What Factors Influence the Outcome of Surgically Treated Soft Tissue Sarcomas of the Hand and Wrist?

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Matthew T. Houdek¹, Brian E. Walczak¹, Benjamin K. Wilke¹, Sanjeev Kakar¹, Peter S. Rose¹, and Alexander Y. Shin¹

Abstract

Background: Soft tissue sarcomas (STS) of the hand are exceedingly rare. The aim of this study was to review our institution's experience with STS of the hand to identify factors affecting outcomes and survivorship. **Methods:** We retrospectively reviewed the records of 46 hand STS treated with definitive surgery at our institution between 1992 and 2013. Pertinent demographics as well as information regarding the surgical procedure, and disease status at latest follow-up were reviewed. Mean age at diagnosis was 38 years with a mean follow-up of 5 years. **Results:** The most common tumor subtypes were epithelioid ($n = 10$) and synovial sarcoma ($n = 8$). Sixty-one percent were superficial in location. Thirty-three patients had had a nononcologic resection prior to definitive surgical treatment at our institution. Ultimately, negative margins were obtained in all cases. Local recurrence was observed in 5 patients and distant metastases in 14 patients. Tumor sizes ≥ 2 cm, American Joint Committee on Cancer (AJCC) grade, and depth of the tumor were found to adversely affect the outcome in terms of disease-free and overall survival. Reexcision of an inadvertently excised tumor at an outside institution did not adversely affect the outcome. The 10-year overall and disease-free survival was 72% and 63%. **Conclusions:** Local recurrence after a wide excision was observed infrequently; however, distant disease was relatively common. Tumors with a size ≥ 2 cm were associated with a worse disease-free and overall survival, highlighting the aggressive nature of these tumors.

Keywords: hand, wrist, outcome, soft tissue sarcoma, sarcoma

Introduction

Soft tissue sarcomas (STS) of the hand are exceedingly rare, accounting for only 3% of all upper extremity STS.^{3,5} Due to the unique anatomy of the hand, historically the treatment for STS of the hand was amputation; however, with advances in adjuvant therapy and surgical techniques, limb salvage surgery is a viable treatment option.^{2,11-16,21,22-24,26,28} Due to the rarity of these tumors in the hand, treatment outcomes reported in the literature are limited.^{2,3,15,16,20,23,27}

Previous studies examining prognostic factors for the oncologic outcome in the treatment of STS of the hand and wrist have shown positive surgical margins, tumor grade, and size (>3 cm) were associated with worse outcome.^{20,23} The purpose of this study was to report our institutions outcomes on the surgical treatment of STS of the hand, with an analysis on risk factors for local and distant recurrence, as well as disease-free and overall survival.

Methods

Following institutional review board approval, we performed a retrospective review of the records of 198 patients with

primary upper extremity sarcomas using our institutions cancer registry between 1992 and 2013. A hand sarcoma was defined as a sarcoma located at or distal to the ulnar styloid and radiocarpal joint.¹⁵ We identified 50 patients with a primary STS of the hand and wrist over this time period. For all patients to have at least 2 years of clinical follow-up, 4 patients were removed, leaving a cohort of 46 patients with a minimum of 2 years of follow-up. Age, sex, anatomic location, tumor size, subtype, stage, neoadjuvant and adjuvant treatments, previous surgery, surgical procedure, and disease status at latest follow-up were recorded, at a mean age of 5 years (range, 2-21 years) for treatment survivors.

Tumor staging was performed in accordance with the American Joint Committee on Cancer (AJCC) system.⁷ Histology was graded based on the Fédération Nationale

¹Mayo Clinic, Rochester, MN, USA

Corresponding Author:

Alexander Y. Shin, Department of Orthopedic Surgery, Mayo Clinic, 200 First Street South West, Rochester, MN 55905, USA.
Email: shin.alexander@mayo.edu

Table 1. Patient and Tumor Demographics.

