Soft Tissue Sarcoma of the Hand and Wrist: Epidemiology and Management Challenges

S. Nicholson¹ R. H. Milner¹ M. Ragbir¹

¹Department of Plastic Surgery, Royal Victoria Infirmary, Newcastle Upon Tyne, United Kingdom

Address for correspondence S. Nicholson, FRCS, Department of Plastic Surgery, Pulvertaft Hand Centre, Royal Derby Hospital, Uttoxeter Road, Derby, DE22 3NE, United Kingdom (e-mail: si.nicholson@doctors.org.uk).

J Hand Microsurg 2018;10:86–92

Abstract

Keywords

- soft tissue
- sarcoma
- hand
- wrist
- outcomes
- management

Soft tissue sarcomas (STSs) of the hand and wrist are rare and confer a unique set of management challenges. We present a 15-year review and discussion of the epidemiology, tumor characteristics, treatment, and reconstructive strategies for such cases presenting to our regional sarcoma service. Three case examples are described. Of 218 STSs of the upper limb, 17 involved the hand or wrist. Alveolar rhabdomyosarcoma, synovial, and myxofibrosarcoma were the most common ones. Two patients required amputation for recurrence. Eight patients required flap reconstruction, of which five were free flaps with no failures or wound healing complications. Two-year overall survival rate was 92%. Local recurrence occurred in 12%. Limb-sparing surgery is possible in most patients, although there is often a degree of functional loss due to the surgical resection, and complex multistage reconstruction may be required. These lesions are still often incidental or unexpected findings when patients are treated for a presumed benign swelling. Clinicians treating localized swellings of the hand and wrist should maintain vigilance toward the possibility of a sarcoma diagnosis, to avoid delays in definitive treatment.

Introduction

There are around 50 types and subtypes of soft tissue sarcoma (STS), of which the greatest number occurs in the limbs, yet this rare group of tumors represents only 1% of all cancers. It is estimated that less than 1% of all upper limb tumors occur in the hand,¹ and as such the behavior of tumors at this body site is not well studied. Many studies of STS of the hand are limited to reports of single cases that provide little evidence to guide the modern sarcoma service.^{2–4}

We reviewed all cases of STS of the hand and wrist at our regional sarcoma service over a 15-year period. We present the demographics of the cohort, tumor epidemiology, and mode of presentation, along with individual treatment strategies and outcomes, and reconstructive details. Three case examples aid in the description of types of presentation, management strategies, and outcomes of these patients.

Methods

Our database records all patients with histologically confirmed sarcoma that present to our multidisciplinary team (MDT). The database was searched for STS of the upper limb. The results were manually filtered according to body site to identify only those at, or distal to, the distal radioulnar joint (DRUJ). Medical records were analyzed for each patient to obtain demographics, tissue diagnosis, tumor grade, stage, surgical management, subsequent management, and outcome. Results were recorded in an encrypted Excel spreadsheet.

A literature review from the past 20 years was performed following a PubMed search using the terms (sarcoma NOT bone) AND ([hand OR wrist] OR [upper limb]) in the title or abstract. Articles without an English language version were excluded. Twenty-two full-text articles were appraised, along with 28 further abstracts also felt to be relevant.

received
April 17, 2017
accepted after revision
January 20, 2018
published online
April 3, 2018

©2018 Society of Indian Hand & Microsurgeons

DOI <https://doi.org/10.1055/s-0038-1636728>.
ISSN 0974-3227.

Results

The database search yielded 218 STSs of the upper limb over the 15-year study period; a mean of 14.5 tumors per year. Seventeen of these (7.7%) were of the hand or wrist (12 hand vs. 5 wrist), giving a mean of 1.1 cases per year. The male-to-female ratio was equal (8:9), and ages ranged from 10 to 84 years (mean 44.6 years).

Tissue diagnosis included synovial sarcoma, alveolar rhabdomyosarcoma, and myxofibrosarcoma most commonly, with other subtypes also present (►Fig. 1). ►Table 1 demonstrates the precise locations of these tumors and structures sacrificed in their surgical excision.

Of those tumors for which complete data were available, six were grade II (intermediate), four were grade I (low), and two were grade III (high). Interestingly, 11 out of 17 tumors (65%) involved the radial aspect of the hand or wrist, compared with five of the central hand or middle ray and only one

Fig. 1 Proportion of sarcomas presenting, by subtype.

