Endoscopic and Open Surgical Approaches to Locally Advanced Sinonasal Melanoma Comparing the Therapeutic Benefits

Warren Sweeney, MD; Shlomo Koyfman, MD; Joseph Scharpf, MD; Raj Sindwani, MD; John Greskovich, MD; Ernest Borden, MD; Brian B. Burkey, MD

**IMPORTANCE** This study helps to elucidate the appropriate surgical treatment for sinonasal melanoma.

**OBJECTIVE** To compare open resection (OR) and endoscopic resection (ER) as surgical approaches to sinonasal mucosal melanoma (SNM) and evaluate their associations with treatment-related outcomes.

**DESIGN, SETTING, AND PARTICIPANTS** Retrospective review of the medical records of 25 patients with sinonasal mucosal melanoma (SNM) treated by either OR or ER in an academic tertiary care medical center.

**INTERVENTIONS** The patients underwent either OR or ER of their SNM tumors.

**MAIN OUTCOMES AND MEASURES** Overall survival was the primary outcome measured; secondary outcomes were postoperative complications, lengths of hospital stay, patterns of failure, and disease-free survival.

**RESULTS** Thirteen patients with SNM underwent an OR, while 12 had ER of their tumors. The OR and ER groups did not differ significantly in demographic and tumor characteristics. In the OR vs ER group comparisons, mean age (67.8 vs 65.5 years) \((P = .63)\), the proportions of patients who received adjuvant radiotherapy (85\% [n = 11] vs 92\% [n = 11]) \((P > .99)\), and the proportion who achieved negative surgical margins on resection (54\% [n = 7] vs 58\% [n = 7]) \((P = .82)\) were similar. Overall, the median survival (12.7 and 1.9 years) \((P = .87)\) and disease-free survival (1.9 and 1.2 years) \((P = .72)\) were modest and did not differ between OR and ER groups, respectively. Likewise, the OR and ER groups, respectively, showed comparable mean lengths of hospital stay (3.6 and 3.8 days) \((P = .87)\), rates of postoperative bleeding (8\% [n = 1] and 17\% [n = 2]) \((P = .59)\), and rates of cerebrospinal fluid leak (15\% [n = 2] and 25\% [n = 3]) \((P = .64)\). In addition, the OR and ER groups, respectively, had high rates of local (23\% [n = 3] and 8\% [n = 1]) \((P = .59)\), distant (15\% [n = 2] and 25\% [n = 3]) \((P = .64)\), and multiple failures (15\% [n = 2] and 25\% [n = 3]) \((P = .64)\).

**CONCLUSIONS AND RELEVANCE** This retrospective study of a rare disease suggests that endoscopic resection of sinonasal melanoma offers an attractive, minimally invasive surgical option. In the hands of an experienced surgeon, an endoscopic approach yields survival and morbidity outcomes comparable to those of an open approach.

**Author Affiliations:** Department of Otolaryngology, Henry Ford Hospital, Detroit, Michigan (Sweeney); Department of Radiation Oncology, Taussig Cancer Center, Cleveland Clinic Foundation, Cleveland, Ohio (Koyfman, Greskovich, Borden); Head and Neck Institute, Cleveland Clinic Foundation, Cleveland, Ohio (Scharpf, Sindwani, Burkey).

**Corresponding Author:** Warren Sweeney, MD, Department of Otolaryngology, Henry Ford Hospital, 2799 W Grand Blvd, Detroit, MI 48202 (wsweeney1@hfhs.org).
An endoscopic approach to the treatment of sinonasal malignant neoplasms has become more common in recent years. The promise of lower complication rates along with disease-free and overall survival outcomes comparable to those of an open approach make it an appealing prospect. Case series and institutional reports have heralded an endoscopic approach as a viable treatment option for those patients with sinonasal malignant lesions in general. This is especially true for the more common diseases of squamous cell carcinoma and adenocarcinoma. However, there is a paucity of data examining the endoscopic approach in sinonasal mucosal melanoma (SNM).