Demographics	
Total number of patients	46
Males	22
Females	24
Mean age, y	38
Tumor pathology	
Epithelioid sarcoma	10
Synovial sarcoma	8
Myxoid fibrosarcoma	7
Fibrosarcoma	5
Angiosarcoma	3
Leiomyosarcoma	3
Other sarcomas ^a	10
Tumor location	
Hand or wrist	26
Finger	13
Thumb	7
Superficial to fascia	28
Adjuvant treatments	
Neoadjuvant chemotherapy	4
Adjuvant chemotherapy	7
Neoadjuvant radiation	14
Intraoperative radiation	4
Brachytherapy	1
Adjuvant radiation	5
Surgical treatments	
Wide local excision	41
Marginal excision	5
Single-ray resection	17
Multiple-ray resection	2
Amputation (transradial)	6

^aUndifferentiated sarcoma (n = 2), soft tissue osteosarcoma (n = 1), glomangiosarcoma (n = 1), soft tissue chondrosarcoma (n = 1), pleomorphic sarcoma (n = 1), rhabdomyosarcoma (n = 1), small cell sarcoma (n = 1), spindle cell sarcoma with epithelioid features (n = 1), alveolar soft part sarcoma (n = 1).

des Centres de Lutte Contre le Cancer (FNCLCC) scoring system.⁹ Surgical margins were defined as intralesional, marginal, and wide (1 cm of normal tissue). Limb salvage was defined as the ability to save at least part of the hand. A single-ray or multiple-ray resection was not considered a failure of limb salvage.^{21,22,25} Superficial tumors were defined as those above the fascia.

Patient Cohort

Our study cohort consisted of 22 males and 24 females, with a mean age at diagnosis of 38 years (4-77 years). The most common STS subtypes (Table 1) were epithelioid (n = 10) and synovial sarcoma (n = 8). A majority of the tumors were superficial (n = 28, 60%). At the time of presentation, 4 patients were noted to have distant metastases. The mean tumor volume based on the pathology measurements was

50 cm³ (range, 0.14-658 cm³) at the time of tumor extirpation. The mean longest dimension of the tumor was 2.7 cm (range, 0.15-10.5 cm).

Thirty-three (72%) patients had had an unplanned excision prior to definitive surgical treatment at our institution. Neoadjuvant and adjuvant radiation was given in 18 patients (Table 1), with a mean dose of 49 Gy (range, 15-60 Gy). There was no difference in the mean dose between the neoadjuvant and adjuvant radiation groups (50 Gy vs 44 Gy, *P* = .25). Neoadjuvant and adjuvant chemotherapy was given in 11 patients (Table 1) at the discretion of the staff medical oncologists. All patients underwent surgical treatment with curative intent. Negative margins were obtained in all cases, with complete resection of the tumor bed in cases of reexcision. Forty (87%) patients underwent a limb salvage procedure and six patients had an amputation, either transradial or below elbow. Limb salvage was performed for all patients where it was felt the patient would have a functional hand following tumor excision. Limb salvage failed in 2 patients due to local recurrence, necessitating amputation. The overall limb salvage rate was 83%.

Accounting for All Patients

Following the surgical procedure, patients were followed longitudinally for recurrence for every 3 to 4 months for the first 2 years, then every 6 months for years 2 to 5, and then annually for years 5 to 10 with a chest computerized tomography (CT) scan and magnetic resonance imaging (MRI) of the involved extremity for surveillance. Of the surviving patients, 13 (35%) of the patients have not been clinically evaluated in the past 5 years. However, only 2 of these patients had not made it to their 5-year clinical follow-up visit.

Statistical Analysis

Continuous variables were compared using the unpaired Student *t* tests, and the Fischer exact tests were used to compare categorical variables. The Kaplan-Meier survival method was used to estimate survival. Proportional hazard regression and log-rank analysis was performed to assess the risk of local and distant recurrence as well as overall survival. Multivariate regression analysis was not performed due to the limited number of events. Statistical significance was set at a *P* value < .05.

