Head and neck soft tissue sarcomas treated with radiation therapy

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Abstract

Head and neck soft tissue sarcomas (HNSTSs) are rare and heterogeneous cancers in which radiation therapy (RT) has an important role in local tumor control (LC). The purpose of this study was to evaluate outcomes and patterns of treatment failure in patients with HNSTS treated with RT. A retrospective review was performed of adult patients with HNSTS treated with RT from January 1, 1998, to December 31, 2012. LC, locoregional control (LRC), disease-free survival (DFS), overall survival (OS), and predictors thereof were assessed. Forty-eight patients with HNSTS were evaluated. Five-year Kaplan-Meier estimates of LC, LRC, DFS, and OS were 87, 73, 63, and 83%, respectively. Angiosarcomas were found to be associated with worse LC, LRC, DFS, and OS. Patients over the age of 60 had lower rates of DFS. HNSTSs comprise a diverse group of tumors that can be managed with various treatment regimens involving RT. Angiosarcomas have higher recurrence and mortality rates.

Introduction

Head and neck soft tissue sarcomas (HNSTSs) are a rare and heterogeneous group of malignancies that pose a considerable therapeutic challenge owing to their location and the paucity of data related to their management. HNSTS makes up approximately 1% of head and neck cancers and 10% of soft tissue sarcomas.1 Surgery is considered necessary for curative treatment; however, the anatomy of the head and neck often makes wide local excision difficult, placing patients at risk for locoregional recurrence in the absence of adjuvant therapy.2 In addition to survival implications of local recurrence, the high density of critical structures in the head and neck makes wide local excision difficult, placing patients at risk for local recurrence in the absence of adjuvant therapy.3 In addition to survival implications of local recurrence, the high density of critical structures in the head and neck make local control (LC) especially important because treatment failure can be highly morbid and challenging to salvage. Radiation therapy (RT), when used as part of a multimodal regimen with surgery, has been shown to improve LC of soft tissue sarcomas in the extremities.3 Limited published series describe the treatment and outcome of HNSTSs.4-19 Even fewer reports address the role of RT in HNSTS.12,13 Defining optimal management of HNSTS is further complicated by the great heterogeneity within this diverse group of tumors, which possess a range of clinical and pathologic characteristics.4 Herein, we report the outcomes, patterns of recurrence, and potential prognostic factors in patients treated for HNSTS with RT at our institution.

Materials and Methods

Patient population

With the permission of the Mayo Clinic Institutional Review Board, a retrospective review was performed of patients with soft tissue sarcomas of the head and neck treated with RT between January 1, 1998, and December 31, 2012. Included were adult patients presenting with nonmetastatic disease who received RT as a component of treatment with curative intent. Patients with less than 3 months of follow-up were excluded, as were those with embryonal type rhabdomyosarcoma, extraskeletal Ewing sarcoma, and desmoid tumors. Fifty patients met inclusion criteria for the study. In compliance with Minnesota statutes, all living patients consented to review of their medical records for research purposes.

Surgery

Surgical intervention typically consisted of wide local excision with gross total resection and primary closure or pedicled flap reconstruction. Positive margin was defined as disease present within 1 mm of the final resected edge.

Radiation therapy

All patients received RT and were treated with intensity-modulated RT (IMRT), 3-dimensional (3-D) conformal RT, or en face electron beam RT. The RT dose and modality differed depending on the timing of RT relative to surgery; clinical characteristics of the tumor, including depth, proximity to adjacent critical structures, and availability of technology at the time. Our institution began using IMRT to treat head and neck malignancies in September 2003. Patients were treated preoperatively or postoperatively at the discretion of the oncologic team. Patients received treatment once daily, with 5 fractions per week. The median dose per fraction was 2 Gy (range, 1.8-2.4 Gy). Two patients with disease in the neck received intraoperative RT (10 and 11 Gy) at the time of tumor resection following a course of preoperative RT. One other patient was treated with Gamma Knife (Elekta AB) stereotactic radiosurgery postoperatively. He received 20 Gy, prescribed to the 50% isodose line.

Chemotherapy

Chemotherapy was given preoperatively, postoperatively, or concurrently with RT at the discretion of the oncologic team. Common regimens included neoadjuvant or adjuvant paclitaxel or neoadjuvant methotrexate, doxorubicin, and cisplatin.

