CT-guided Radiofrequency Ablation in the Palliative Treatment of Recurrent Advanced Head and Neck Malignancies

Allan L. Brook, MD, Menachem M. Gold, MD, Todd S. Miller, MD, Tamar Gold, BA, Randall P. Owen, MD, Laurie S. Sanchez, MD, Joaquim M. Farinhas, MD, Keivan Shifteh, MD, and Jacqueline A. Bello, MD

PURPOSE: To evaluate the safety and effectiveness of computed tomography (CT)-guided radiofrequency (RF) ablation in the palliative treatment of recurrent advanced head and neck cancers.

MATERIALS AND METHODS: From November 2002 to January 2005, the authors identified 14 patients (median age, 61 years) with 14 recurrent advanced primary head and neck malignancies who underwent 27 CT-guided RF ablation applications during 20 sessions at their institution. RF ablation was performed in all patients with the intent of palliative therapy. Radiologic tumor response was assessed by using Response Evaluation Criteria in Solid Tumors. Patients were assessed clinically by means of University of Washington Head and Neck Quality of Life questionnaires.

RESULTS: Technical success in tumor targeting and electrode deployment was 100%. University of Washington quality of life surveys completed by six of 14 patients (43%) showed an index increase by a median of 3.1 percentage points, with four of six patients (67%) demonstrating improvement. Three major complications (in 27 applications, 11%) occurred 7 days to 2 weeks after the procedure. These included stroke, carotid blowout leading to death, and threatened carotid blowout with subsequent stroke. Retrospective analysis of intraprocedural CT scans revealed that the retractable electrodes were within 1 cm of the carotid artery during ablation in these cases.

CONCLUSIONS: RF ablation in patients with advanced head and neck malignancies is feasible and effective for palliation. CT-guidance provides accurate probe placement and electrode deployment. The energy level used and proximity of the ablation sphere to the carotid artery may predispose to vascular complications.

J Vasc Interv Radiol 2008; 19:725–735

Abbreviations: MIP = maximum intensity projection, RECIST = Response Evaluation Criteria in Solid Tumors, RF = radiofrequency, SCC = squamous cell carcinoma
In fact, concomitant debilitating conditions are estimated to account for 30% of deaths among patients with head and neck cancer (4). In such situations, patients are typically offered palliative or investigational chemotherapy or simply provided comfort measures. Hence, it would seem likely that minimally invasive treatment options effecting palliation would prove useful in this patient population.

Radiofrequency (RF) ablation is a technique in which a high-frequency alternating current emitted from electrodes generates ionic vibration and frictional heating of the affected tissue. The tissue heats resistively in the area of contact with the electrode tip, and the heat then transfers conductively to adjacent tissue. RF ablation has recently received much attention as an effective minimally invasive approach in the treatment of a variety of malignancies (8–19).

Limited preliminary data from this patient series have been previously reported (20,21). The purpose of this study was to evaluate the safety and effectiveness of computed tomography (CT)–guided RF ablation in the palliative treatment of recurrent advanced head and neck cancers.

**MATERIALS AND METHODS**

**Patients and Tumor Characteristics**

From November 2002 to January 2005, we identified 14 patients from our quality assurance database who underwent 27 CT-guided RF ablation applications during 20 sessions for the treatment of 14 primary head and neck malignancies. The patient population included nine men and five women. The median age of the cohort was 61 years (range, 36–81 years). All patients had previously undergone surgery, radiation therapy, and chemotherapy for the treatment of a primary head and neck malignancy and had biopsy-proved recurrent stage IV disease. Institutional review board approval was granted for this retrospective study.

Patients selected for RF therapy were not candidates for further standard radiation and/or surgical interventions for a variety of reasons. These included comorbid conditions, refusal to undergo further standard care, or judgment by a multidisciplinary tumor board that the functional and/or cosmetic damage of standard surgical therapy warranted consideration of an alternative, albeit noncurative approach. In all patients, the underlying rationale for performing RF ablation was to palliate local symptoms related to aggressive tumor growth. These included pain (n = 8), airway obstruction (n = 3), dysphagia (n = 4), inability to close the mouth (n = 1), and trismus (n = 1).