Table 1 Tumor locations, structures sacrificed in surgical excision, and reconstruction method

Tumor site	Structures sacrificed	Flap reconstruction	Notes
Dorsum right hand	None—tumor only	None	
Dorsal fourth MCP joint	None at primary treatment	None	Amputation of fourth ray for recurrence at 2 years
Left first web space	FPB, RDN thumb, AbP, radial portion TCL, thenar branch MN, flexor sheath of index	Free groin flap	Amputation of first ray for recurrence
Right hand (NOS)	None	No	
Radial side right wrist	None	No	
Left dorsoradial wrist	First metacarpal and partial carpals	Free fibula flap	
Right volar radial wrist	Radial vessels, FPL, FCR, radial wrist joint, thumb	Free rectus abdominis flap	
Left radial styloid	Radial wrist extensor tendons, thumb extensors, and abductors	Distally based radial forearm flap	
Volar right thumb	None	No	
Right first web space	First dorsal interosseous muscle	No, but eventual skin flaps for web space deepening	
Left middle finger	None	No	
Left dorsoradial wrist	ECRL, ECRB, EPL, EPB	Free anterolateral thigh flap	Later EIP to EPL tendon transfer
Right middle finger	Middle finger ray	No	
Ulnar right wrist within DRUJ	Distal ulna, TFCC, FCU	No	
Right first dorsal interosseous	First dorsal interosseous muscle	No	Presented at stage IV with leg pain from metastasis
Right first web space	EPL, superficial branch of radial nerve	Distally based radial forearm flap	Simultaneous EPL reconstruction with plantaris tendon graft
Left palm second ray	Skin, fascia, flexor sheath	Free medial plantar flap	

Abbreviations: AbP, adductor pollicis; ECRB, extensor carpi radialis brevis; ECRL, extensor carpi radialis longus; EIP, extensor indicis proprius; EPB, extensor pollicis brevis; EPL, extensor pollicis longus; FCR, flexor carpi radialis; FCU, flexor carpi ulnaris; FPB, flexor pollicis brevis; FPL, flexor pollicis longus; MN, median nerve; RDN, radial digital nerve; TFCC, triangular fibrocartilage complex.

of the ulnar wrist structures. Sixteen (94%) out of 17 tumors presented with a lump, of which only 2 were reported to be painful or uncomfortable. The final patient presented with metastatic disease in the thigh manifesting as an ache, with synchronous metastases of the lung and axilla and the presumed primary at the first dorsal interosseous muscle detected on whole-body positron emission tomography-computed tomography (PET-CT). ▶**Table 2** demonstrates tumor characteristics and outcomes for each patient.

The percentage of patients with negative margins at excision was 76% ($n = 13$), of whom 3 (23%) developed recurrence (local or distant). Of the three patients (18%) with involved margins at wide excision, one developed recurrence—an

alveolar rhabdomyosarcoma of stage IIA at diagnosis. In one patient the margin status was not available.

The 2-year overall survival rate in this series is 92%, and 2-year disease-free survival 62%.

The local recurrence rate is 12% ($n = 2$), and rate of distant metastases is 29% ($n = 5$).

Ten (59%) patients required adjuvant radiotherapy, of whom one was for recurrent disease, an angiosarcoma, and one was for metastases detected at presentation. No patients received neoadjuvant radiotherapy.

All eight flaps used in this cohort healed without failure or wound healing complications. Four patients went on to have a second reconstructive procedure; either tendon transfers