Analysis and statistical methods

Descriptive statistics are reported as frequency (percentage) or mean, as appropriate. Events are reported from the patient’s last day of RT. Estimates of LC, locoregional control (LRC), disease-free survival (DFS), and overall survival (OS) were computed using the Kaplan-Meier product-limit method.20 The Wilcoxon test among groups was performed to analyze differences in LC, LRC, DFS, and OS when patients were grouped in accordance with presenting location (i.e., scalp or face, neck, and paranasal sinus) or histologic finding (leiomyosarcoma, malignant peripheral nerve sheath tumor, malignant fibrous histiocytoma or undifferentiated pleomorphic sarcoma (MFH/UPS), spindle cell sarcoma not oth-
Table 1. Patient and tumor characteristics by site of presentation.

| Characteristic | Neck (n=16) | Paranasal sinus (n=3) | Scalp/face (n=27) | Supraclavicular (n=2) | Total (N=48) |
|---------------|-------------|-----------------------|-------------------|-----------------------|---------------|
| Age at diagnosis, y | Median 48.8 (19.1-65.6) | Median 74.4 (41.8-82.6) | Median 70.0 (23.5-86.8) | Median 27.6 (25.9-29.2) | Median 68.5 (19.1-86.9) |
| Sex | Female 4 (25.0) | 1 (33.3) | 9 (33.3) | 0 (0.0) | 14 (29.2) |
| | Male 12 (75.0) | 2 (66.7) | 18 (66.6) | 2 (100.0) | 34 (70.8) |
| Presentation | Recurrent 5 (31.3) | 0 (0.0) | 4 (14.8) | 1 (50.0) | 10 (20.8) |
| | Primary 11 (68.8) | 3 (100.0) | 23 (85.2) | 1 (50.0) | 38 (79.2) |
| Histologic finding | DFSP 1 (6.3) | 0 (0.0) | 0 (0.0) | 0 (0.0) | 1 (2.1) |
| | Leiomyosarcoma 2 (12.5) | 0 (0.0) | 3 (11.1) | 0 (0.0) | 5 (10.4) |
| | MPNST 0 (0.0) | 0 (0.0) | 1 (3.7) | 0 (0.0) | 1 (2.1) |
| | MFH/UPS 3 (18.8) | 0 (0.0) | 4 (14.8) | 2 (100.0) | 9 (18.8) |
| | Spindle cell 2 (12.5) | 0 (0.0) | 2 (7.4) | 0 (0.0) | 4 (8.3) |
| | Synovial sarcoma 5 (31.3) | 0 (0.0) | 1 (3.7) | 0 (0.0) | 6 (12.5) |
| | Angiosarcoma 0 (0.0) | 1 (25.0) | 15 (48.1) | 0 (0.0) | 14 (29.2) |
| | Liposarcoma 1 (6.3) | 0 (0.0) | 2 (7.4) | 0 (0.0) | 3 (6.3) |
| | Other 2 (12.5) | 1 (25.0) | 0 (0.0) | 0 (0.0) | 3 (6.3) |
| | Hemangiopericytoma 0 (0.0) | 1 (25.0) | 1 (3.7) | 0 (0.0) | 2 (4.2) |
| | Rhabdomyosarcoma 0 (0.0) | 1 (25.0) | 0 (0.0) | 0 (0.0) | 1 (2.1) |
| Grade | Low 2 (12.5) | 0 (0.0) | 4 (14.8) | 0 (0.0) | 6 (12.5) |
| | High 7 (43.8) | 1 (33.3) | 18 (66.8) | 2 (100.0) | 28 (58.3) |
| | Not available 7 (43.8) | 2 (66.7) | 5 (18.5) | 0 (0.0) | 14 (29.1) |
| Size, cm | ≤5 11 (68.8) | 3 (100.0) | 17 (63.0) | 2 (100.0) | 33 (68.8) |
| | >5 5 (31.3) | 0 (0.0) | 10 (37.0) | 0 (0.0) | 15 (31.2) |
| Depth | Superficial 2 (12.5) | 0 (0.0) | 16 (59.3) | 1 (50.0) | 19 (39.6) |
| | Deep 14 (87.5) | 3 (100.0) | 11 (40.3) | 1 (50.0) | 29 (60.4) |