Treated tumors included squamous cell carcinoma (SCC) of the tongue (n = 7), SCC of the tonsil (n = 2), SCC of the oropharynx (n = 1), SCC of the maxillary sinus (n = 1), medullary cancer of the thyroid (n = 1), basal cell cancer of the skull base (n = 1), and angiomatoid fibrous histiocytoma involving the neck and posterior fossa (n = 1). Preablation tumor size ranged from 3.5 to 10.0 cm in largest diameter (mean ± standard deviation, 6.3 cm ± 2.2; median, 5.3 cm).

The pretreatment imaging workup included unenhanced and contrast-enhanced CT (75-mL iohexol [Omnipaque 240, Amersham Health, Princeton, New Jersey]) in all patients. Three patients were also evaluated before treatment with contrast-enhanced magnetic resonance (MR) imaging (gadopentetate dimeglumine [Magnevist; Berlex Laboratories, Wayne, New Jersey]).

**RF Ablation Technique**

An RF ablation session was defined as a visit to the radiology department in which the mass was treated with RF ablation under CT guidance (22). An RF application constitutes deployment of an RF electrode into the lesion and application of RF energy. Thus, a patient could undergo more than one RF application in a single session. Treatment was not performed in patients with a platelet count of less than 100,000/mm³ (<100 × 10⁹/L) or those in whom there is an internationally normalized ratio greater than 2.1 (prothrombin time, >23 seconds).

Patients were intubated, and general anesthesia was induced in the operating room before arrival at the radiology department. If indicated, the patient’s oropharynx was packed with surgical gauze in the operating room to separate the RF probe from the endotracheal tube and to protect the surrounding tissues from the probe. All RF treatments were performed in a hospital CT suite by an experienced interventional neuroradiologist (A.L.B.), a head and neck surgeon (R.P.O.), a CT technologist, and a registered nurse. Once the patient was positioned to facilitate access of the target lesion, two dispersive grounding pads were placed on the patient’s upper thighs. Immediately before RF ablation, all patients underwent unenhanced and contrast-enhanced CT (30-mL iohexol) with a first-generation spiral CT scanner (HighSpeed Spiral CT/i; GE Medical Systems, Milwaukee, Wisconsin). Selected transverse images were obtained within the area of interest with 5–10-mm-thick sections, depending on the size of the lesion. The unenhanced images were assessed for calcifications and hemorrhage within the area of interest. Contrast medium was administered for tumor localization and major vessel identification. CT fluoroscopy was not used in any case.

Thirteen of the 14 patients were treated with a multitined thermal ablation probe (Starburst XI; RITA Medical Systems, Mountain View, California) and model 1500 generator (RITA Medical Systems). The probe consists of a 14-gauge, 25-cm needle-cannula that contains nine curved, flexible stainless steel electrodes that can be deployed outside the probe in the shape of an umbrella. The decision to use a nine-array probe configuration was made because it enables the ablation of larger tumors with fewer overlapping RF applications and shorter operative times when compared with four or seven electrode probes (23). The electrodes on the Starburst XI probe can be deployed to a maximum length of 5 cm. The length of electrode deployment determines the size of the induced zone of necrosis. With deployment of the electrodes over a distance of 5 cm and adequate electrical parameters, a theoretical spherical thermal lesion 5 cm in diameter can be created.

One patient was treated with a Starburst XIli probe (model 1500 generator) with electrodes capable of deploying to a length of 7 cm. This third-generation probe can infuse hypertonic saline into the tissues surrounding the electrodes tips during ablation. The continuous injection of saline solution during ablation has been shown to conduct the large thermal mass surrounding the RF.
Lateral (Fig 1), subzygomatic (Fig 2), transoral (Figs 3, 4), submental (Fig 5), paramaxillary (Figs 3, 6), retromandibular, submastoid, and posterior approaches to introduce the RF ablation probe into tumor. In two cases, more than one approach was necessary during the same session to attain maximal tumor ablation (Fig 3).