One of the more rare cancers, SNM accounts for around 5% of all malignant neoplasms of the nasal cavity and paranasal sinuses. It affects men slightly more often than women and often presents in the sixth decade of life. A subtype of melanoma, mucosal melanoma of the sinonasal region accounts for less than 1% of all melanomas and has a high rate of metastasis and poor prognosis. Since it is a rare entity, SNM is often included in studies of treatment strategies for other sinonasal malignant lesions. However, SNM carries a worse prognosis, with low 5-year overall survival rates of 20% to 50% and median survival of about 2 years compared to 83% for adenocarcinoma, 54% for squamous cell carcinoma, and 70% for adenoid cystic carcinomas. Furthermore, achieving local control of SNM is difficult; it has a high propensity for metastasis and a 2-year disease-free survival rate of around 30%. In addition, the incidence of SNM continues to increase, further highlighting the importance of optimizing treatment strategies.

The advent of endoscopic surgery for sinonasal tumors was met with concern given the piecemeal nature of endoscopic resections and the fear that this violation of the traditional oncologic operative principles of an en bloc technique may compromise outcomes. This is especially concerning for SNM, since obtaining negative margins and adequate local control has prognostic implications, and SNM already carries a relatively high risk for false-negative interpretations of frozen margins. These concerns are counterbalanced by the potential benefits of endoscopic resection, including potentially lower complication rates, a more tolerable procedure, and improved cosmesis for patients. In addition, while the use of adjuvant radiotherapy is still debatable, there is some evidence to suggest that adjuvant irradiation may help with local control. Finally, endoscopic resection may allow for future salvage surgery if needed.

While the arguments on both sides abound, there is a paucity of data addressing the efficacy of endoscopic surgery for SNM. We review herein our 15-year experience with both operative endoscopic and open approaches to SNM and compare our outcomes.

Methods

Our study was approved by the Cleveland Clinic institutional review board; informed consent was waived. We conducted a retrospective review of medical records for patients with SNM treated with primary surgery at the Cleveland Clinic between 1998 and 2012. Patient, tumor, and treatment details were extracted from our Head and Neck Tumor Registry and the medical record. We used data from the full time span, since endoscopic surgery was widely being used to treat sinonasal malignant lesions by the mid-1990s. The choice of surgery was determined by physician discretion.

Patient factors that were studied included age, sex, race, comorbidities (diabetes, hypertension, and vasculopathy), total smoking pack-years, and prevalence of alcohol abuse. Tumor characteristics were categorized according to the 2010 American Joint Committee on Cancer (AJCC) staging system for SNM. All patients were retrospectively restaged by this system according to their operative and pathologic reports. Treatment details were abstracted as follows: patients with SNM who had undergone primary surgical treatment were then grouped by surgical procedure performed, either OR or ER. Open resection included mid-face degloving, craniofacial resection, the Caldwell-Luc procedure, and lateral rhinotomy approaches. Endoscopic procedures included endoscopic skull base resection, ethmoidectomy, maxillectomy, and sphenoidectomy. Patients who underwent an initial ER that was converted to an OR were placed in the OR group.

Prior surgery included open and endoscopic approaches and did not include biopsies. Margin status was obtained from pathology reports. Total radiation dose, fractionation, and technique were obtained from the medical record. Traditional and immunotherapy treatments were grouped into 1 category. Toxic effects were categorized into postoperative complications and treatment-related toxic effects up to 90 days after treatment. These complications included prolonged length of stay after primary surgery, bleeding (the occurrence of intraoperative bleeding >1 L or the need for transfusion), cerebrospinal fluid (CSF) leak either intraoperatively or postoperatively, optic injury, postoperative infection, and death.

Finally, we evaluated treatment failure in both groups, defined as pathologically proven disease recurrence after the primary surgery. Primary failure was defined as the first location at which disease recurrence was noted. Any tumor recurring in the sinonasal region was considered a recurrence at the primary site, while cervical lymph node disease was classified as regional lymph node recurrence. All other locations were considered distant metastases. Disease-free and overall survival rates were calculated from the date of primary surgery until recurrence or death, respectively.