DFSP, dermatofibrosarcoma protuberosans; MFH, malignant fibrous histiocytoma; MPNST, malignant peripheral nerve sheath tumor; UPS, unclassified pleomorphic sarcoma. *Values are presented as number and percentage of patients unless specified otherwise. Other histologic findings include interdigitating dendritic cell sarcoma, chordoma, and hemangioidothelioma.
leiomyosarcoma. Three patients had recurrences within the RT treatment volume and 2
had recurrences at the margin of the treatment volume. The patients with in-field recurred
ences were treated with 60 Gy in 30 fractions, 66 Gy in 33 fractions, and 69.96 Gy in 33 frac-
tions. All local recurrences occurred within the first 2 years of follow-up. Two patients had pos-
tive margins at the time of surgery and one had gross residual disease after resection; none of these patients experienced local recur-
rence. Regional nodal recurrence developed in 5 patients. No patients had concurrent local
and regional nodal recurrence. Four of these patients had angiosarcoma of the face or scalp
and 1 had synovial sarcoma of the neck. Of the 10 patients who underwent ENI, 1 patient
(10%) with an angiosarcoma had recurrence within the treated nodal volume. Thirty-eight
patients did not undergo ENI, 4 (11%) of whom developed nodal recurrence in the neck.

One patient with angiosarcoma developed a nodal recurrence and distant metastasis that were
discovered simultaneously. Isolated dis-
tant metastasis occurred in 6 patients. Of these patients, 3 had angiosarcoma; 1, synovial
sarcoma; 1, spindle cell sarcoma not otherwise specified; and 1, MFH/UPS. Sites of distant
metastasis were the lungs, vertebrae, brain, and peripheral bony sites.

Table 2. Treatment characteristics by site of presentation.

| Characteristic | Neck* (n=16) | Paranasal sinus# (n=3) | Treatment by site* | Supraventricular (n=2) | Total (N=48) |
|----------------|-------------|-----------------------|--------------------|------------------------|-------------|
| **Treatment**  |             |                       |                    |                        |             |
| Trimodality    | 3 (18.8)    | 2 (66.7)              | 8 (28.6)           | 1 (50.0)               | 14 (29.2)   |
| Surgery and RT | 13 (81.3)   | 1 (33.3)              | 15 (55.6)          | 1 (50.0)               | 30 (62.5)   |
| RT alone       | 0 (0.0)     | 0 (0.0)               | 2 (7.4)            | 0 (0.0)                | 2 (4.2)     |
| Chemotherapy and RT | 0 (0.0) | 0 (0.0) | 2 (7.4) | 0 (0.0) | 2 (4.2) |
| **Timing of RT** |            |                       |                    |                        |             |
| Definitive     | 0 (0.0)     | 0 (0.0)               | 4 (14.8)           | 0 (0.0)                | 4 (8.3)     |
| Preoperative   | 4 (25.0)    | 1 (33.3)              | 4 (14.8)           | 1 (50.0)               | 10 (20.8)   |
| Postoperative  | 12 (75.0)   | 2 (66.7)              | 19 (70.4)          | 1 (50.0)               | 34 (70.8)   |
| **Type of closure** |         |                       |                    |                        |             |
| Report unavailable | 1 (6.3)   | 1 (33.3)              | 0 (0.0)            | 0 (0.0)                | 2 (4.2)     |
| Nonoperative   | 0 (0.0)     | 0 (0.0)               | 4 (14.8)           | 0 (0.0)                | 4 (8.3)     |
| Primary closure | 10 (62.5)  | 0 (0.0)               | 8 (29.6)           | 2 (100.0)              | 20 (41.7)   |
| Skin graft     | 0 (0.0)     | 0 (0.0)               | 6 (22.2)           | 0 (0.0)                | 6 (12.5)    |
| Pedicle flap   | 4 (25.0)    | 1 (33.3)              | 4 (14.8)           | 0 (0.0)                | 9 (18.8)    |
| Free flap      | 1 (6.3)     | 1 (33.3)              | 5 (18.5)           | 0 (0.0)                | 7 (14.6)    |
| **Margin**     |             |                       |                    |                        |             |
| Nonoperative   | 0 (0.0)     | 0 (0.0)               | 4 (14.8)           | 0 (0.0)                | 4 (8.3)     |
| Negative       | 15 (93.8)   | 2 (66.7)              | 22 (81.5)          | 2 (100.0)              | 41 (85.4)   |
| Positive       | 1 (6.3)     | 0 (0.0)               | 1 (3.7)            | 0 (0.0)                | 2 (4.2)     |
| Gross positive | 0 (0.0)     | 1 (33.3)              | 0 (0.0)            | 0 (0.0)                | 1 (2.1)     |
| **Type of RT** |             |                       |                    |                        |             |
| IMRT           | 7 (43.8)    | 3 (100.0)             | 17 (63.0)          | 1 (50.0)               | 28 (58.3)   |
| Electrons      | 0 (0.0)     | 0 (0.0)               | 5 (18.5)           | 0 (0.0)                | 5 (10.4)    |
| 3-D conformal  | 9 (56.3)    | 0 (0.0)               | 5 (18.5)           | 1 (50.0)               | 15 (31.3)   |
| **Preoperative EBRT dose, Gy** |         |                       |                    |                        |             |
| Median         | 50.4        | 50.4                  | 58.8               | 39.6                   | 50.4        |
| Range          | (50.0-56.3) | (50.4-50.4)           | (50.0-66.0)        | (39.6-39.6)            | (39.6-66.0) |
| **Postoperative EBRT dose, Gy** |         |                       |                    |                        |             |
| Median         | 61.0        | 59.4                  | 60.0               | 63.0                   | 60.0        |
| Range          | (56.3-70.0) | (55.8-59.4)           | (59.4-70.0)        | (63.0-63.0)            | (55.8-70.0) |
| **Definitive** |             |                       |                    |                        |             |
| Median         | NA          | NA                    | 66.0               | NA                     | NA          |
| Range          | NA          | NA                    | (60.0-70.0)        | NA                     | (60.0-70.0) |
| **Dose per fraction, Gy** |         |                       |                    |                        |             |
| Median         | 2.0         | 1.8                   | 2.0                | 2.0                    | 2.0         |
| Range          | (1.8-2.3)   | (1.8-1.8)             | (1.8-2.4)          | (1.8-1.2)              | (1.8-2.4)   |
| **ENI**        |             |                       |                    |                        |             |
| Yes            | 5 (31.2)    | 0 (0.0)               | 4 (14.8)           | 1 (50.0)               | 10 (20.8)   |
| No             | 11 (68.8)   | 3 (100.0)             | 23 (85.2)          | 1 (50.0)               | 38 (79.2)   |
| **RT treatment time, days** |         |                       |                    |                        |             |
| Median         | 43          | 39                    | 43                 | 34.5                   | 42.5        |
| Range          | (34-49)     | (38-46)               | (32-50)            | (31-38)                | (31-50)     |