Table 2 Tumor characteristics and outcome for each patient

Age	Sex	Diagnosis	Grade	Size (mm)	AJCC stage at diagnosis	Histologic excision margin (mm)	Radiotherapy	Local recurrence	Distant metastases	Status
36	M	Synovial	II	18	IIB	Clear	No	No	No	Disease free
84	F	Angiosarcoma	I	nd	nd	2.5	Adjuvant for recurrence	Yes	Yes	Alive with recurrence
14	M	Alveolar rhabdomyosarcoma	–	25	IIA	Involved deep margin at WLE	Adjuvant	Yes	Yes	Alive with recurrence
14	F	Alveolar rhabdomyosarcoma	–	nd	III	nd	Adjuvant	No	No	Alive with recurrence
83	M	Leiomyosarcoma	II	50	IIA	Involved	Adjuvant	No	No	Disease free
36	M	Synovial	II	19	IIA	15	Adjuvant	No	No	Disease free
59	M	Myxofibrosarcoma	III	95	III	4	Adjuvant	No	Yes	Disease free
64	M	Epithelioid	II	nd	At least IIA	Clear	nd	No	No	Disease free
48	F	Leiomyosarcoma	I	6	IA	Clear	nd	No	No	Disease free
16	F	Alveolar rhabdomyosarcoma	–	30	IA	involved	Adjuvant	No	No	Disease free
68	F	Myxofibrosarcoma	I	5	IA	Clear	No	No	No	Disease free
72	M	Chondrosarcoma	II	33	IIA	1	Adjuvant	No	No	Disease free
50	F	Small round blue cell	III	25	IIA	7	No	No	Yes	Alive with recurrence
34	F	Synovial	II	10	IIA	Clear	Adjuvant	No	No	Disease free
10	F	Alveolar rhabdomyosarcoma	–	20	IV	1	To sites of metastasis only	No	Yes	Died of recurrence 21 mo post diagnosis
17	M	Fibromyxoid	I	40	IA	0.1	No	No	No	Disease free
46	F	Nodular spindle cell sarcoma	nd	13	IA	Clear	No	No	No	Disease free

Abbreviations: AJCC, American Joint Committee on Cancer; F, female; M, male; nd, not documented; WLE, wide local excision.

($n = 3$), or first web space deepening and fat transfer ($n = 1$). Two patients developed painful neuromata in the superficial branch of radial nerve, of which one required excision and burial and the other was managed non-surgically.

Two of the 17 cases developed local recurrence, both of which were managed by amputation—one of the fourth digital ray and one of the first and second rays. Both of these patients were alive at 5 years but with distant metastases. Eleven of 17 patients are alive with no evidence of disease. The remaining six patients are currently being followed up for recurrent disease. Of those patients who have so far been discharged from the sarcoma service, median follow-up was 63 months.

Case Examples

Case 1

A 36-year-old right-handed man presented in 2009 with a 1-year history of discomfort at the left dorsoradial wrist, thought to represent de Quervain's tenosynovitis. After an attempt at steroid injection, the patient became aware of an ill-defined mass at the site, which magnetic resonance imaging (MRI) suggested being a ganglion cyst. The lesion was therefore excised at the referring hospital, with an unexpected histopathologic result of synovial sarcoma. Repeat

MRI demonstrated residual tumor (►Fig. 2), and staging CT demonstrated no distant metastases. The patient underwent a wide excision of the residual tumor including the first metacarpal, trapezium and distal pole of scaphoid, and simultaneous reconstruction with a free fibula osteocutaneous flap (►Fig. 3 and ►Fig. 4).

Histology confirmed a 19-mm intermediate-grade synovial sarcoma completely excised with 15-mm clear margins. The patient received adjuvant radiotherapy, and because of extensor lag at the metacarpophalangeal (MCP) joint, they later underwent transfer of extensor indicis for extensor pollicis longus reconstruction. He remained free from recurrence at discharge 6 years later.

Case 2

A 17-year-old right-handed boy presented in 2014 with a 2-year history of a mass in the right first web space, originally thought to be a ganglion due to its size remaining static for most of this time. Ultrasound-guided core biopsy demonstrated a low-grade fibromyxoid sarcoma. MRI demonstrated the lesion to be superficial to the muscle fascia. The 40-mm-wide lesion was excised with an incomplete deep margin, and a further wide excision with sacrifice of the first dorsal interosseous muscle and extensor pollicis longus tendon was performed. Simultaneously, the defect was reconstructed with a distally based radial forearm flap (►Fig. 5) and a plantaris tendon interposition graft to reconstruct the extensor tendon. Histology confirmed complete excision. No adjuvant therapies were required. The patient remains disease free at last follow-up, 2 years after presentation.

Fig. 2 Residual tumor with enhancement around the left scapho-trapezotrapezoidal joint.

Fig. 4 Healed skin paddle of free fibula flap. Note extensor lag of the thumb.

Fig. 3 Radiograph of left hand and wrist following reconstruction of first metacarpal with free fibula flap. Note metacarpal head was preserved to maintain MCP joint.

Fig. 5 Distally based radial forearm flap inset to first web space and donor site at volar forearm closed directly.