Once proper probe positioning was confirmed with CT, the electrodes were deployed at 1-cm intervals by pushing the piston down the shaft of the probe. The appropriate length of the exposed electrode tips was chosen by the operator according to the size and location of the tumor. Centimeter markers just distal to the piston inform the operator of the deployment diameter in any given position. The area of interest was reimaged during deployment to assess electrode position relative to the tumor mass, airway, and major vessels (Fig 1). During the process of electrode deployment, it was occasionally necessary (seven of 27 applications, 26%) to reinject the patient with a small bolus of intravenous contrast medium (25–30 mL) for better visualization of vascular structures (Fig 1).

Once the electrodes were deemed to be in satisfactory position, the probe was connected to the generator and the generator switched on. The target temperature was initially set at 105°C. After the first five sessions, we noted the appearance of gas bubbles within the zone of necrosis (Fig 2). These bubbles are a result of intratumoral temperatures higher than 100°C during ablation, which causes water in tissue to boil and vaporize (31). This process may retard optimal ablation as a result of the insulating effects of gas, thereby decreasing thermal conduction in tissues (32). As a result of observing this phenomenon, we reduced our target temperature from 105°C to 80°–90°C for all subsequent RF applications.

Thermocouples placed at the tips of five electrodes of the nine-array probe enabled continuous temperature monitoring during the ablation. With activation of the device by using the temperature control mode, power was increased slowly to 100 W. Then, by means of feedback from the thermocouples, the power applied was automatically regulated to maintain the average target temperature at the electrode tips. Application of energy was continued until temperatures fell and


e. f. g. h.

Figure 1. Patient 2. Images in a 74-year-old woman with a large recurrent medullary carcinoma of the thyroid treated with RF ablation by using multiple ablation spheres. (a–c) Axial unenhanced CT scans demonstrate an anterolateral probe approach with progressive deployment of electrodes within the tumor (arrow in a). (d) Axial CT scan obtained during electrode deployment after administration of 25 mL of iodinated contrast medium demonstrates an electrode to be in close proximity to the internal carotid artery (arrow). To prevent potential complications, the electrodes were subsequently partially retracted and the probe was repositioned before initiation of ablation. (e–h) Axial maximum intensity projection (MIP) images demonstrate multiple probe repositionings within the tumor to achieve maximal tumor ablation. MIP reconstructions allow for the demonstration of the three-dimensional orientation of the curved electrodes in the axial projection.

Electrode deeper into the tissues (24–26). In addition, the simultaneous injection of saline increases tissue ionicity and electrical conductivity, thereby enabling greater current flow, up to 200 W (27). We treated one patient with the XL5 probe because the size and geometry of this patient’s tumor necessitated a larger ablation sphere.

The technique described herein involves the use of monopolar RF ablation and is distinctly different from RF-induced thermotherapy, which uses bipolar RF energy. Although RF-induced thermotherapy has been used for the palliative treatment of head and neck cancers (28), it is not approved by the U.S. Food and Drug Administration at this time.

Lesion Targeting

Both superficial and deep lesions of the head and neck are accessible with various needle trajectories (29,30). The approach is planned to ensure that the needle does not transgress the path of any major nerve, vessel, or aerodigestive organ. Under CT guidance, this is done primarily by using anatomic landmarks such as the styloid process. The RF probe can be thought of as a large-gauge needle, and, as such, the same general technique as is used in CT-guided needle biopsy can be used when introducing an RF probe into a targeted lesion.

In our study, all patients had undergone extensive surgery and radiation before RF ablation. Therefore, the anatomy in the region of the tumor was sometimes distorted and normal anatomic relationships difficult to use. To avoid direct puncture of vessels while safely ablating adjacent tumor, the exact location of major vessels such as the carotid and vertebral arteries was determined with use of intravenous contrast material or vessel calcification rather than relying on anatomic landmarks.