EBRT, external beam radiation therapy; ENI, elective nodal irradiation; IMRT, intensity-modulated radiation therapy; NA, not applicable; RT, radiation therapy; 3-D, 3-dimensional. *Values are presented as number and percentage of patients unless specified otherwise. **Two patients with neck disease received intraoperative RT (10 and 11 Gy) after a course of preoperative RT. One patient with paranasal sinus disease was treated with 20 Gy postoperative radiosurgery with Gamma Knife.
RT. Similarly, no differences in any measured outcomes were found among those who received ENI and those who did not. Patient presentation (i.e. primary vs. recurrent), and sex were not associated with a significant difference in outcome. In addition, tumor size, tumor grade, and depth of tumor invasion were not associated with a significant difference in observed outcome.

Radiation therapy complications
Seven (15%) of the 48 patients reported grade 3 RT-related acute toxicity. Two patients required percutaneous endoscopic gastrostomy tube placement because of poor oral intake. Other grade 3 adverse effects were severe dermatitis (n=2), wound infection requiring intravenous antibiotics (n=3), severe mucositis (n=1), and split thickness skin graft failure (n=1). One patient had both percutaneous endoscopic gastrostomy tube placement and severe dermatitis, and 1 patient had both abscess formation and skin graft failure. No statistically significant difference was found in toxicity of grade 3 or higher among patients treated with IMRT and those treated with 3-D conformal RT (P=0.84). No grade 4 or grade 5 RT-related acute toxicity was observed.

Long-term grade 3 toxicities included cataracts requiring surgery (n=1) and osteonecrosis (n=1) requiring surgical debridement of the zygoma and maxilla 9 years after receiving RT of 70 Gy. One patient had grade 2 Lhermitte syndrome that gradually improved over 5 years. No grade 4 or grade 5 long-term RT complications were documented.