Results

Disease-Free Survival

Over the course of the study, 16 (35%) patients developed local recurrence or distant disease. Local recurrence was observed in 5 (11%) patients, 3 of whom also developed distant disease. Local recurrence was treated with transradial

Figure 1. a, Disease-free survival; b, local recurrence-free survival; c, distant disease-free survival; and d, overall survival following surgical excision of a soft tissue sarcoma of the hand and wrist.

Note. The 5-year survival for each of these factors was 63%, 86%, 66%, and 78%, respectively.

amputation ($n = 2$) and wide reexcision ($n = 3$). Distant disease occurred in 14 (30%) patients. The location for metastatic disease included lungs ($n = 7$), distant lymph nodes ($n = 4$), brain ($n = 1$), soft tissue of the thigh ($n = 1$), and pancreas ($n = 1$). The mean time to recurrence was 2 years (range, 1 month to 8 years). The overall 2-, 5-, and 10-year overall disease-free survival was 71%, 63%, and 63%, respectively (Figure 1).

Due to the limited number of local recurrences in the study, it was difficult to identify risk factors for local recurrence. Age, sex, tumor location, tumor size, and tumor grade were not associated with local recurrence in our patient cohort (Table 2). The overall 2-, 5-, and 10-year local recurrence-free survival was 91%, 86%, and 86%, respectively (Figure 1).

In an analysis of risk factors associated with distant disease recurrence, it was found that tumors located deep to the fascia (hazard ratio [HR] = 4.79, $P = .004$); AJCC Grade III/IV (HR = 14.49, $P < .0001$); tumors ≥ 2 cm (HR = 4.68, $P = .007$), ≥ 3 cm (HR = 3.74, $P = .03$), ≥ 4 cm (HR = 3.74, $P = .03$), or ≥ 5 cm (HR = 10.33, $P \leq .0001$) in maximal dimension; tumors necessitating primary limb amputation (HR = 11.92, $P < .0001$); and use of adjuvant chemotherapy (HR = 7.71, $P = .0009$) were all associated with an increased risk

of the development of distant disease. Likewise tumors superficial to the fascia (HR = 0.20, $P = .004$), < 2 cm in maximal dimension (HR = 0.21, $P = .007$), AJCC Grade I/II (HR = 0.06, $P < .0001$), and patients with a history of an unplanned excision (HR = 0.30, $P = .03$) had a reduced risk of distant disease (Table 3). The overall 2-, 5-, and 10-year distant disease-free survival was 75%, 66%, and 66%, respectively (Figure 1).

Overall Survival

Over the course of the study, 9 patients expired at a mean 3 years (range, 1-6 years) following surgical resection. All patients died due to a complication of their disease, with all patients having metastatic disease at the time of death. The overall 2-, 5-, and 10-year survival was 96%, 78%, and 72%, respectively (Figure 1). All patients that expired during the course of the study had evidence of distant disease spread ($P < .0001$). In an analysis of risk factors associated with overall survival, it was found that patients with metastatic disease at presentation (HR = 11.07, $P = .02$); age > 40 years (HR = 4.05, $P = .04$); AJCC Grade III/IV (HR = 49.86, $P \leq .0001$); tumors ≥ 2 cm (HR = 5.93, $P = .01$), ≥ 3 cm (HR = 8.62, $P = .003$); ≥ 4 cm (HR = 9.12, $P = .002$), or

Table 2. Factors Associated With Local Recurrence.