Our approach to lesion targeting depended on lesion location, size, geometry, and potential damage to surrounding structures. We used antero-
On the basis of the size and geometry of the lesion, overlapping RF applications were performed by repositioning the probe to ablate as much of the tumor as safely possible (Fig 1). In cases where destruction of bone was believed to be the primary cause of the patient’s pain (five of 14 patients, 36%), the portion of the tumor adjacent to bone was particularly targeted for ablation.

After the ablation, the prongs were retracted and the probe was removed. The probe track was cauterized in all patients to prevent oozing and substantial bleeding, as described in the setting of hepatic RF ablation (33,34). Cauterization was achieved by continuing power during slow withdrawal of the probe after retraction of the prongs. Immediately after all sessions, an unenhanced targeted CT scan was obtained to assess for bleeding and damage to vessels or adjacent aerodigestive organs and to serve as a baseline for future imaging. After seven of the 20 sessions (35%), immediate postprocedure contrast-enhanced CT was also performed to assess residual tumor status and to serve as a baseline for future follow-up imaging.

Nineteen of the 20 treatment sessions were scheduled as inpatient procedures. After nine of these 19 sessions, patients were observed overnight and discharged home the following day. After the other 10 sessions, patients remained hospitalized for several days after RF ablation due to comorbid conditions requiring treatment. One session was scheduled as an outpatient procedure due to the superficial location of the lesion. This patient was discharged to home 4 hours after ablation.

Follow-up

The poor general health of many of the patients in this study precluded their return for follow-up imaging at set intervals. All follow-up imaging was performed by using...
contrast-enhanced CT or MR imaging. Follow-up images were evaluated by two authors (A.L.B., J.A.B.), and differences in interpretation were resolved by consensus. Response Evaluation Criteria in Solid Tumors (RECIST) (35) were used for the assessment of tumor response by using a binary outcome of either progressive or nonprogressive disease. The RECIST define progressive disease as at least a 20% increase in the maximum diameter of the target lesion. Nonprogressive disease is therefore defined as less than a 20% increase in the maximum diameter of the target lesion.

Patients were assessed clinically for improvement in quality of life as measured with University of Washington Head and Neck Quality of Life questionnaire (36). This questionnaire allows patients to evaluate nine domains pertaining to quality of life. The nine domains are pain, activity, recreation, employment, disfigurement, speech, swallowing, chewing and shoulder function. Each of these domains has three to six possible choices of items. The highest level or “normal” function is assigned 100 points, whereas the lowest level, or greatest dysfunction, scores 0 points. The nine domains contribute equally to the final score, which is out of 900 points. A composite score, consisting of the mean of the nine individual domain scores, is then calculated. Clinical follow-up was also performed during office visits and by means of phone conversations.

Intra- and postprocedural complications were evaluated and recorded in accordance with Society of Interventional Radiology reporting guidelines (37). Deaths during the observation period were recorded, along with causes of death, as available.

RESULTS

RF Ablation Procedure

Complete results according to tumor characteristics are given in Table 1. Successful placement of the RF ablation probe was achieved in all sessions. Owing to the wide disparity in lesion geometry and size, ablation times per session varied greatly (range, 8.0–70.0 minutes; median, 12.5 minutes). If we exclude the patient treated with the XLi probe, the number of RF applications per tumor was one for each of six tumors (mean maximal diameter, 5.0 cm ± 1.2), two for each of two tumors (7.3 cm ± 3.9), three for each of four tumors (6.5 cm ± 2.1), and four for one tumor (maximal diameter, 8.5 cm) (average number of applications, 2.0; median, 2). The maximal diameter of the tumor treated with the internally cooled XLi probe was 9.6 cm.

Target temperature, as measured by the average temperature in the active-tip electrodes, was successfully reached in all tumors. However, target temperatures could not always be reached in the electrodes deployed adjacent to cortical bone.