Table 3. Univariate analysis of local control, locoregional control, disease-free survival, and overall survival for various patient, tumor, and treatment characteristics.

| Characteristic | LC Univariate analysis* | LRC Univariate analysis* | DFS Univariate analysis* | OS Univariate analysis* |
|---------------|-------------------------|--------------------------|--------------------------|------------------------|
|               | HR (95% CI) | P Value   | HR (95% CI) | P Value   | HR (95% CI) | P Value   | HR (95% CI) | P Value   |
| Sex, male vs female | 1.8 (0.2-16.0) | 0.60 | 1.1 (0.3-4.1) | 0.93 | 1.4 (0.4-4.3) | 0.58 | 1.4 (0.4-5.5) | 0.63 |
| Age, >60 vs ≤60 | 3.4 (0.5-67.2) | 0.22 | 3.5 (0.88-23.4) | 0.08 | 3.7 (1.18-16.1) | 0.02 | 3.6 (0.9-23.7) | 0.07 |
| Size, >5 cm vs ≤5 cm | 3.0 (0.5-23.1) | 0.24 | 2.1 (0.6-7.5) | 0.25 | 2.1 (0.8-5.7) | 0.15 | 1.25 (0.32-4.4) | 0.73 |
| Histology | | | | | | | | |
| High vs low grade | 0.6 (0.1-12.6) | <0.005 | 1.0 (0.2-18.7) | 0.99 | 0.85 (0.22-5.6) | 0.38 | 0.66 (0.15-4.5) | 0.62 |
| Angio vs other | 15.5 (2.3-306.5) | <0.005 | 17.7 (4.4-118.1) | <0.001 | 8.9 (3.2-28.5) | <0.001 | 4.5 (1.3-17.8) | 0.02 |
| Deep vs superficial | 0.4 (0.05-2.3) | 0.29 | 0.57 (0.16-2.1) | 0.39 | 0.74 (0.28-2.1) | 0.43 | 0.33 (0.08-1.2) | 0.08 |
| Presentation, recurrent vs. primary | 1.3 (0.11-14.7) | 0.80 | 0.62 (0.03-29.7) | 0.63 | 1.2 (0.23-3.8) | 0.78 | 1.0 (0.15-4.1) | 0.99 |
| RT | | | | | | | | |
| >60 Gy vs ≤60 Gy | 3.3 (0.5-24.9) | 0.19 | 2.6 (0.7-9.4) | 0.14 | 2.4 (0.86-6.4) | 0.09 | 2.3 (0.6-8.5) | 0.19 |
| Preoperative vs post-operative | 0 (-) | 0.30 | 0.63 (0.03-3.9) | 0.66 | 0.66 (0.10-2.5) | 0.57 | 0.56 (0.03-3.5) | 0.57 |
| Alone vs with surgery | 28.2 (4.5-218.8) | <0.001 | 15.1 (3.8-53.8) | <0.001 | 6.9 (1.9-20.4) | 0.006 | 6.1 (1.3-22.0) | 0.03 |
| IMRT vs 3-D RT | 0.82 (0.14-4.2) | 0.83 | 2.2 (0.55-14.7) | 0.28 | 1.12 (0.43-3.6) | 0.83 | 2.0 (0.45-13.6) | 0.57 |
| Elective nodal RT | 0.93 (0.05-43) | 0.95 | 0.92 (0.14-37) | 0.92 | 0.87 (0.20-2.7) | 0.82 | 1.3 (0.28-4.7) | 0.72 |

3-dimensional. *Boldface type indicates statistically significant data.

Figure 1. Kaplan-Meier plots for rates of local (A) and locoregional (B) control and for overall (C) and disease-free (D) survival._hash marks in lines represent excluded patients. The number of patients still at risk is plotted below the x-axis. Lighter graph lines indicate 95% confidence interval.
may have contributed to improved LRC in the present series.