Case 3

A 46-year-old woman presented with a painless nodule in the left palm over the index finger ray several years after an episode of trauma to that site. The 13-mm-wide lesion was felt to be an epidermoid inclusion cyst and was excised with narrow margins. Histology demonstrated an unexpected finding of nodular spindle cell sarcoma. A wide excision was undertaken, preserving the flexor tendons and neurovascular bundles, along with reconstruction using a free medial plantar flap to replace the excised glabrous skin (►Fig. 6 and ►Fig. 7). Histology confirmed no residual tumor, and the patient did not require any adjuvant therapy. She remains disease free at 3 months postoperatively.

Discussion

Our regional sarcoma service receives around 150 newly diagnosed STS every year and covers a population of around 4 to 5 million.

Seven out of 17 of the lesions in our series were initially excised either outside of our sarcoma service or on the assumption that they were not malignant, with unexpected findings on histopathology results. This disappointing figure highlights the challenges that we still face in ensuring that atypical soft tissue masses receive appropriate investigations before excision, namely MRI scan and core biopsy if they involve a body site that makes wide local excision as primary treatment difficult. This is in keeping with previous authors' work.⁵ If there is a suspicion of a sarcoma diagnosis, biopsy should be performed by a surgeon on the soft tissue tumor MDT, and ideally the same person performing the definitive resection.

The diagnostic difficulty arises, in part, from the fact that many of these tumors are detected while still small and as such do not meet the size criterion of 5 cm for referral to a sarcoma MDT. It is essential that all clinicians treating soft tissue tumors, in these cases hand surgeons, maintain a high index of suspicion for lesions that may turn out to be malignant. Early referral to a specialist sarcoma service for management is the key to improving oncologic outcomes.

With this in mind, it is fortuitous that these tumors are rare; for example, a consultant hand surgeon not specializing in sarcoma may be expected to encounter one synovial sarcoma over the course of their career.²

When an "unplanned" excision of a sarcoma is performed outside of an STS MDT, initial histopathologic assessment is considered unreliable and should not be used to plan future treatment.⁶ It should always be discussed at an MDT and followed by a re-excision of the affected area if appropriate, though this may be dependent on anatomical constraints such as adjacent neurovascular structures, the additional morbidity it may cause, and potential efficacy of adjuvant therapy. Residual tumor at re-excision correlates with a risk of earlier and more likely local recurrence.⁶ Although not a statistically significant difference, 3 of the 7 (43%) lesions in our results excised elsewhere, or when not initially treated as sarcoma, developed metastases, compared with 2 of 9 (22%) excised after formal workup via sarcoma MDT.

One article⁷ proposes an algorithm for assessing dorsal wrist masses, which includes transillumination and aspiration at the initial clinic visit, and MRI and referral to a specialist center in atypical lesions. Longitudinal incisions are recommended for excision if the lesion is thought to be an "atypical" ganglion.

The difficulty in surgical management of STS of the hand arises from the intimate proximity to the many functionally important structures of this unique anatomical site. Small tumors, that is, those less than 5 cm diameter, may not be constrained by a single anatomical compartment.¹ An adequate margin of excision is necessary to reduce the risk of local recurrence, yet this frequently requires sacrifice of such structures as tendons or entire digital rays. Amputation, while reliable in ensuring local control, is debilitating and can impact on many aspects of a patient's life including the ability to self-care and earn a living.

Currently the treatment of choice involves excision of the lesion with a margin of clearance, although the minimum acceptable margin is yet to be determined,⁸ followed by immediate or delayed reconstruction, including skin, bone, nerves, tendons, blood vessels, or composite tissue structures.

Fig. 6 Excision defect left index finger ray.

Fig. 7 Medial plantar free flap inset to palm.

A wide variety of reconstructive options exist, whose success is determined by stable wound coverage, preservation of health, function, sensation, and cosmesis.¹ Free flaps offer durable and well-vascularized tissue of sizes greater than those achievable with local or regional flaps, and they are more often required in the hand than at other body sites. We have shown examples of these including their overall good outcomes without resorting to amputation in most cases.

