/M</td>
<td>Nasal fullness, hyposmia</td>
<td>Right upper nasal cavity</td>
<td>Epithelioid</td>
<td>Absent</td>
<td>Present</td>
<td>Present</td>
<td>T3</td>
</tr>
<tr>
<td>5/66/F</td>
<td>Epistaxis for 3 mo</td>
<td>Right nasal septum</td>
<td>Spindle cell</td>
<td>Absent</td>
<td>Absent</td>
<td>Absent</td>
<td>T1</td>
</tr>
<tr>
<td>6/78/M</td>
<td>Epistaxis</td>
<td>Left upper nasal cavity</td>
<td>Epithelioid</td>
<td>Present</td>
<td>Present</td>
<td>Absent</td>
<td>T4</td>
</tr>
<tr>
<td>7/69/F</td>
<td>Nasal obstruction, epistaxis</td>
<td>Right nasal cavity</td>
<td>NA</td>
<td>Present</td>
<td>Absent</td>
<td>Absent</td>
<td>T4</td>
</tr>
<tr>
<td>8/75/F</td>
<td>Epistaxis</td>
<td>Right maxillary sinus</td>
<td>NA</td>
<td>Present</td>
<td>Absent</td>
<td>Absent</td>
<td>T4</td>
</tr>
<tr>
<td>9/75/F</td>
<td>Congestion</td>
<td>Left maxillary sinus</td>
<td>NA</td>
<td>Absent</td>
<td>Absent</td>
<td>Absent</td>
<td>T1/T4</td>
</tr>
<tr>
<td>10/75/M</td>
<td>Nasal obstruction, epistaxis</td>
<td>Left inferior concha</td>
<td>Epithelioid</td>
<td>Present</td>
<td>Absent</td>
<td>Absent</td>
<td>T1</td>
</tr>
<tr>
<td>11/62/F</td>
<td>Nasal obstruction</td>
<td>Left nasal cavity</td>
<td>Epithelioid</td>
<td>Present</td>
<td>Absent</td>
<td>Absent</td>
<td>T3</td>
</tr>
<tr>
<td>12/81/M</td>
<td>Nasal obstruction</td>
<td>Left upper nasal cavity</td>
<td>Epithelioid</td>
<td>Absent</td>
<td>Absent</td>
<td>Absent</td>
<td>T3</td>
</tr>
</tbody>
</table>

* NA = not available.
† Tumor not identified at imaging.
‡ T1 at first MR imaging examination, T4 at second MR imaging examination.

The signal intensity of the tumor relative to those of adjacent fat, gray matter, white matter, and muscle was carefully evaluated on the T1- and T2-weighted images and recorded (Table 1). The images were analyzed by a single reviewer (D.M.Y.) on two occasions spaced over 6 months. When a discrepancy was found between the first and second readings of the T1- or T2-weighted images (four occasions out of 176 readings), a second reviewer (C.L.) provided the tie-breaking vote.

Gadolinium enhancement was graded by comparison with adjacent mucosal and muscle uptake. Tumor uptake as avid as that of adjacent inflamed mucosa was graded as marked enhancement. Tumor uptake similar to that of muscle was graded as mild enhancement. Tumor uptake between that of muscle and inflamed mucosa was graded as moderate enhancement.

The pathologic specimens were retrospectively reevaluated in all cases. The specimens were analyzed for the predominant cell type of the tumor and the presence of melanin, hemorrhage, and necrosis.

RESULTS
Clinical staging and histopathologic data on our 12 patients with primary malignant melanoma of the sinonasal cavity are summarized in Table 2.

Ten of the 12 tumors were thought to arise from the nasal cavity, but growth often extended into the paranasal sinuses (only four cases were stage T1 at presentation). Two tumors appeared to arise in the maxillary antrum. There was one case of multifocal disease (patient 10).
There were seven melanotic melanomas (Figs 1-4) and five amelanotic melanomas (Figs 5, 6). Five of the tumors demonstrated hemorrhage (Figs 3-6); three of these also demonstrated extensive melanin formation. Two of the melanomas were necrotic (Figs 4, 5).

One in situ amelanotic melanoma was not detected at imaging (patient 5). At histopathologic analysis, the tumor cells were infiltrating the mucosa and submucosa without hemorrhage, necrosis, or invasion of nasal cartilage. Even at retrospective review of the MR images and accompanying computed tomographic (CT) scans, the reviewer could not detect an abnormality.