Most recurrences occurred early in our series, with 100% of local recurrences and 90% of loco-regional recurrences occurring within the first 2 years. These data are corroborated by previous studies showing that up to 96% of recurrences occurred within the first 3 years.7

### Prognostic factors

Angiosarcoma has been shown to be associated with poorer LC, greater risk of distant metastasis, and poorer OS relative to other HNSTS. Our study corroborates these findings and shows that in the era of modern RT modalities and concurrent chemotherapy, angiosarcomas continue to portend a poorer prognosis. A recent study by Chang and colleagues found that patients over the age of 60 had lower cause specific survival (CSS) compared to younger patients.18 Our study found patients 60 and older had significantly lower rates of DFS and a non-significant trend towards poorer OS (P=0.07). These results can largely be explained by the later onset of angiosarcomas, with a median age of 79 years old at diagnosis. Angiosarcomas accounted for 43% (12/28) of the HNSTS in patients older than 60 compared to 5% (1/20) of patients under 60 years of age. Previous studies have implicated tumor size, grade, and margin status with poorer cause-specific survival.5,9,12,15,17 We were not able to duplicate those findings. Larger tumor size and positive margin status has been associated with poorer LC.6,9,17 We were not able to demonstrate the same. Having only three patients in our cohort with positive surgical margins limited our ability to observe the effects of this proven prognostic factor.

### Role of radiation therapy

Maximal safe tumor resection continues to be the primary treatment modality for HNSTS. Total compartmental resection results in high rates of LC but is often not feasible anatomically.18 RT is given for tumors with close (<1 cm) or positive surgical margins5,18 and other high risk features. Although the rarity of the disease has prevented studies directly evaluating the benefit of RT in the head and neck, RT for soft tissue sarcomas of the extremities has been shown to increase rates of LC in prospective randomized trials.38 In the present study, a range of RT modalities and regimens were used, including preoperative, postoperative, and definitive fractionated therapy, stereotactic radiosurgery, and intraoperative RT. No prospective study has compared preoperative to postoperative RT in HNSTS. However, O’Sullivan and colleagues19 performed a prospective trial for soft tissue sarcomas of the extremities and found that although preoperative RT was associated with higher rates of severe wound complications, patients treated...
with postoperative RT tended to have higher risk of fibrosis and edema. The investigators observed no difference in survival outcomes between preoperative and postoperative RT. Because of tumor bed hypoxia following surgical resection, higher doses of RT are typically administered postoperatively, and larger fields are often required to encompass surgical changes. Thus, for soft tissue sarcomas of an extremity, preoperative RT is typically favored in order to reduce treatment-associated toxicity. However, in patients with HNSTS, only those patients with advanced, marginally resectable tumors are routinely considered for preoperative RT. Preoperative RT often is avoided in operations that violate mucosal membranes because of risk of fistula formation. In our study, no difference was observed in any outcomes between preoperative RT and postoperative RT. No prospective studies have looked at dose effect for RT in HNSTS. In soft tissue sarcomas of the extremities, preoperative RT doses are typically about 50 Gy and postoperative doses range from 64 to 66 Gy. In our study, median doses for preoperative, postoperative, and definitive fractionated RT were 50.5, 60, and 66 Gy, respectively.

Small patient numbers and selection bias make it difficult to assess the efficacy of RT without surgery because these patients tend to have comorbid illnesses and more advanced disease. Indeed, in our study, RT alone was associated with worse outcomes for DFS, LC, LRC, and OS; however, this small group of patients had advanced disease or serious medical comorbidities, or both. Chen and colleagues also report lower crude rates of LC with RT alone vs. RT with surgery (50 vs. 82%) that are attributed to higher-risk disease in the cohort receiving RT alone. The role of ENI is unclear in the treatment of HNSTS. For angiosarcomas presenting in any location of the body, Ward and colleagues have recommended ENI for large tumors (>5 cm). In our study, we observed no difference in LRC among patients treated with ENI and those who were not; however, our sample size was small, there is inherent selection bias in the determination of which patients should receive ENI, precluding meaningful comparison.

Limitations

The present study is limited by its retrospective nature, the relatively small sample size and subsequent small subgroups, and the heterogeneity of the included histologic entities. Variations in the medical, surgical, and RT treatments made identifying prognostic factors difficult. Our study also investigated a large number of univariate analyses. Four end points were assessed for 12 unique variables, resulting in a total of 48 significance tests. At an α level of 0.05, it can be expected that 2 or 3 significant results may be type I errors. Despite these limitations and given the rarity of HNSTS, this study adds a valuable contribution to understanding the prognosis, patterns of recurrence, and prognostic factors associated with this disease.

Conclusions

This study describes a diverse group of HNSTS with treatment regimens involving RT and reviews the literature and current practices using RT in HNSTS. Angiosarcomas have significantly higher rates of recurrence and disease-specific death. Patients older than 60 years of age were found to have lower rates of DFS. Further studies are required to elucidate indications for RT, as well as the optimal dose and timing of RT.

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