Squamous Cell Carcinoma of the Temporal Bone
A Radiographic-Pathologic Correlation

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Objective: To assess the utility of a previously proposed staging system for patients with primary squamous cell carcinoma of the temporal bone.

Methods: Retrospective chart review of 15 patients treated for squamous cell carcinoma of the temporal bone over a 13-year period at an academic tertiary referral center. A review of the medical and surgical records, radiographic studies, and surgical pathology reports allowed for an evaluation of the University of Pittsburgh staging system. Outcome analysis was performed on 13 patients with more than 24 months of follow-up.

Results: Radiographic and surgical pathology staging according to the University of Pittsburgh staging system correlated in 11 (73%) of 15 cases. The radiographic staging system was more accurate for larger (T3/T4) tumors than for smaller (T1/T2) tumors (83% vs 67%). When compared with patients with no evidence of disease, non-survivors were more likely to present with otalgia (67% vs 43%), facial nerve paralysis (33% vs 0%), and T3/T4 tumors (100% vs 14%).

Conclusions: Pathologic staging by the University of Pittsburgh staging system closely correlates with patient outcome and is more sensitive than preoperative radiographic staging. Prognosis in squamous cell carcinoma of the temporal bone is largely determined by the extent of local disease at the time of presentation.


Primary Squamous cell carcinoma of the external auditory canal and temporal bone is an uncommon malignancy with an estimated incidence of 5 cases per million population. The best methods of tumor staging and treatment are still a matter of debate. Adequate outcome data have been difficult to obtain from the medical literature owing to the small number of patients with the disease, the variety of staging classifications used, inconsistency in treatment methods and terminology, inclusion of tumors of various histopathologic characteristics, poor patient follow-up, and the lack of prospective randomized trials.

The goal of tumor staging is to group together patients with a similar extent of disease prior to treatment. An accurate staging system facilitates the comparison of treatment outcomes for patients with similar disease severity treated by different modalities and institutions. Conclusions can then be made with regard to treatment efficacy and disease prognosis. Currently, there is no universally accepted staging system for malignancies of the temporal bone.

The University of Pittsburgh staging system for primary squamous cell carcinoma of the external auditory canal was proposed in 1990 as a straightforward, accurate, reproducible system for classifying disease prior to treatment. Owing to the rarity of the tumor, the pooling of data from multiple institutions using the same tumor classification scheme was advocated. Several studies have since affirmed the utility of the University of Pittsburgh staging system.

The present study reviews the treatment and outcome of 15 patients with primary squamous cell carcinoma of the temporal bone treated at Johns Hopkins Hospital, The Johns Hopkins University School of Medicine, Baltimore, Md, over a 13-year period. The goal of the review is to assess the utility of the University of Pittsburgh staging system, to identify patient and tumor factors that may have prognostic significance, and to report our experience with this uncommon aggressive malignancy.

RESULTS

Fifteen patients received treatment for primary squamous cell carcinoma of the tem-
POPPULATION, MATERIALS, AND METHODS

The medical and surgical records of 15 patients with primary squamous cell carcinoma of the temporal bone treated at the Johns Hopkins Hospital between January 1, 1986, through December 31, 1998, were reviewed. The hospital surgical pathology databank was searched to identify patients with a diagnosis of carcinoma of the temporal bone. To be included in the study, patients had to (1) have primary squamous cell carcinoma originating within the temporal bone, and (2) have undergone computed tomographic (CT) imaging and primary surgical resection at our institution. Fifteen patients were identified who met these criteria. Clinical information on these patients was obtained from a review of the hospital and outpatient charts and the electronic patient record, which included radiology reports, operative notes, pathology reports, discharge summaries, and outpatient clinical follow-up examinations. Factors evaluated included patient demographics, presenting symptoms, physical examination findings, radiographic findings, surgical treatment, method of reconstruction, surgical complications, histopathologic findings, and the use of postoperative radiation therapy. Three types of surgical resection were performed in this series. Local resection is defined as any resection less than an en bloc lateral temporal bone resection, including resection of external canal skin and modified or radical mastoidectomy. Lateral temporal bone resection consisted of a formal en bloc removal of the bony and cartilaginous external auditory canal, tympanic membrane, malleus, and incus with identification and preservation of the facial nerve along its vertical segment. Subtotal temporal bone resection involved the removal of the lateral temporal bone with the additional resection of a portion of the otic capsule with preservation of the petrous apex and carotid artery. No total temporal bone resections were performed in this series.