Immediate postprocedure unenhanced CT performed after the first five RF ablation sessions, during which intraprocedural target temperatures of 105°C were reached, demonstrated air bubbles in the zone of ablation with surrounding residual soft tissue. Postprocedure unenhanced CT after the subsequent sessions, during which intraprocedural target temperatures ranged from 80°C to 90°C, dem-
onstrated a vague area of hypoattenuation in the region of ablation, which often could not be distinguished from residual tumor. Gas bubbles were not noted at the lower target temperatures. No hemorrhage was noted on any immediate postprocedure unenhanced CT scans. Immediate postprocedure contrast-enhanced CT performed in seven of 20 sessions (35%) demonstrated central necrosis in the zone of ablation with surrounding residual enhancing tumor.

Follow-up

Complete imaging and clinical follow-up results are given in Table 2. Thirteen of the 14 patients (93%) died during follow-up (range, 20–449 days after initial RF ablation; median, 123 days). No postmortem examinations were performed and, therefore, the immediate cause of death in these patients is unknown. None of the patients died while hospitalized for the ablation procedure. The remaining patient, patient 10, continues to be followed up and has survived well over 2 years since the initial RF ablation. This patient underwent two RF ablation sessions for the treatment of a superficial 4.5-cm basal cell cancer arising just posterior to the right ear and causing severe otalgia. He reported improvement in right ear pain after RF ablation.

The difficulty of obtaining consistent patient follow-up in this population precluded our complete collection of quality of life data. University of Washington quality of life surveys completed by six of the 14 patients (43%) showed an index increase by a median of 3.1 percentage points, with four of six patients (67%) demonstrating improvement. Eight of the 14 patients (57%) reported subjective improvement at various intervals after RF ablation in the following areas: pain (n = 8), appearance (n = 1), and function (n = 4). Functional improvement included improved ability to swallow, improved breathing through the nose, immediate relief from trismus, and regained ability to close the mouth.

Ten of the 14 patients (71%) returned for follow-up imaging at least 4 weeks after the initial ablation. The duration of imaging follow-up from the date of the first ablation ranged from 1 to 11 months (mean, 3.6 months; median, 2.0 months). Follow-up imaging in these patients generally demonstrated a persistent central area of necrosis with surrounding enhancing tumor. Disease progression, as defined with RECIST, was seen in five of these 10 patients (50%). Five of the 10 patients who returned for follow-up imaging underwent repeat treatment with RF ablation due to either tumor progression or recurrent pain.

Complications

No major intraprocedural complication or death occurred. There were three major periprocedural complications (in 27 applications, 11%), two of which were directly attributable to the proce-
Retrospective analysis of intraprocedural CT scans revealed that either the RF probe tip or retractable electrodes were within 1 cm of the carotid artery during the ablation in these three cases.

Two weeks after RF ablation treatment, one patient (patient 12) died of massive pharyngeal hemorrhage. The patient had most likely developed a pharyngocutaneous fistula and acute carotid blowout syndrome.

Another patient (patient 13) was noted to have developed a pharyngocutaneous fistula with air bubbles adjacent to the right carotid artery at routine follow-up CT performed 2 weeks after RF treatment. Given our experience with patient 12, we initiated an