Limb- or hand-sparing surgery is possible in most patients,⁹ but the type of resection depends on the size and location of the tumor. Compartmentectomy is mainly historical and rarely indicated.¹⁰ Tumor invasion of nerves is rare, and in cases in which the tumor is in close proximity to nerves, epineural dissection is considered a safe means of nerve preservation.¹⁰

Many of the tumors in this series have been small (< 5 cm), making limb-sparing surgery more practical. Previous authors have stated that surgical margins should never be sacrificed in attempt to maintain hand function (Upton et al, 1996),¹¹ as a wide surgical margin is the most predictive factor of tumor control,¹ and a positive surgical margin has a significant negative effect on survival.¹²

Importantly, whereas postoperative radiation helps reduce local recurrence in STSs, it appears to be ineffective in the hand when there are positive resection margins.⁵

Adjuvant Therapy

Adjuvant radiotherapy can improve local control of high-grade STS of the limbs, but not survival.¹³ High-grade tumors, those deep to the fascia, and those greater than 5 cm diameter are commonly cited indications for radiotherapy.¹⁴

Neoadjuvant radiotherapy is sometimes used to decrease tumor size before surgery, with the aim of reducing the overall dose or treatment volumes and increasing the likelihood of negative margins. However, it gives an increase in wound healing complications postoperatively. In the hand, radiotherapy is also associated with periarticular fibrosis that may adversely affect joint function. Joint stiffness appears to be less pronounced with neoadjuvant than adjuvant radiotherapy.¹⁴

Tumors of American Joint Committee on Cancer (AJCC) stage III or higher are considered an indication for neoadjuvant or adjuvant chemotherapy in STS. The most widely used agents are Adriamycin, ifosfamide, and cisplatin.¹ Different tumors have different sensitivities to chemotherapy. Synovial sarcoma, for example, is relatively chemosensitive.⁸

Metastasis

It has been observed that STSs of the hand metastasize to the lymph nodes more readily than those of other body sites,¹⁵ and it is suggested that this is probably a reflection of the tumor type, rather than the site of origin. Synovial sarcoma, which commonly but not exclusively occurs close to the joints, tendons and bursae, was shown in one study to metastasize to the lymph nodes in 27% of cases.²

Follow-up

In our unit, patients attend follow-up clinics every 3 months for 3 years, then every 6 months until year 5. At each clinic

visit, they undergo clinical examination and a chest radiograph is taken. If the tumor is considered high risk, the patient receives a baseline MRI scan of the primary site at 6 months postoperatively. Some of the pediatric patients attend a single surgical outpatient clinic, and thereafter they attend an oncology clinic for long-term follow-up.

Other authors describe clinical examination and chest X-ray (CXR) at each visit, plus yearly MRI of the primary site and CT of the chest.¹⁶

Survival

Buecker et al¹⁷ demonstrated a statistically significant improvement in overall survival of sarcomas occurring in the hand compared with other musculoskeletal sites. This is thought to be due to earlier diagnosis as a result of the restricted anatomical confines of the area. Decreased vascularity and temperature could also play a role. There is also evidence to the contrary, such as Campanacci et al¹⁸ who showed that those with hand tumors have a lower survival rate compared with other extremity sites.

This Study

The focus of this study is on demographic and epidemiologic characteristics of these rare tumors, and on the challenges in hand preservation by complex reconstructive approaches. The number of patients presented is comparable to the average of individual centers in previous work,^{5,19} but they remain insufficient to provide accurate evidence of the true rate of local recurrence, metastases, and survival. In addition, the follow-up period of this study is short, and it provides less useful information on oncologic outcomes. A higher rate of tumor recurrence may be expected with longer follow-up, and the magnitude of effect of positive excision margins on recurrence is not yet known. Many of the patients in the study had been treated within the past 5 years, so revisiting these cases in the intermediate future will give an opportunity to obtain 5-year survival data.

Unlike other studies, we have not specifically considered the impact of treatment and reconstruction on measurable hand function parameters. Our hand therapy department personnel do not routinely document objective measurements such as grip strength or perform formal DASH (Disabilities of the Arm, Shoulder and Hand) score assessments on such patients. Each sarcoma resulted in a different defect, and a different effect on function, such that standardization of such results would not be possible. It would be useful, however, in future work, to establish the proportion of patients who returned to their original occupation after treatment and over what timescale.

Conclusion

Only a few series specifically deal with primary STS of the hand, and as such there remains controversy over the significance of this particular body site on survival.

The widely understood notion that a painful mass is more likely to represent a sarcoma than a painless one may not be as applicable in the hand as would be assumed. This study found only a small proportion of patients presented with

pain, which may contribute to a delay in diagnosis, and this was statistically significant.