The tumors of the 15 patients were staged using the University of Pittsburgh staging system for squamous cell carcinoma of the external auditory canal, both on the basis of the preoperative temporal bone CT findings and the intraoperative and surgical pathologic findings (Table 1). A comparison of possible prognostic factors was performed on the 13 patients with sufficient follow-up. Patients were considered to have no evidence of disease if they had clear pathologic margins and no evidence of recurrence after at least 24 months of follow-up.

Nine patients (60%) received postoperative radiation therapy, which was given to patients with large tumors (T3/T4), close (<1 mm) or positive margins, extensive soft tissue involvement, or regional lymph node involvement. The mean radiation therapy dose was 6000 rads (60 Gy) to the primary site and 4500 rads (45 Gy) to the ipsilateral neck.

A multifactorial comparison of potential prognostic factors was performed on the 13 patients who had ei-
Primary squamous cell carcinoma of the temporal bone is an uncommon malignancy without a universally accepted staging system.2 Arriaga et al3 attempted to address this problem by introducing the University of Pittsburgh TNM staging system for squamous cell carcinoma of the external auditory canal in 1990. The staging system is limited to a single tumor type and anatomic location to avoid the confusion that arises when tumors of various histopathologic characteristics and locations are lumped together under a single staging scheme. When clinical outcomes were compared with histopathologic findings in surgical specimens of 39 patients, it was found that the extent of local disease closely correlated with patient outcome. The TNM staging system that emerged from these observations reflects a 100% 2-year survival for patients with T1 and T2 tumors, 50% in patients with T3 tumors, and 15% in the T4 group.

The histopathologic-clinical correlation of the University of Pittsburgh staging system has been supported in recent studies.4-6 In a study of 33 patients with squamous cell carcinoma of the temporal bone, Zhang et al6 found a 5-year survival of 100% in the T1/T2 group, a 69% survival in patients with T3 tumors, and 20% survival in the T4 group. In our study, a group of patients with T1 and T2 tumors had 100% survival during the study period (mean follow-up 54 months), whereas there was a 25% and 0% survival rate in patients with T3 and T4 tumors, respectively. The University of Pittsburgh staging system is therefore consistent in its prediction of survival rate among patients with a similar extent of disease.

An additional strength of the University of Pittsburgh staging system is its ability to stage disease in patients prior to surgery using preoperative CT of the temporal bone. High-resolution CT scans of the temporal bone can readily detect erosion of the bony external canal, which is often the first sign of local spread of disease.2,3 In a blinded study of 13 patients with squamous cell carcinoma of the external auditory canal, Arriaga et al3 found that interpretation of a preoperative temporal bone CT correlated with surgical histopathologic findings in 94 of the 96 anatomic sites compared, for an overall accuracy of 98%. In one case, CT failed to detect the spread of tumor through the anterior canal wall that occurred without bony erosion. In the other case, mucosal inflammation of the middle ear was falsely interpreted as tumor. Arriaga et al3 concluded that preoperative high-resolution CT scans of the temporal bone accurately reflect the extent of disease and can therefore be used for pre-

### Table 1. University of Pittsburgh Staging System for Squamous Cell Carcinoma of the Temporal Bone

**T Status**

- **T1**: Tumor limited to the external auditory canal without bony erosion or evidence of soft-tissue extension.
- **T2**: Tumor with limited external auditory canal bony erosion (not full thickness) or radiographic finding consistent with limited (<0.5 cm) soft-tissue involvement.
- **T3**: Tumor eroding the osseous external auditory canal (full thickness) with limited (<0.5 cm) soft-tissue involvement, or tumor involving middle ear and/or mastoid, or patients presenting with facial paralysis.
- **T4**: Tumor eroding the cochlea, petrous apex, medial wall of the middle ear, carotid canal, jugular foramen or dura, or with extensive (>0.5 cm) soft-tissue involvement.