Table 1
Tumor Characteristics and RF Ablation Treatments

<table>
<thead>
<tr>
<th>Patient No./Age (y)/Sex</th>
<th>Tumor Type</th>
<th>Tumor Location</th>
<th>No. of Sessions</th>
<th>No. of RF Applications</th>
<th>Approach</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/51/M 51/F</td>
<td>SCC</td>
<td>Tonsil, Masticator space</td>
<td>2</td>
<td>Session 1:1</td>
<td>Subzygomatic</td>
</tr>
<tr>
<td>2/74/F 74/F</td>
<td>Medullary thyroid</td>
<td>Anterior infrahyoid neck</td>
<td>2</td>
<td>Session 1:2</td>
<td>Anterolateral</td>
</tr>
<tr>
<td>3/78/F 78/F</td>
<td>SCC</td>
<td>Maxillary sinus, MS, PPS</td>
<td>1</td>
<td>Session 2:1</td>
<td>Anterolateral, TO</td>
</tr>
<tr>
<td>4/59/M*</td>
<td>SCC</td>
<td>BOT, SMS</td>
<td>1</td>
<td>Session 1:3</td>
<td>Submental</td>
</tr>
<tr>
<td>5/57/F 57/F</td>
<td>SCC</td>
<td>Tonsil, PPS, CS, Parotid space</td>
<td>1</td>
<td>Session 2:1</td>
<td>Transoral, RM</td>
</tr>
<tr>
<td>6/57/F 57/F</td>
<td>SCC</td>
<td>BOT, SMS, MS, PPS</td>
<td>3</td>
<td>Session 3:1</td>
<td>Paramaxillary, Retromandibular</td>
</tr>
<tr>
<td>7/62/M 62/M</td>
<td>SCC</td>
<td>BOT, SMS</td>
<td>1</td>
<td>Session 1:1</td>
<td>Transoral</td>
</tr>
<tr>
<td>8/56/M 56/M</td>
<td>SCC</td>
<td>BOT, SMS</td>
<td>1</td>
<td>Session 2:1</td>
<td>Transoral</td>
</tr>
<tr>
<td>9/81/M 81/M</td>
<td>SCC</td>
<td>Tongue</td>
<td>2</td>
<td>Session 2:2</td>
<td>Transoral</td>
</tr>
<tr>
<td>10/81/M 81/M</td>
<td>BCC</td>
<td>Posterior auricular</td>
<td>2</td>
<td>Session 1:1</td>
<td>Submastoid</td>
</tr>
<tr>
<td>11/36/M 36/M</td>
<td>AFH</td>
<td>Posterior fossa, Posterior neck</td>
<td>1</td>
<td>Session 2:1</td>
<td>Submastoid</td>
</tr>
<tr>
<td>12/79/M 79/M</td>
<td>SCC</td>
<td>BOT, PPS, SMS, CS</td>
<td>1</td>
<td>Session 1:1</td>
<td>Retromandibular</td>
</tr>
<tr>
<td>13/56/M 56/M</td>
<td>SCC</td>
<td>Oropharynx, PPS, CS</td>
<td>1</td>
<td>Session 1:1</td>
<td>Retromandibular</td>
</tr>
<tr>
<td>14/68/F 68/F</td>
<td>SCC</td>
<td>BOT</td>
<td>1</td>
<td>Session 1:1</td>
<td>Transoral</td>
</tr>
</tbody>
</table>

Note.—SCC = Squamous cell carcinoma, BCC = Basal cell carcinoma, AFH = Angiomatoid fibrous histiocytoma, MS = masticator space, PPS = Parapharyngeal Space, BOT = Base of tongue, SMS = Submandibular Space, CS = Carotid Space, RM = Retromandibular Space, TO = Transoral

* Treated with Xli probe
aggressive effort to prevent carotid blowout. An esophageal stent was immediately placed to prevent salivary leakage. At the same time, a right carotid balloon test occlusion was done to assess the patient’s collateral brain circulation in preparation for elective occlusion of the right internal carotid artery. The patient passed the balloon occlusion test without clinical or electroencephalographic evidence of ischemia and was scheduled for elective carotid occlusion. Before the completion of his planned elective treatment, the patient presented with bleeding from the skin and oral cavity. Emergent cerebral angiography demonstrated a pseudoaneurysm of the external carotid artery, presumed to be the origin of the hemorrhage. The pseudoaneurysm was embolized with polyvinyl alcohol particles. Due to potential life-threatening hemorrhage from the carotid artery, the distal common and entire cervical internal carotid arteries were also occluded with coils at that time. The patient developed left hemiparesis the following day. A follow-up ultrasonographic examination performed 6 months after RF ablation demonstrated that the patient’s functionality substantially improved but that a neurologic deficit remained.