Statistical analysis was carried out using JMP Pro software, version 10 (SAS Institute Inc). For continuous data, means and standard deviations (SDs) were calculated and compared with a t test. Categorical data were displayed as the number of patients and the proportion of their group. We performed a Fisher exact test on all categorical data where at least 1 group totaled 5 or fewer patients. A χ² test was used on all other categorical data. Kaplan-Meier survival curves were generated for both disease-free and overall survival, and data were censored at last follow-up if treatment failure or patient death had not occurred by that time. All statistical tests of significance were analyzed as 2 sided, with P < .05 considered significant.
Table 1. Patient Demographic and Tumor Characteristics

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Open Resection (n = 13)</th>
<th>Endoscopic Resection (n = 12)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, mean (SD)</td>
<td>67.8 (11.8)</td>
<td>65.5 (12.5)</td>
<td>.63</td>
</tr>
<tr>
<td>Sex</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>8 (62)</td>
<td>6 (50)</td>
<td>.70</td>
</tr>
<tr>
<td>Female</td>
<td>5 (39)</td>
<td>6 (50)</td>
<td></td>
</tr>
<tr>
<td>Race</td>
<td></td>
<td></td>
<td>&gt; .99</td>
</tr>
<tr>
<td>White</td>
<td>12 (92)</td>
<td>12 (100)</td>
<td></td>
</tr>
<tr>
<td>African American</td>
<td>1 (8)</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Comorbidities</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diabetes</td>
<td>1 (8)</td>
<td>1 (8)</td>
<td>&gt; .99</td>
</tr>
<tr>
<td>Hypertension</td>
<td>8 (62)</td>
<td>5 (42)</td>
<td>.43</td>
</tr>
<tr>
<td>Vasculopathy</td>
<td>2 (15)</td>
<td>2 (17)</td>
<td>&gt; .99</td>
</tr>
<tr>
<td>Smoking history, mean (SD) pack-years</td>
<td>13.3 (27.9)</td>
<td>13.2 (15.1)</td>
<td>.99</td>
</tr>
<tr>
<td>Alcohol abuse</td>
<td>1 (8)</td>
<td>2 (17)</td>
<td>.59</td>
</tr>
<tr>
<td>Follow-up, mean (SD), y</td>
<td>3.9 (3.0)</td>
<td>2.7 (4.6)</td>
<td>.43</td>
</tr>
<tr>
<td>Tumor TNM stage</td>
<td></td>
<td></td>
<td>.35</td>
</tr>
<tr>
<td>III</td>
<td>4 (31)</td>
<td>5 (42)</td>
<td></td>
</tr>
<tr>
<td>IVA</td>
<td>5 (39)</td>
<td>1 (8)</td>
<td></td>
</tr>
<tr>
<td>IVB</td>
<td>3 (23)</td>
<td>5 (42)</td>
<td></td>
</tr>
<tr>
<td>IVC</td>
<td>1 (8)</td>
<td>1 (8)</td>
<td></td>
</tr>
<tr>
<td>Tumor location</td>
<td></td>
<td></td>
<td>.46</td>
</tr>
<tr>
<td>Nasal cavity</td>
<td>7 (54)</td>
<td>10 (83)</td>
<td></td>
</tr>
<tr>
<td>Sinus</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ethmoid</td>
<td>2 (15)</td>
<td>1 (8)</td>
<td></td>
</tr>
<tr>
<td>Maxillary</td>
<td>3 (23)</td>
<td>1 (8)</td>
<td></td>
</tr>
<tr>
<td>Sphenoid</td>
<td>1 (8)</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Prior surgery</td>
<td>3 (23)</td>
<td>3 (25)</td>
<td>&gt; .99</td>
</tr>
</tbody>
</table>

*Unless otherwise noted, data are reported as number (percentage) of patients. Percentages may not total 100% due to rounding.

Table 2. Adjuvant Treatment Details

<table>
<thead>
<tr>
<th>Adjuvant Treatment</th>
<th>Open Resection (n = 13)</th>
<th>Endoscopic Resection (n = 12)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radiation therapy</td>
<td>11 (85)</td>
<td>11 (92)</td>
<td>&gt; .99</td>
</tr>
<tr>
<td>Dose, mean (SD), Gy</td>
<td>43.5 (20.5)</td>
<td>51.3 (15.4)</td>
<td>.35</td>
</tr>
<tr>
<td>Systemic/immunotherapy</td>
<td>5 (39)</td>
<td>1 (8)</td>
<td>.16</td>
</tr>
<tr>
<td>Negative margin status</td>
<td>7 (54)</td>
<td>7 (58)</td>
<td>.82</td>
</tr>
</tbody>
</table>

*Unless otherwise noted, data are reported as number (percentage) of patients. Percentages may not total 100% due to rounding.