The typical appearance of the seven melanotic melanomas on T1-weighted MR images was high signal intensity whether hemorrhage was present (n = 3) or not (n = 4). All seven were iso- or hyperintense to gray matter and muscle, and six were also hyperintense to white matter (Table 1). On T2-weighted images, the signal intensity was more variable: The melanotic melanomas were hypo-, hyper-, or isointense to gray and white matter, but all were hyperintense to muscle. The four non-hemorrhagic melanotic melanomas were all hypointense to fat and hyperintense to gray matter, white matter, and muscle on T1-weighted images. All four were hypointense to fat, gray matter, and white matter and hyperintense to muscle on T2-weighted images.

Figure 1. Melanotic melanoma without hemorrhage in a 69-year-old woman (patient 7). (a) Unenhanced coronal T1-weighted MR image through the anterior nasal cavity shows an expansile hyperintense mass (*) with heterogeneous texture in the right nasal cavity. (b) Axial T2-weighted MR image shows that the mass (*) has very low signal intensity and extends into the maxillary and sphenoid sinuses. The high-signal-intensity area in the right maxillary sinus is due to an obstructed secretion (S).

Figure 2. Natural progression of multifocal melanotic melanoma in a 75-year-old man (patient 10). (a) Unenhanced axial T1-weighted MR image shows a small focal lesion (arrow) along the inferior turbinate. (b) Coronal T1-weighted MR image shows that the lesion (arrowhead) is lobulated and of limited extent. The high signal intensity is suggestive of melanin within the lesion. (c) Unenhanced T1-weighted MR image shows a second focus of melanoma (arrow) in the left ethmoid sinus. This lesion is also hyperintense. (d) Long TR MR image shows that the left ethmoid sinus mass (arrow) has low signal intensity. (e) Axial MR image obtained 2½ years later shows marked growth of the tumor (T) with infiltration of the left orbit, proptosis, and growth into the ethmoid sinuses. The tumor remains hyperintense to cortical gray matter. (f) Corresponding T2-weighted MR image shows that the tumor (T) has low signal intensity relative to that of gray matter. The high signal intensity anteriorly and within the right ethmoid sinus is probably due to mucosal edema and retained secretions. (g) Gadolinium-enhanced coronal MR image shows moderate enhancement of the tumor (T). However, grading of enhancement is difficult when the lesion is hyperintense on the unenhanced short TR image.
Figure 3. Melanotic melanoma with hemorrhage in a 78-year-old man (patient 6). (a) T1-weighted MR image shows an anterior sinonasal mass (*) with high signal intensity. The mass should therefore contain melanin. (b) T2-weighted MR image shows that the lesion (*) is isointense to gray matter and does not have the signal intensity characteristics of either deoxyhemoglobin (very low signal intensity on T2-weighted images) or methemoglobin (very low signal intensity if intracellular and very high signal intensity if extracellular). Nevertheless, the lesion demonstrated hemorrhage as well as melanin. (c) Photomicrograph (original magnification, ×132; hematoxylin-eosin stain) shows melanin as brown staining (arrows) within the tumor cells. There is a mild amount of melanin. (d) Photomicrograph (original magnification, ×40) obtained with an S100 immunohistochemical stain shows marked uptake (brown staining) in the tumor cells, which denotes melanocytic derivation. (e) Photomicrograph (original magnification, ×40; S100 stain) of a specimen from another patient (patient 2) shows much more striking melanin deposition. (f) Photomicrograph (original magnification, ×40; hematoxylin-eosin stain) of the tumor in e also shows considerable acute hemorrhage (straight arrows) and hemosiderin deposition (curved arrows).
Figures 4, 5. (4) Nasal hemorrhagic melanotic melanoma with necrosis in a 66-year-old man (patient 1). (a) Sagittal T1-weighted MR image shows a hyperintense mass (arrow) anteriorly within the nasal cavity. (b) Fast spin-echo T2-weighted MR image without fat saturation shows high signal intensity, which is unusual for a melanin-containing melanoma. The lesion was markedly necrotic, which probably accounts for the high signal intensity. (5) Extensive hemorrhagic necrotic amelanotic melanoma in a 61-year-old man (patient 4). (a) Sagittal T1-weighted MR image through the right nasal cavity shows a homogeneous mass (*) filling the right anterosuperior nasal cavity and right ethmoid air cells. (b) Axial T2-weighted MR image shows an intermediate-signal-intensity mass (*) filling the right nasal cavity and ethmoid sinuses. The mass is hyperintense to gray matter. The area of very high signal intensity posteriorly represents obstructed secretions (arrowhead). (c) Photomicrograph (original magnification, ×40; hematoxylin-eosin stain) shows necrosis (*) and hemosiderin deposition (arrowheads) in the melanoma (arrows).
The amelanotic melanomas that were visible at MR imaging (four of five) had low signal intensity on T1-weighted images whether they were hemorrhagic \((n = 2)\) or not \((n = 2)\). The signal intensity characteristics differed from those of the nonhemorrhagic melanotic melanomas: The amelanotic melanomas were less likely to be hyperintense to gray or white matter on T1-weighted images and were more often isointense to gray matter on T2-weighted images (three of four cases). The amelanotic melanomas with hemorrhage were not distinguishable from those without hemorrhage.