Patient factors	Hazard ratio (95% CI)	P value
Age, y		
≤40	0.82 (0.13-6.22)	.82
>40	1.21 (0.16-7.36)	.82
Male gender	0.70 (0.09-4.28)	.70
Tumor characteristics		
Location		
Finger/thumb	0.56 (0.02-3.82)	.59
Hand/wrist	1.76 (0.26-34.59)	.59
Superficial to fascia	0.78 (0.12-5.98)	.79
Deep to fascia	1.27 (0.16-7.76)	.79
Low grade (FNCLCC)	0.39 (0.01-3.15)	.39
High grade (FNCLCC)	2.50 (0.31-51.08)	.39
AJCC Grade I/II	0.29 (0.03-6.18)	.35
AJCC Grade III/IV	3.34 (0.16-27.83)	.35
Tumor size, cm (maximal dimension)		
≤2	0.73 (0.12-5.60)	.73
≥2	1.36 (0.17-8.31)	.73
≥3	1.49 (0.07-10.25)	.72
≥4	1.49 (0.07-10.25)	.72
≥5	2.04 (0.10-14.64)	.55
Surgical considerations		
Ray resection	0.81 (0.10-4.94)	.82
Amputation	—	—
Wide resection	0.20 (0.03-1.59)	.11
Reexcision of previous unplanned excision	0.08 (0.004-0.56)	.01
Adjuvant treatment considerations		
Neoadjuvant radiation	1.38 (0.18-8.39)	.72
Adjuvant radiation	—	—
Neoadjuvant chemotherapy	—	—
Adjuvant chemotherapy	2.01 (0.06-9.95)	.56

Note. CI = confidence interval; FNCLCC = Fédération Nationale des Centres de Lutte Contre le Cancer; AJCC = American Joint Committee on Cancer.

≥5 cm (HR = 12.73, $P = .0007$) in maximal dimension; those necessitating primary amputation (HR = 9.85, $P = .002$); or patients undergoing adjuvant chemotherapy (HR = 9.18, $P = .001$) had an increased risk with mortality over the study period. Likewise AJCC I/II tumors (HR 0.02, $P \leq .0001$), <2 cm in maximal dimension (HR = 0.17, $P = .01$), age ≤40 years (HR = 0.24, $P = .04$), and patients undergoing a reexcision of a previously excised tumor (HR = 0.15, $P = .008$) all had a decreased risk of mortality over the course of the study period (Table 4).

Complications

Posttreatment complications associated with the treatment of a STS in the hand occurred in 11 (24%) patients.

Table 3. Factors Associated With the Development of Distant Disease.

Patient factors	Hazard ratio (95% CI)	P value
Age, y		
≤40	0.52 (0.17-1.53)	.23
>40	1.90 (0.65-5.58)	.23
Male gender	1.06 (0.36-3.10)	.91
Tumor characteristics		
Location		
Finger/thumb	0.60 (0.13-1.95)	.42
Hand/wrist	1.64 (0.51-7.28)	.42
Superficial to fascia	0.20 (0.05-0.62)	.004
Deep to fascia	4.79 (1.59-17.53)	.004
Low grade (FNCLCC)	0.41 (0.09-1.41)	.16
High grade (FNCLCC)	2.38 (0.70-10.77)	.16
AJCC Grade I/II	0.06 (0.02-0.23)	<.0001
AJCC Grade III/IV	14.49 (4.32-48.39)	<.0001
Local recurrence	4.42 (0.98-14.43)	.05
Tumor size, cm (maximal dimension)		
<2	0.21 (0.05-0.65)	.007
≥2	4.68 (1.51-17.33)	.007
≥3	3.74 (1.12-11.27)	.03
≥4	3.74 (1.12-11.27)	.03
≥5	10.33 (3.35-32.88)	<.0001
Surgical considerations		
Ray resection	0.68 (0.21-1.98)	.49
Limb salvage	0.08 (0.02-0.26)	<.0001
Amputation	11.92 (3.72-37.20)	<.0001
Wide resection	0.81 (0.22-5.26)	.79
Reexcision of previous unplanned excision	0.30 (0.10-0.90)	.03
Adjuvant treatment considerations		
Neoadjuvant radiation	0.82 (0.22-2.48)	.74
Adjuvant radiation	2.38 (0.53-7.67)	.22
Neoadjuvant chemotherapy	0.78 (0.04-3.95)	.80
Adjuvant chemotherapy	7.71 (2.44-23.17)	.0009

Note. CI = confidence interval; FNCLCC = Fédération Nationale des Centres de Lutte Contre le Cancer; AJCC = American Joint Committee on Cancer.