Results

Patient Demographic and Tumor Characteristics

Twenty-five patients were identified and stratified into 2 groups based on primary surgical management. Eleven patients underwent primary OR, and 2 others were converted to an open procedure, while ER only was performed on 12 patients (Table 1). Both groups were well balanced for mean age, race, sex, comorbidities, and tobacco use.

Median follow-up was also calculated at 2.0 years for the OR group and 1.4 for the ER group, with an overall follow-up range of 0.2 to 14.4 years. We reclassified each patient’s tumor at the time of surgery according to the criteria of the 2010 AJCC TNM staging system. All 4 clinical stages were represented in each group in comparative proportions (P = .46). Tumor location was also similar, with the nasal cavity having the highest proportion with 54% (n = 7) and 83% (n = 10) in the OR and ER groups, respectively (P > .99) (Table 1). Three patients in each group had undergone prior surgery for previous SNM tumors (P > .99).

Treatment Details

Several patients in both groups had prior surgeries (Table 2). Prior surgery included full ER or debulking without intent to assess margin status. Twenty-two patients also underwent postoperative radiotherapy. The earliest patients were treated with a 3-dimensional conformal approach, while in more recent years, intensity-modulated radiotherapy was used. Total radiation therapy dose and fractionation varied widely. While some patients were treated with more conventionally fractionated regimens (eg, 60 Gy in 30 fractions over 40-50 days), hypofractionated, high-dose radiation was used more frequently in recent years to try to overcome the radioresistant nature of melanoma. The mean dose was comparable in the OR vs ER groups (43.5 Gy vs 51.3 Gy) (P = .35). Five patients in the OR group and 1 patient in the ER group underwent systemic immunotherapy (P = .16). This included interferon as well several different chemotherapeutic agents. Margin status was also obtained from pathology results from each surgery. Negative margins were achieved in 7 patients from each group, which was not a significant difference between the 2 groups (P = .82).

Postoperative Morbidity

We examined both postoperative morbidity and chronic late effects in this cohort. The average length of hospital stay was similar between the OR and the ER groups (3.6 vs 3.8 days) (P = .87). Other major complications investigated included significant intraoperative bleeding, CSF leak, optic injury, postoperative infection, and death. In the OR and ER groups, respectively, rates of significant intraoperative bleeding (8% [n = 1] and 17% [n = 2]) (P = .59) and CSF leak (15% [n = 2] and 25.0% [n = 3]) (P = .64) were comparable (Table 3). However, both CSF leaks in the OR group and 2 of the 3 in the ER group were intentionally induced to assess for dural involvement. All CSF leaks were repaired primarily, and there were no postoperative leaks. No patients developed postoperative infection or optic injury, and no patients died as a result of their surgery. There were no instances of significant late radiation-induced optic toxic effects or radionecrosis.

Patterns of Failure

Patterns of failure were similar between the 2 groups. Melanoma recurred in 14 patients, 7 in each group (Table 4). In the
OR group, treatment initially failed locally in 3 patients while 2 developed distant metastasis. There were failures in multiple locations in 2 patients, including 1 patient with lymph node disease, who initially experience local failure and subsequently developed nodal and distant metastasis. There were 3 patients in the ER group who first developed distant metastases and only 1 whose tumor recurred solely at the primary site. There were also 3 patients in the ER group for whom treatment failed at multiple locations, of whom experienced both regional and distant failure but no local recurrence. Overall, 10 of the 14 recurrences involved metastatic disease, although nodal metastasis was rare.

Survival
Both surgical approaches had early failures due to both local recurrence and distant metastasis. Survival was limited for both groups. In the OR and ER groups, respectively, the median disease-free survival (1.9 and 1.2 years) (P = .72) and median overall survival (2.7 and 1.9 years) (P = .87) were comparable (Figure). Furthermore, the 2-year overall survival rates were 63% for the OR group and 44% for the ER group.

Discussion
Our goal was to examine our experience with both open and endoscopic surgical approaches for SNM and their association to treatment-related outcomes. In our cohort, which was well-balanced in terms of baseline demographics, tumor characteristics, and treatment regimens, survival outcomes and treatment-related morbidity were comparable in the OR and the ER groups. While the difference in follow-up was greater than 1 year between groups, it was not significant. The difference was likely owing to more open procedures being performed early during the study timeframe, while the surgeons favored an endoscopic approach later.