Among the seven cases (four melanotic melanomas and three amelanotic melanomas) evaluated with gadolinium-enhanced imaging, four showed moderate enhancement and three showed mild enhancement. Enhancement was often difficult to grade when the tumor was hyperintense on unenhanced images. Nonetheless, it was noted that two of the melanotic melanomas showed moderate enhancement and two showed minimal enhancement. Two amelanotic melanomas showed moderate enhancement, and one showed minimal enhancement.

**DISCUSSION**

Malignant melanoma is uncommon in the nasal cavity and paranasal sinuses. In fact, in a recent exhaustive listing of over 30 nasal masses in a review article in the radiology literature \((4)\), melanoma was not even mentioned. Less than 1\% of all melanomas arise in the nasal cavity or adjacent sinuses. In a review of 1,546 cases of malignant melanoma \((5)\), only nine cases \((0.6\%)\) originated in the sinonasal area. Mucosal melanoma arises more often in the nasal cavity than in the paranasal sinuses, with the anterior nasal septum, lateral nasal wall, and inferior turbinate being the preferred sites \((6)\). In the paranasal sinuses, the maxillary antrum is the most likely site.

Nasal bleeding with obstruction is the most common presenting symptom. Others include deformity of the nose, hyposmia, facial pain, and visual disturbance. There is a slightly greater incidence of these tumors in men, and the peak incidence is in the 5th to 7th decades.

**Figure 6.** Amelanotic melanoma with hemorrhage in a 49-year-old man (patient 3). (a) Coronal T1-weighted MR image shows a low-signal-intensity tumor \((T)\) in the left nasal cavity and ethmoid sinus that protrudes into the left maxillary antrum. (b) T2-weighted MR image shows that the tumor \((T)\) has low signal intensity—in contrast with the high-signal-intensity retained secretions in the aerated left pterygoid air cell and the gray matter—even though the lesion has no melanin within it. This combination of signal intensities on T1- and T2-weighted images is unusual for hemorrhage, yet histopathologic analysis demonstrated moderate intratumoral hemorrhage. (c) Gadolinium-enhanced MR image shows a mildly enhancing mass extending into the left sinonasal cavity. The extension into the superomedial orbit (arrow) makes this a stage T4 lesion.
of life (1,2). About one-third of these melanomas are amelanotic lesions, and the tumor may be multifocal (6). Rapid growth occurs with mucosal melanomas. This may account for the poor prognosis associated with sinonasal melanoma (mean survival, approximately 24 months) (7).

The signal intensity characteristics of melanoma elsewhere in the body have been reported (8-11). Melanotic melanoma is expected to have high signal intensity on T1-weighted images and low signal intensity on T2-weighted images owing to the paramagnetic properties of melanin (10). While some researchers believe that the T1 shortening effect is due to free radical formation (8,10), others believe that this shortening is derived from paramagnetic metal ions (such as Fe2+) bound to the melanin (12). However, a few recent articles (13-15) reported sinonasal melanomas without these signal intensity characteristics, some melanotic, others not (13,14). In fact, one article (14) suggested that the T1 shortening associated with melanoma reflects the presence or absence of hemorrhage rather than melanin content. Our results do not agree with this conclusion, since nonhemorrhagic melanotic melanomas were hyperintense and two hemorrhagic amelanotic melanomas were not hyperintense. In an in vitro study, Enoch et al (12) showed that hemorrhage need not be implicated to explain the T1 shortening behavior of melanin-containing compounds. In addition, we believe that the signal intensity characteristics are inherent to melanin, not blood.