Posttreatment complications included fibrosis and contracture of the fingers ($n = 4$), neuroma formation ($n = 2$), neuralgia ($n = 2$), skin necrosis requiring skin grafting ($n = 1$), superficial skin sloughing ($n = 1$), and radiation fibrosis of the carpal tunnel leading to acute carpal tunnel syndrome ($n = 1$). In analyzing risk factors for postoperative complications, it was found that patients having neoadjuvant (HR = 3.56, $P = .04$) or intraoperative radiation (HR = 7.80, $P = .006$) were at a significantly increased risk for the development of postoperative complications (Table 5). Likewise patients with tumors ≥3 cm (HR = 4.43, $P = .03$) and ≥4 cm (HR = 4.83, $P = .02$) were at increased risk of postoperative complications.

Table 4. Factors Associated With Overall Survival.

Patient factors	Hazard ratio (95% CI)	P value
Age, y		
≤40	0.24 (0.05-0.94)	.04
>40	4.05 (0.106-19.33)	.04
Male gender	2.44 (0.64-11.58)	.19
Tumor characteristics		
Location		
Finger/thumb	0.45 (0.09-1.74)	.25
Hand/wrist	2.18 (0.57-10.42)	.25
Superficial to fascia	0.43 (0.10-1.66)	.21
Deep to fascia	2.28 (0.59-9.29)	.21
Metastatic disease at presentation	11.07 (1.57-51.82)	.02
Low grade (FNCLCC)	0.66 (0.13-2.74)	.57
High grade (FNCLCC)	1.50 (0.36-7.36)	.57
AJCC Grade I/II	0.02 (0.001-0.12)	<.0001
AJCC Grade III/IV	49.86 (7.76-970.01)	<.0001
Tumor size, cm (maximal dimension)		
<2	0.17 (0.02-0.73)	.01
≥2	5.93 (1.36-40.58)	.01
≥3	8.62 (2.08-42.42)	.003
≥4	9.12 (2.22-44.65)	.002
≥5	12.73 (3.07-62.91)	.0007
Surgical considerations		
Ray resection	0.77 (0.19-2.96)	.71
Amputation	9.85 (2.38-38.32)	.002
Wide resection	0.97 (0.17-18.16)	.97
Reexcision of previous unplanned excision	0.15 (0.03-0.62)	.008
Local disease recurrence	3.11 (0.45-13.61)	.21
Adjuvant treatment considerations		
Neoadjuvant radiation	0.27 (0.01-1.52)	.15
Adjuvant radiation	1.97 (0.12-3.43)	.43
Neoadjuvant chemotherapy	—	—
Adjuvant chemotherapy	9.18 (2.41-37.36)	.001

Note. CI = confidence interval; FNCLCC = Fédération Nationale des Centres de Lutte Contre le Cancer; AJCC = American Joint Committee on Cancer.

Discussion

STS of the hand tend to be small and more aggressive than other malignancies of the same size in other areas of the extremities.² Previous studies have advocated for an aggressive approach at achieving negative margins at the time of tumor extirpation.^{2,13,20,23} Even with negative tumor margins in all patients in our study, the 10-year overall and disease-free survival was 72% and 63%, respectively, highlighting the aggressive nature of these tumors.

Tumor size has been found in multiple studies to adversely affect outcomes, with tumors 5 cm or larger having poorer

Table 5. Factors Associated With Postoperative Complications.