Table 3. Operative Complications*

<table>
<thead>
<tr>
<th>Complication</th>
<th>Open Resection (n = 13)</th>
<th>Endoscopic Resection (n = 12)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length of hospital stay, mean (SD), d</td>
<td>3.6 (2.3)</td>
<td>3.8 (2.3)</td>
<td>.87</td>
</tr>
<tr>
<td>Significant intraoperative bleeding*</td>
<td>1 (8)</td>
<td>2 (17)</td>
<td>.59</td>
</tr>
<tr>
<td>CSF leak*</td>
<td>2 (15)</td>
<td>3 (25)</td>
<td>.64</td>
</tr>
<tr>
<td>Optic injury (nerve or orbit)</td>
<td>0</td>
<td>0</td>
<td>&gt; .99</td>
</tr>
<tr>
<td>Infection/meningitis</td>
<td>0</td>
<td>0</td>
<td>&gt; .99</td>
</tr>
<tr>
<td>Death</td>
<td>0</td>
<td>0</td>
<td>&gt; .99</td>
</tr>
</tbody>
</table>

Abbreviation: CSF, cerebrospinal fluid.

*Unless otherwise noted, data are reported as number (percentage) of patients. Percentages may not total 100% due to rounding.

While the nonsurgical aspects of the treatment regimens did not differ between the 2 groups, their role in the treatment of SNM is still heavily debated. There has been mixed evidence with regard to the effectiveness of radiation therapy. Clifton et al31 showed that radiation therapy for SNM may help with local control but not overall survival, and this point was echoed in reviews by others.32,34 Still, even improved local control has not been shown to be true in all studies.35 Dose and fractionation may also play a role in whether radiation therapy is beneficial, as suggested by Moreno et al.9

In addition, while there was a proportional difference between the patients receiving adjuvant systemic therapy in our study, the difference was not statistically significant, and there is still mixed evidence to show that the therapy would confer any survival benefit. Moreno et al,9 found no survival benefit with the use of postoperative systemic therapy. However, Sun et al32 recently demonstrated a 2-fold increase in 5-year survival for patients who received interferon and interleukin-2 bi- therapy vs those who did not after multivariable analysis. Thus, further studies of specific biotherapy and/or chemotherapy may be warranted for the treatment of SNM.

Concerning the most beneficial surgical approach, a lack of randomized evidence in this rare disease has fueled the debate about the ideal choice of resection.32 One important issue pertains to the ability to obtain negative surgical margins, which is associated with improved prognosis.31,32 Both Nicolai et al4 and Arnold et al1 make the argument that while ER is a piece-meal resection, it allows for a closer view of the anatomy, which can help with margin resection. Furthermore, an endoscopic approach provides for greater preservation of normal anatomy, helping to ensure a complete resection, which has been demonstrated over several types of sinonasal malignant neoplasms.33,34 We have demonstrated herein that both approaches are able to achieve negative margins equally, and thus the ER is similar to the OR in this regard.

It is important to note, though, that the surgeons who performed the endoscopic procedures in our study were experienced in the removal of sinonasal malignant lesions using this method and that the ER technique is more demanding for the removal of cancerous lesions than it is for removing benign inflammatory masses. Furthermore, as seen in 2 cases, it is important to perform these endoscopic procedures with a treatment team that has the skill and equipment to convert to an open approach if the tumor extent demands this effort.

The other potential advantages of ER over OR are the reduced morbidity, shorter hospital stays, and fewer facial incisions. Arnold et al1 and Nicolai et al4 suggest that these ad-
Advantages favor the endoscopic technique for resection of sinonasal malignant masses. However, we found that complications were rare and did not differ significantly between the operative groups. With regard to the CSF leaks, only 1 in the ER group was incidental, and all were repaired primarily without further complication. Furthermore, rates of local failure were also similar between groups. The study was not adequately powered to assess these outcomes though. A larger sample size with greater power would be necessary to establish whether ER is truly noninferior to OR with regard to complications or local control.