The characteristics of melanoma on T2-weighted images are much more variable. Some lesions are reported to be hypointense (8,10,16,17), but others are reported to be iso- or hyperintense (9,10,13,15). Some of these discrepancies are due to lack of an internal standard and to use of fast (or turbo) spin-echo (rapid acquisition with relaxation enhancement [RARE]) T2-weighted imaging in some cases, since this technique is less sensitive to the presence of hemorrhage. Uveal melanoma is hypointense to vitreous humor on T2-weighted images because the signal intensity of vitreous humor is as high as that of cerebrospinal fluid. When compared with muscle, which is very hypointense on T2-weighted images, melanoma is hyperintense. For this reason, we chose to compare signal intensity characteristics with those of adjacent fat, muscle, gray matter, and white matter. We recommend use of the gray matter as the best internal standard, since nonhemorrhagic melanotic melanomas were distinguished from amelanotic melanomas by being hyperintense to gray matter on T1-weighted images and hypointense to gray matter on T2-weighted images. In contrast, nonhemorrhagic melanotic melanomas and hemorrhagic melanotic melanomas were more likely to be isointense or hyperintense to gray matter on T2-weighted images. These patterns should hold true for both fast and conventional spin-echo T2-weighted imaging.

A recent study by Isiklar et al (18) of 30 patients with melanoma metastatic to the brain sheds some light on the confusion with regard to the signal intensity characteristics of melanoma. Masses that were hyperintense to gray matter on T1-weighted images and hypointense to gray matter on T2-weighted images had a larger number of melanin-containing cells than those with other combinations of signal intensities. In other words, highly melanotic masses (over 10% melanin-containing cells) were more likely to be hyperintense to gray matter on T1-weighted images and hypointense to gray matter on T2-weighted images (87.5%) than were those with minimal melanin (<10% melanin-containing cells) (14.3%) or no melanin (0%) (18). Thus, the signal intensity characteristics of melanoma may depend not on classification as melanotic or amelanotic but on how much melanin is present.

When one identifies a hyperintense mass on a T1-weighted image of the sinonasal cavity, the differential diagnosis is limited: (a) a hemorrhagic process, (b) fungal disease, (c) hyperproteinaceous secretions or mucocele, or (d) a fat-containing lesion. Gadolinium enhancement may be particularly useful in this scenario, since inflammatory lesions usually will not enhance in a solid fashion (though inflamed mucosa may enhance in a peripheral pattern) and lipomatous lesions will often not enhance at all. Use of fat-suppressed imaging may also eliminate confusion caused by fatty lesions. Hemorrhagic masses may have signal intensity characteristics similar to those of melanoma, and clearly melanomas may bleed. Other hemorrhagic lesions to be considered include hemorrhagic metastasis (eg, from primary malignancies of the thyroid, lung, breast, or kidney) or hemorrhagic primary sinonasal masses (eg, hemangioma, lymphangioma, and juvenile angiofibroma). Fortunately, the pigmented nature of melanoma may be fairly obvious at nasal endoscopy. Endoscopic findings and silver stains may also eliminate any confusion between fungal masses and melanoma (which may have similar signal intensity "signatures").
With respect to amelanotic melanoma, the MR imaging appearance is nonspecific. Squamous cell carcinoma, adenocarcinoma, and minor salivary gland malignancies may simulate amelanotic melanoma, as can inverted papilloma and olfactory neuroblastoma. Plasmacytoma and fibro-osseous lesions may also occur in the sinonasal cavity and may have comparable MR imaging characteristics. Chondrosarcoma may have characteristic whorls of calcification on a CT scan, allowing differentiation of this lesion, and some olfactory neuroblastomas may also have a calcified matrix, which would be unusual for an amelanotic melanoma. Particularly in this clinical setting, CT results may add specificity to the histologic diagnosis predicted with MR imaging. CT also has a paramount role in planning the surgical resection of sinonasal masses, since the integrity of the sinonasal, orbital, carotid, optic canal, and skull base walls must be assessed before the operation. Since many upper nasal vault masses require craniofacial resection performed by a combination of head and neck surgeons and neurosurgeons, the maximum amount of information available is required before this laborious operation is undertaken. MR imaging and CT have complementary roles in tumor mapping: The former is superior in differentiating obstructed secretions from neoplasm, and the latter is superior in defining bony landmarks.

In summary, sinonasal melanoma is an uncommon mass that is usually seen in the nasal cavity in older individuals with epistaxis or nasal congestion. The signal intensity of this lesion may be perplexing due to the variable amounts of melanin in the lesion coupled with concomitant hemorrhage or necrosis, but the characteristic high signal intensity on T1-weighted images appears to be intrinsic to the melanin content of the mass. High signal intensity (relative to that of gray matter) on T1-weighted images and low signal intensity on T2-weighted images is the most common pattern for a nonhemorrhagic melanotic melanoma, but in most cases the endoscopic results make the histopathologic diagnosis self-evident.

**REFERENCES**