Patient factors	Hazard ratio (95% CI)	P value
Age, y		
≤40	1.51 (0.53-6.94)	.53
>40	0.66 (0.14-2.30)	.53
Male gender	0.81 (0.21-2.72)	.74
Tumor characteristics		
Location		
Finger/thumb	0.50 (0.13-1.68)	.26
Hand/wrist	1.98 (0.59-7.65)	.26
Superficial to fascia	0.56 (0.16-1.98)	.35
Deep to fascia	1.78 (0.50-6.07)	.35
Low grade (FNCLCC)	0.79 (0.22-2.69)	.71
High grade (FNCLCC)	1.25 (0.37-4.44)	.71
AJCC Grade I/II	0.15 (0.01-4.02)	.22
AJCC Grade III/IV	6.32 (0.24-160.85)	.22
Tumor size, cm (maximal dimension)		
<2	0.37 (0.10-1.36)	.13
≥2	2.68 (0.73-9.83)	.13
≥3	4.43 (1.09-16.87)	.03
≥4	4.83 (1.18-18.47)	.02
≥5	2.04 (0.30-8.59)	.40
Surgical considerations		
Ray resection	0.28 (0.05-1.00)	.05
Amputation	1.21 (0.06-6.61)	.85
Wide resection	0.45 (0.10-3.13)	.37
Reexcision of previous unplanned excision	1.07 (0.23-3.75)	.91
Adjuvant treatment considerations		
Neoadjuvant radiation	3.56 (1.04-12.82)	.04
Intraoperative radiation	7.80 (1.91-29.83)	.006
Adjuvant radiation	—	—
Neoadjuvant chemotherapy	2.16 (0.31-9.61)	.38
Adjuvant chemotherapy	—	—

Note. CI = confidence interval; FNCLCC = Fédération Nationale des Centres de Lutte Contre le Cancer; AJCC = American Joint Committee on Cancer.

survival and recurrence outcomes.^{15,28} In our series, 87% of tumors were smaller than 5 cm. This is similar to other studies examining sarcomas of the hand, where a majority of the tumors were smaller than 5 cm.^{2,15,20,28} Previous studies have shown factors important to metastatic risk and overall survival for sarcomas of the extremity are tumor grade, depth, and size, with 5 cm being the cutoff point where a significant increase in mortality and also metastases occur.^{4,8,19,28,29,31} In cases of STS in the distal extremities, Talbert and colleagues showed that there were no cases of metastatic disease in tumors smaller than 3 cm; however, those greater than 3 cm in size were associated with an increased prevalence of metastasis.²⁸ Unlike the study by Talbert, our study only focused on STS

of the hand, and 7 patients developed metastatic disease with a tumor smaller than 3 cm in maximal dimension.²⁸ This finding has led us to critically reevaluate the risk of mortality and metastatic disease based on the maximal size for tumors in our series. We found that in the hand, there is a significantly increased risk for mortality and metastatic disease for STS with a maximal dimension of 2 cm or greater. We acknowledge that these data are from univariate analysis; however, this finding potentially has a significant impact on the care of patients with STS of the hand, as tumor grading and adjuvant treatment protocols typically focus on a maximal dimension of 5 cm, with “low-grade” tumors defined as those less than 5 cm in maximal dimension.⁷ For STS of the hand, this may need to be reevaluated with further, larger, multicenter studies to determine whether a modification to the current scoring system needs to occur.

The results of this study support the use of wide surgical excision and limb salvage surgery if obtainable.^{2,20,23} We found limb salvage surgery did not have an adverse effect on patient outcomes in regard to posttreatment complications and survival. We did note an increased rate of distant disease and also poorer overall survival in patients treated with an amputation. We believe this is due to the inherent nature of the tumor at the time of excision. All amputations occurred in patients with tumors greater than 5 cm in maximal dimension, and 5 of the 6 were high-grade tumors at the time of amputation. Previous studies have shown tumors 5 cm or greater to have a high metastatic potential, with over 50% of tumors greater than 5 cm metastasizing and having a worse overall survival.^{15,28}

Similar to other reports, a majority of patients (72%) in our study underwent a nononcologic excision at an outside facility prior to their definitive oncological resection at our institution.^{1,13,23} Gustafson and colleagues showed patients with a history of an unplanned surgical excision had higher rates of local recurrence; however, there was no effect on overall survival.¹⁰ An unplanned surgical excision in our study had no detrimental effect on patient outcome, both in terms of recurrence and survival. In cases of inadvertently excised STS, we advocate for a multidisciplinary team approach, with wide local excision of the tumor bed along with adjuvant treatment on an individualized basis.