**N Status**

Lymph node involvement is a poor prognostic sign and places the patient in an advanced stage (ie, T1N1 [Stage III] and T2, 3, 4 N1 [Stage IV]).

**M Status**

M1 disease is stage IV and is considered a very poor prognostic sign.

### Table 2. Clinical Summary for Patients With Squamous Cell Carcinoma of the Temporal Bone*

<table>
<thead>
<tr>
<th>Patient No.</th>
<th>Treatment</th>
<th>Resection</th>
<th>Radiographic Findings</th>
<th>Pathologic Findings</th>
<th>Status</th>
<th>Follow-up, mo</th>
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<tbody>
<tr>
<td>1</td>
<td>S</td>
<td>LTB</td>
<td>T1N0</td>
<td>T1N0</td>
<td>NED</td>
<td>120</td>
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<td>2</td>
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<td>NED</td>
<td>27</td>
</tr>
<tr>
<td>3</td>
<td>S + XRT</td>
<td>Local</td>
<td>T2N0</td>
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<td>6</td>
</tr>
<tr>
<td>4</td>
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<td>T1N0</td>
<td>T1N0</td>
<td>NED</td>
<td>26</td>
</tr>
<tr>
<td>5</td>
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<td>LTB</td>
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<td>T2N0</td>
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<td>94</td>
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<tr>
<td>7</td>
<td>S</td>
<td>LTB</td>
<td>T2N0</td>
<td>T2N0</td>
<td>LTF</td>
<td>16</td>
</tr>
<tr>
<td>8</td>
<td>S</td>
<td>Local</td>
<td>T3N0</td>
<td>T2N0</td>
<td>NED</td>
<td>88</td>
</tr>
<tr>
<td>9</td>
<td>S + XRT</td>
<td>LTB</td>
<td>T3N0</td>
<td>T3N0</td>
<td>NED</td>
<td>32</td>
</tr>
<tr>
<td>10</td>
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<td>T3N2b</td>
<td>T3N2b</td>
<td>DOD</td>
<td>7</td>
</tr>
<tr>
<td>11</td>
<td>S + XRT</td>
<td>LTB</td>
<td>T1N0</td>
<td>T3N0</td>
<td>DOD</td>
<td>7</td>
</tr>
<tr>
<td>12</td>
<td>S + XRT</td>
<td>STB</td>
<td>T3N0</td>
<td>T3N0</td>
<td>DOD</td>
<td>7</td>
</tr>
<tr>
<td>13</td>
<td>S + XRT</td>
<td>STB</td>
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<td>T4N1</td>
<td>DOD</td>
<td>2</td>
</tr>
<tr>
<td>14</td>
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<td>T4N0</td>
<td>DOD</td>
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<tr>
<td>15</td>
<td>S + XRT</td>
<td>Local</td>
<td>T4N0</td>
<td>T4N0</td>
<td>DOD</td>
<td>1</td>
</tr>
</tbody>
</table>

*S indicates surgery; XRT, radiation therapy; LTB, lateral temporal bone; STB, subtotal temporal bone; NED, no evidence of disease; LTF, lost to follow-up; and DOD, dead of disease.
operative staging and planning for an en bloc resection of the temporal bone. It was also suggested that MRI may be a helpful adjunct for determining the soft tissue extent of disease.3

The inability of CT scan findings to predict the anterior soft tissue extent of the tumor has been noted in other studies.7,8 Tumor can spread anteriorly via the cartilaginous fissures of Santorini and the bony foramen of Huschke without evidence of bony canal erosion.2 Leonetti et al3 reviewed the accuracy of predicting tumor extent by radiographic means in 17 patients with T3/T4 squamous cell carcinoma of the temporal bone who had undergone both CT and MRI scanning. In a site-by-site comparison with intraoperative findings, CT and MRI had an overall accuracy of 85%. Disease was most frequently underestimated in the infratemporal fossa, the mastoid cavity, and the carotid canal.5 Because of concern about anterior spread of tumor via preformed pathways, Leonetti et al5 routinely perform superficial parotidectomy at the time of temporal bone resection and total parotidectomy in cases in which the bony canal has been violated.