Assessing survival outcomes between the 2 groups was our main objective in this study. Prior work has shown that the results with ER appear equivalent to OR in more common sinonasal malignant lesions such as adenoid cystic and squamous cell carcinomas. Furthermore, an endoscopic approach conferred improved survival in patients with either sinonasal adenocarcinoma or esthesioneuroblastoma, although these studies were all subject to selection bias, and as in the present study, the procedure type was often chosen based on the surgeons’ comfort and experience. With regard to SNM, Lund et al reported improved survival outcomes in patients who underwent endoscopic resection. However, the patient groups in that study were not compared for demographics, tumor stage, or treatment regimens. Furthermore, the open group consisted of many patients who were operated on between 1963 and 1996, while all of the endoscopic patients underwent surgical treatment after 1996. Stage migration and better supportive care could certainly account for this finding. Our study did not find a significant difference between the OR and ER study arms, and the survival rates were within the published range for this disease.

This study has several limitations. The sample size is small, and there is significant potential for selection and time-related bias. Although statistically not significant, the ER group had a higher proportion of nasal cavity tumors, and SNM in the nasal cavity has a better prognosis than in other locations. This may indicate a potential selection bias which could influence overall outcomes, with surgeons preferring an endoscopic technique for nasal cavity SNM. We were also not able to account for particular histologic characteristics (such as the presence of S-100, mitotic activity, and pigmentation level) on the majority of the patients, which may have had prognostic implications. There were important qualitative variables that we were unable to capture, such as cosmesis and quality-of-life data, which may shed light on the optimal surgical approach. However, in general, patients with malignant sinonasal tumors have better quality-of-life outcomes after endoscopic surgery than after open surgery.

Given that endoscopic surgery is less invasive, uses fewer operating room resources, and creates fewer facial scars, it may be preferred to an open approach; we have shown no difference in disease control or survival between the 2 approaches. Unfortunately, the incidence of SNM is increasing, while prognostic has remained stagnant; therefore, now is the time to focus on new approaches and treatment options that might provide significant improvements in local control and survival.

**Conclusions**

This retrospective study of a rare disease suggests that an endoscopic approach to SNM allows an experienced surgeon to achieve the same rates of negative margins with similar morbidity as an open approach does. There is also no statistical difference in disease-free and overall survival between the 2 approaches. The sample size, follow-up times, and selection bias are all limits to this study. However, when considered with the current literature, the data suggest that an endoscopic approach is a safe alternative to an open procedure when a primary surgical approach is chosen.
Open vs Endoscopic Sinonasal Melanoma Approaches

ARTICLE INFORMATION
Submitted for Publication: January 13, 2014; final revision received June 2, 2014; accepted June 10, 2014.

Author Contributions: Dr Swegal had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.
Study concept and design: Swegal, Koyfman, Scharpf, Sindwani, Greskovich, Burkey.
Acquisition, analysis, or interpretation of data: Swegal, Koyfman, Scharpf, Sindwani, Greskovich, Burkey.
Drafting of the manuscript: Swegal, Koyfman, Burkey.
Critical revision of the manuscript for important intellectual content: Swegal, Koyfman, Scharpf, Sindwani, Greskovich, Burkey.
Statistical analysis: Swegal.
Obtained funding: Burkey.
Administrative, technical, or material support: Swegal, Koyfman, Scharpf, Sindwani, Burkey.
Study supervision: Koyfman, Sindwani, Burkey.
Conflict of Interest Disclosures: None reported.

Funding/Support: This research received internal funding from the Head and Neck Institute and the Department of Radiation Oncology, Cleveland Clinic Foundation.

Role of the Sponsor: The Cleveland Clinic Foundation had no role in the design and conduct of the study; collection, management, analysis, and interpretation of the data; preparation, review, or approval of the manuscript; and decision to submit the manuscript for publication.

Previous Presentation: Data from this study were presented as a poster at the Multidisciplinary Head and Neck Symposium; February 20–22, 2014; Scottsdale, Arizona.

Additional Contributions: We thank the Cleveland Clinic Foundation, Taussig Cancer Center Department of Radiology residents, and Head and Neck Institute residents for their contributions to the Head and Neck Tumor Registry. We also would like to thank the many support staff members for their maintenance and upkeep of the Head and Neck Tumor Registry.

REFERENCES