The long-term outcomes of recurrence and overall survival in this study suggest improvement compared with those of previous authors,^{5,15} but there remains much room to improve. It is likely that the rate of unanticipated sarcoma diagnoses will play a role in this. Vigilance toward the possibility of a sarcoma diagnosis is essential if patients are to be referred early to a sarcoma service for a chance of improved outcomes.

Limb-sparing surgery is possible in most cases of hand tumors, most likely because they present at an earlier stage (i.e., they are smaller) than at other body sites.

Funding

None.

Conflict of Interest

None.

References

- 1 Muramatsu K, Ihara K, Yoshida K, Tominaga Y, Hashimoto T, Taguchi T. Musculoskeletal sarcomas in the forearm and hand: standard treatment and microsurgical reconstruction for limb salvage. *Anticancer Res* 2013;33(10):4175–4182
- 2 Casal D, Ribeiro AI, Mafra M, et al. A 63-year-old woman presenting with a synovial sarcoma of the hand: a case report. *J Med Case Reports* 2012;6:385
- 3 Rubin G, Rinott M, Wolovelsky A, Elmalach I, Rozen N. Low-grade fibromyxoid sarcoma of the hand: a case report. *Hand (NY)* 2010;5(4):449–452
- 4 Seal A, Tse R, Wehrli B, Hammond A, Temple CL. Sentinel node biopsy as an adjunct to limb salvage surgery for epithelioid sarcoma of the hand. *World J Surg Oncol* 2005;3:41
- 5 Pradhan A, Cheung YC, Grimer RJ, et al. Soft-tissue sarcomas of the hand: oncological outcome and prognostic factors. *J Bone Joint Surg Br* 2008;90(2):209–214
- 6 Koulaxouzidis G, Schwarzkopf E, Bannasch H, Stark GB. Is revisional surgery mandatory when an unexpected sarcoma diagnosis is made following primary surgery? *World J Surg Oncol* 2015;13:306
- 7 Crosby SN, Alamanda VK, Weikert DR, Holt GE. Avoiding unplanned resections of wrist sarcomas: an algorithm for evaluating dorsal wrist masses. *Am J Orthop* 2013;42(9):401–406
- 8 Outani H, Hamada K, Oshima K, et al. Clinical outcomes for patients with synovial sarcoma of the hand. *Springerplus* 2014;3:649
- 9 Puhaindran ME, Athanasian EA. Double ray amputation for tumors of the hand. *Clin Orthop Relat Res* 2010;468(11):2976–2979
- 10 Koulaxouzidis G, Simunovic F, Bannasch H. Soft tissue sarcomas of the arm—oncosurgical and reconstructive principles within a multimodal, interdisciplinary setting. *Front Surg* 2016;3:12
- 11 Upton J, Kocher MS, Wolford FG. Reconstruction following resection of malignancies of the upper extremity. *Surg Oncol Clin N Am* 1996;5(4):847–892
- 12 Brien EW, Terek RM, Geer RJ, Caldwell G, Brennan MF, Healey JH. Treatment of soft-tissue sarcomas of the hand. *J Bone Joint Surg Am* 1995;77(4):564–571
- 13 Okunieff P, Suit HD, Proppe KH. Extremity preservation by combined modality treatment of sarcomas of the hand and wrist. *Int J Radiat Oncol Biol Phys* 1986;12(11):1923–1929
- 14 Green CM, Nguyen N, Wylie J, Choudhury A, Gregory JJ. The treatment of periarticular soft tissue sarcoma following neo-adjuvant radiotherapy: a cohort study. *World J Surg Oncol* 2015;13:108
- 15 McPhee M, McGrath BE, Zhang P, Driscoll D, Gibbs J, Peimer C. Soft tissue sarcoma of the hand. *J Hand Surg Am* 1999;24(5):1001–1007
- 16 Puhaindran ME, Rothrock CP, Athanasian EA. Surgical management for malignant tumors of the thumb. *Hand (NY)* 2011;6(4):373–377
- 17 Buecker PJ, Villafuerte JE, Hornicek FJ, Gebhardt MC, Mankin HJ. Improved survival for sarcomas of the wrist and hand. *J Hand Surg Am* 2006;31(3):452–455
- 18 Campanacci M, Bertoni F, Laus M. Soft tissue sarcoma of the hand. *Ital J Orthop Traumatol* 1981;7(3):313–327
- 19 Puhaindran ME, Steensma MR, Athanasian EA. Partial hand preservation for large soft tissue sarcomas of the hand. *J Hand Surg Am* 2010;35(2):291–295