In the present study, 11 of the 15 patients were correctly staged by preoperative radiography for an overall staging accuracy of 73%. This percentage is lower than the previous studies because only the pathologic stage was considered, and a site-by-site comparison between radiographic interpretation and intraoperative or histopathologic findings was not undertaken. Using only temporal bone CT, we underestimated the anterior extent of disease in one case and had difficulty distinguishing tumor from inflammation in another. The radiographic staging system seemed to be more accurate for larger (T3/T4) tumors than for smaller (T1/T2) tumors (83% vs 67%) in which subtle bony changes may be misinterpreted.

En bloc surgical resection of the temporal bone has remained the preferred treatment for carcinoma of the temporal bone since subtotal resection was first reported by Parsons and Lewis9 and the laterotemporal bone resection by Conley and Novack.10 Complete tumor resection, the primary aim of these en bloc techniques, is a strong determinant of survival as demonstrated in our patient series. In the present study, 78% of patients with negative margins at the time of surgery were disease survivors compared with 0% of patients with positive margins. Three of our patients with positive margins had dural involvement that could not be fully resected by a subtotal temporal bone resection. An additional patient underwent a limited debridement when carcinoma was found on the carotid artery. When followed by postoperative irradiation, the piecemeal resection of all visible tumor beyond the margins of a subtotal resection is a viable alternative to total temporal bone removal and has shown some benefit in advanced disease.6 Zhang et al7 found 69% and 20% 5-year survival for T3 and T4 disease, respectively, in patients treated with the piecemeal technique. Total temporal bone resection with carotid artery sacrifice is not routinely performed at our institution because of the increased risk of morbidity and no proven survival benefit. In a meta-analysis of 26 studies of patients with squamous cell carcinoma of the temporal bone, Prasad and Janecka8 found 0% 1-year survival in 4 patients who had undergone total temporal bone resection. When specific anatomic sites were considered, patients with dural involvement had 11% 5-year survival, while those with petrous apex, brain, and carotid artery involvement had 0% 2-year survival.1 It has also been noted that many patients with squamous cell carcinoma of the temporal bone are elderly and at risk of dying of intercurrent disease.11

Recent studies, however, have demonstrated improved survival in patients who have undergone total temporal bone resection.5,12 In the series by Moffat et al12 7 (47%) of 15 patients with T3/T4 squamous cell carcinoma of the temporal bone survived 5 years following en bloc total temporal bone resection with carotid artery preservation. Two of the 7 patients had brain involve-

<table>
<thead>
<tr>
<th>Patient No.</th>
<th>Radiographic Stage</th>
<th>Pathologic Stage</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>T2N0 (bone erosion)</td>
<td>T1N0 (no bone erosion)</td>
</tr>
<tr>
<td>5</td>
<td>T1N0 (no bone erosion)</td>
<td>T2N0 (bone erosion)</td>
</tr>
<tr>
<td>8</td>
<td>T3N0 (mastoid opacified)</td>
<td>T2N0 (mastoid clear)</td>
</tr>
<tr>
<td>11</td>
<td>T1N0 (no bone erosion)</td>
<td>T3N0 (tumor in TMJ)</td>
</tr>
</tbody>
</table>

*TMJ indicates temporomandibular joint.
ment at the time of surgery. Moffat et al.\textsuperscript{12} argue that improvements in skull base approaches, interventional radiology, and flap reconstruction have led to improved survival with reduced morbidity. In addition, they emphasize the palliative benefits of total temporal bone resection, including decreased pain and improved hygiene.

The conclusions of the present study are limited by the small number of patients involved. The study findings, however, agree with several recent studies on the accuracy of the University of Pittsburgh staging system for squamous cell carcinoma of the temporal bone.\textsuperscript{6,13} A multi-institution study is needed to elucidate the optimum treatment for patients with squamous cell carcinoma of the temporal bone.

### CONCLUSIONS

The University of Pittsburgh staging system represents an acceptable staging system for primary squamous cell carcinoma of the temporal bone, with excellent correlation between pathologic stage and patient outcome. Although preoperative radiographic staging is relatively insensitive, the extent of tumor may be better determined when both CT and MRI of the temporal bone are performed. The surgeon, however, must be familiar with the common pathways of tumor spread, which may be missed on preoperative imaging.

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### REFERENCES