After preserving the patient's life and obtaining local control, one of the primary goals of treatment is limb and hand preservation.²⁴ To accomplish hand preservation, single-digit or multiple-digit as well as hemihand amputation in the setting of negative margins has been successful at preserving hand function.^{21,22,25} Radiation therapy has been shown to reduce rates of local recurrence in the hand; however, it is ineffective in the setting of positive surgical margins.^{2,20} Although its use has shown benefit in rates of local control, the use of radiation is not without its complications.^{6,17,18,30}

In the hand, it has been shown that complications range from impaired motion, fibrosis, and decreased grip strength, and stress fractures occur in up to 73% of cases.^{22,25,26} In our study, the use of neoadjuvant and intraoperative radiation therapy significantly increased the risk of postoperative complications, most notably fibrosis, wound complications, and functional impairment of the hand. This is similar to a study by Puhaindran and colleagues where they noticed a decrease in hand function in patients with perioperative radiotherapy.²² The complex anatomy of the hand, as well as the need for soft tissue gliding, is thought to contribute to the increased risk of impaired hand function.²⁵ In addition to the decreased motion, 2 patients in our cohort sustained local neurological impairments as a result of their radiation therapy, something that was not reported in the largest series in the literature.²⁵ One patient developed sensory loss over the radial border of the index finger following radiation to the thenar web space, and an additional patient developed postradiation fibrosis of the carpal tunnel requiring an open carpal tunnel release.

We did not evaluate functional impairment following limb salvage surgery in the patients of our cohort. We acknowledge that this is an important factor that needs attention when dealing with STS of the hand. Multiple studies by Puhaindran and colleagues have shown acceptable functional outcomes in terms of Musculoskeletal Tumor Society scores following single-digit, multiple-digit, and even hemihand amputation.^{21,22,25} Intuitively, they noticed that patients with single-ray resections had better results in terms of functional outcomes compared with patients with multiple-digit and hand preservation procedures.^{21,22,25} Even in cases of multiple-digit amputations, patients were able to perform key, tip, and tripod pinch, allowing the hand to assist in 2-handed activities, advocating for limb salvage and hand preservation.^{21,24}

We recognize the limitations to our study. As our data were examined retrospectively, the amount of data we were able to collect from the medical record were limited, and presented constraints on the analysis presented. The number of patients in this cohort was small; however, due to the rare nature of this disease, the numbers are comparable with other studies in the literature. This series was limited to a single institution, with multiple surgeons performing the operation; however, all surgeons performing the tumor resection were orthopedic oncology subspecialty surgeons. Although the method for tumor extirpation varied due to size and location of the tumor, negative margins were achieved in all samples. Although all patients had at least 2 years of clinical follow-up, it is possible that with longer follow-up further recurrence and death due to disease could occur.

Overall STS of the hand are rare, and reexcision is common. The results of our study highlight the aggressive nature of STS of the hand, with tumors more than or equal to 2 cm in maximal dimension having increased risk for the development of metastatic disease. We believe that further studies are needed to determine whether a separate grading system is needed for STS of the hand, which adequately reflects the aggressive nature of these tumors.

Authors' Note

Prior to the start of this retrospective study, the Mayo Clinic Institutional Review Board (IRB) approved this study (IRB Protocol 12-001434). Due to the retrospective nature of the study, the IRB approval included a waiver for the need to have consent from all patients.

Ethical Approval

This study was approved by our institutional review board.

Statement of Human and Animal Rights

This article does not contain any studies with human or animal subjects.

Statement of Informed Consent

Informed consent was obtained when necessary.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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