One patient (patient 5) developed a stroke 7 days after RF ablation. This patient had a long history of heavy smoking, with evidence of extensive atherosclerotic disease of the carotid artery at CT. It is possible that the procedure further compromised an already diseased carotid artery.

Minor complications (four of 27 applications, 15%) included a temporary mental status change (n = 1), cellulitis (n = 2), and postprocedural pneumonia (n = 1). The cellulitis and pneumonia resolved with nominal therapy (antibiotics). None of our patients experienced peripheral neurologic compromise as a direct result of RF ablation treatment.

**DISCUSSION**

Recurrent head and neck malignancies are rarely curable (7). Although both surgery and radiation therapy play an important role in the treatment of these patients, the general approach has been palliative, given the poor long-term results and toxic nature of standard treatment modalities (6,7). In addition, many such patients have compromised cardiopulmonary status or other coexistent medical problems, which leads to substantial postoperative mortality. The substantial morbidity that plagues these patients during the remainder of their lives and the poor results of chemotherapy alone emphasize the need to develop effective palliative treatments. The often-present comorbidities, poor results of repeat surgery, and considerations for quality of life make minimally invasive therapeutic strategies appealing.

RF ablation has been used effectively in the treatment of a variety of malignancies throughout the body with use of both ultrasonographic (US) and CT guidance (8–19). If the aim of thermal tumor ablation therapy is cure, then it is necessary to generate an area of thermocoagulation with a diameter larger than that of the tumor. This was not possible in most of our patients because of tumor size, extent, and proximity to vital structures. Therefore, our aim was to decrease tumor volume with RF ablation, potentially palliating symptoms related to tumor bulk.

CT affords several advantages over US during intraprocedural monitoring of RF ablation. These include more accurate confirmation of probe placement in relation to tumor, improved visualization of the extent of ablation, and better correlation to proved lesion size (38,39). Accurate real-time US monitoring of all margins of lesions undergoing RF ablation appears difficult, if not impossible, because of artifacts from microbubbles formed during the ablation (40,41). This may result in uncertainty in determining the extent of ablation during an RF ablation procedure (42,43). Furthermore, if multiple ablations are planned, the gas and hyperechogenicity produced from initial

---

**Table 2**

<table>
<thead>
<tr>
<th>Patient No.</th>
<th>PRECIST Criteria</th>
<th>Tumor Size (cm)</th>
<th>Radiologic</th>
<th>Imaging Follow-up (mo)**</th>
<th>UW Quality of Life</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Preablation</td>
<td>Postablation</td>
<td>Response</td>
<td></td>
<td>Preablation</td>
</tr>
<tr>
<td>1</td>
<td>8</td>
<td>9</td>
<td>NP</td>
<td>1.5</td>
<td>25</td>
</tr>
<tr>
<td>2</td>
<td>8.5</td>
<td>7.3</td>
<td>NP</td>
<td>1.5</td>
<td>NA</td>
</tr>
<tr>
<td>3</td>
<td>5.1</td>
<td>8.5</td>
<td>PD</td>
<td>2.5</td>
<td>NA</td>
</tr>
<tr>
<td>4*</td>
<td>9.6</td>
<td>NA</td>
<td>NA</td>
<td>None</td>
<td>NA</td>
</tr>
<tr>
<td>5</td>
<td>5.5</td>
<td>NA</td>
<td>NA</td>
<td>None</td>
<td>46.4</td>
</tr>
<tr>
<td>6</td>
<td>4.3</td>
<td>6.8</td>
<td>PD</td>
<td>10</td>
<td>NA</td>
</tr>
<tr>
<td>7</td>
<td>4.7</td>
<td>3.9</td>
<td>NP</td>
<td>1</td>
<td>NA</td>
</tr>
<tr>
<td>8</td>
<td>5</td>
<td>8.2</td>
<td>PD</td>
<td>1</td>
<td>NA</td>
</tr>
<tr>
<td>9</td>
<td>8.5</td>
<td>9</td>
<td>NP</td>
<td>2.5</td>
<td>43.9</td>
</tr>
<tr>
<td>10</td>
<td>4.5</td>
<td>5.8</td>
<td>PD</td>
<td>11</td>
<td>NA</td>
</tr>
<tr>
<td>11</td>
<td>10</td>
<td>10.2</td>
<td>NP</td>
<td>1</td>
<td>46.1</td>
</tr>
<tr>
<td>12</td>
<td>4.2</td>
<td>NA</td>
<td>NA</td>
<td>None</td>
<td>NA</td>
</tr>
<tr>
<td>13</td>
<td>3.5</td>
<td>5.5</td>
<td>PD</td>
<td>4</td>
<td>47.3</td>
</tr>
<tr>
<td>14</td>
<td>7</td>
<td>NA</td>
<td>NA</td>
<td>None</td>
<td>38.3</td>
</tr>
</tbody>
</table>

Note.—NP = Nonprogressive disease, PD = Progressive disease, NA = Not available
* Treated with Xli probe
** From date of first RF ablation
Two of the three major complications in our study were a result of pharyngocutaneous fistula formation. With such a fistula, a salivary leak develops from the pharynx to the skin. Contact with saliva has been shown to cause thrombosis of the vasa vasmorum in the carotid artery adventitia (57). Ischemic damage to the arterial wall is likely because the carotid artery receives 80% of its blood supply from its adventitia (58). Patients with carotid arteries exposed to saliva are described as having “threatened” carotid blowout, and rupture will almost inevitably occur unless the vessel is covered by healthy vascularized tissue. At this stage, available treatment options include endovascular carotid occlusion, covered stent placement, and surgery (59–61). In the one patient treated for this complication, patient 13, we opted for an endovascular approach as we thought this would be safer given that the patient had a large tumor encasing the carotid artery and had previously undergone multiple surgeries and radiation therapy.

On the basis of our experience, we conclude that tumors surrounding or immediately adjacent to the carotid artery should not be treated at the energy levels used in this study to avoid potential damage to the vessel wall and to prevent vessel exposure and blowout. Further research, perhaps in animals, is necessary to determine if a lower energy level or a larger distance between the tines and carotid artery would be safe and effective for such tumors. Although damage to nerves is certainly a possibility when employing RF ablation in the head and neck, we did not encounter this complication.

The proximity of tumors in the head and neck to adjacent bone adds an additional layer of complexity when applying RF energy. Alterations in electrical conductivity can influence RF-induced tissue coagulation surrounding the retractable electrodes (27,62–64). Relative to most soft tissues, cortical bone has poor electrical conductivity, as reported by Dupuy et al (65) in an experimental study performed in bone tumors. Therefore, it is difficult to achieve target temperatures and induce coagulation of tumor when the RF energy source is adjacent to bone. If tumor is adjacent to bone, it should be recognized that RF ablation might be less effective.

One goal of our study was the palliation of symptoms related to tumor growth rather than patient cure. Eight of the 14 patients (57%) reported subjective improvement in pain, function, and/or appearance at various intervals after they received RF ablation. Thus, subjective symptom improvement was achieved in most patients with nonprogressive disease and even in those with disease progression. This suggests that a change in the size of tumor alone may not reflect the clinical value of the ablative procedure in these patients with substantial morbidity. Rather, destruction of the tumor mass may have an important palliative effect by either reducing the ability of the tumor to compress adjacent structures or some other mechanism.

The limitations of the current study include the limited number of patients, incomplete clinical and imaging follow-up with lack of uniform follow-up periods, and variety of tumors treated.

In conclusion, RF ablation in patients with advanced head and neck malignancies is feasible and effective for palliation. CT-guidance provides accurate probe placement and electrode deployment. The energy level used and proximity of the ablation sphere to the carotid artery may predispose to vascular complications.

References


