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Original Article

Functional and oncological outcomes of limb-salvage surgery for foot and ankle tumors

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ABSTRACT

Background: Limb-salvage surgery has become the backbone treatment for musculoskeletal tumors in the last decades. However, limb-salvage with safe margins for tumors of the foot and ankle is challenging, due to the complex anatomy of this region. This study aimed to evaluate functional and oncological outcomes, complications, and local recurrence of limb-salvage procedures for tumors of the foot and ankle.

Methods: This study was a retrospective review of 18 patients with primary tumors of the foot and ankle who underwent limb-salvage surgery between 1996 and 2015, with a minimum follow-up of 2 years. Clinical presentations, radiological and histopathological investigations, surgical procedures, functional and oncological outcomes, complications and local recurrences were analyzed. The Musculoskeletal Tumor Society (MSTS) scoring system was utilized for evaluation of the functional outcome.

Results: With a mean follow-up period of 44.2 months, 7 males and 11 females with a mean age of 29.2 years were included. Nine patients were presented as recurrent cases. The most common location was forefoot in 7 patients. Synovial sarcoma was the histopathologic diagnosis in 7 patients. The final surgical margins were wide in 15 patients, wide-contaminated in one patient, and marginal in two patients. After resection, soft tissue reconstruction and wound coverage were done by soft tissue flaps in 4 patients. The mean MSTS score was 27.5. Four patients developed local recurrence, all of them were recurrent cases.

Conclusion: Limb-salvage surgery for foot and ankle tumors is an effective treatment option with good functional outcome.

Level of Evidence: Level IV, retrospective case series.

1. Introduction

Foot and ankle are considered rare locations for musculoskeletal tumors [1,2]. When a diagnosis of primary malignant tumor in this area is reached, a decision should be made whether to save or amputate the limb. This decision has substantial effects on psychosocial and functional outcomes [3,4].

Limb-salvage surgery for foot and ankle tumors aims to achieve local tumor control with an adequate wide margin while maintaining a sensate and plantigrade foot with satisfactory function [5,6]. Treatment with marginal excision may result in inadequate local control with a high rate of local recurrence, while more extensive wide or radical resection may compromise the function. When this balance cannot be achieved concurrently, amputation is indicated [6–8].

Limb-salvage surgery has some surgical difficulties such as the difficulty of obtaining adequate resection margins, problems with soft tissue coverage, lack of anatomic compartmentalization, and the possibility of contamination resulting from prior biopsy sites or previous surgeries [5,6,9]. Therefore, surgical options for these patients have historically been somewhat limited, and amputation has frequently been required [4,10].

If local disease control can be achieved without affecting the oncologic outcomes, limb-salvage patients may have psychological and physical benefits compared to patients undergone amputation [5,6,9]. Adjuvant treatment options have made limb-salvage surgery a favorable option even in cases with late diagnosis or previous inappropriate treatment [3,10].

This study aimed to evaluate the oncological and functional

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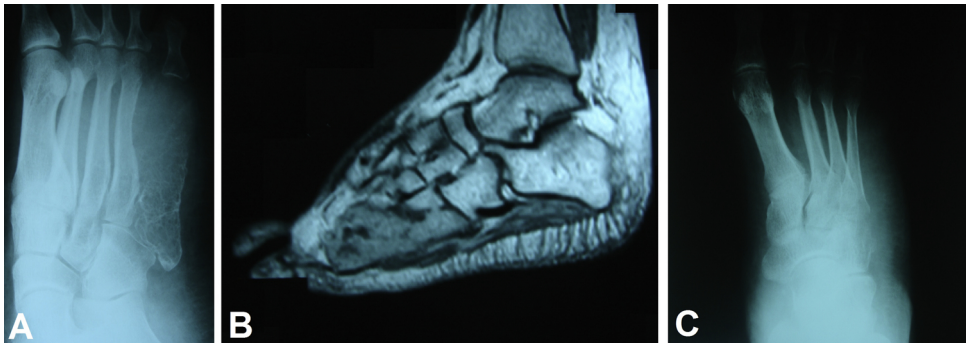

Fig. 1. A case of female patient 34 years old with giant cell tumor of the 5th metatarsal bone. A) Preoperative plain X-ray showing complete wash out of the 5th metatarsal bone. B) Preoperative MRI, sagittal view. C) Three-months postoperative X-ray after resection of the tumor with the 5th ray showing no recurrence.

outcome, complications and recurrence rate following limb-salvage surgery for treatment of the foot and ankle tumors.

2. Methods

2.1. Participants

This study included a retrospective review of medical records, radiographs, and pathology reports of patients with primary tumors of the foot and ankle who had undergone limb-salvage surgery at single musculoskeletal oncology center, after approval of our Institutional Review Board. The study included 18 consecutive patients who had the surgery between 1996 and 2015, with a minimum follow-up of 2 years for surviving patients.

Collected data included age, gender, tumor location, pathology, grade, stage, previous surgical interventions (including open biopsy or previous resections), type of resection, operative margins, and reconstructive techniques. The reviewed data also included complications, adjuvant treatments including chemotherapy and radiotherapy, local recurrence, metastases, functional outcomes, and patient survival.

When previous attempts of excision had been done prior to referral, patients were considered as recurrent cases. MRI was done to evaluate the tumor recurrence and surgical bed, with revision of previous histopathology reports and slides to confirm the diagnosis. Patients with aggressive recurrent tumors in whome limb salvage was not possible and amputation was mandatory, were excluded. Examples include patients with fungating tumor, those with neurovascular involvement, those with deep facial affection, or those leaving behind unreconstructable or functionless foot.

2.2. Surgical procedures

Limb-salvage surgery was determined according to tumor location, extent, skin condition, size and involvement of surrounding structures (neurovascular bundle, deep aponeurotic tissue, and bone). Surgical intervention was decided after discussion with every patient about the high risk of recurrence and possible need for amputation during the salvage surgery or later, and this was consented preoperatively. Wide tumor resection with an adequate wide margin was done for these cases which may have included tendons, small muscles of the foot, periosteum, and margins of bone or complete bone were resected as required to achieve adequate wide margins. Wide resection was defined according to Enneking [11] as a tumor resection with normal tissue all around. After resections, local rotational flaps and skin grafts and were used for wound coverage when necessary.

2.3. Follow up and functional outcomes

After complete wound healing, patients were followed up every 3 months for 2 years, and then every 6 months up to 5 years, and every year later on. During follow-up visits, chest X-ray and bone scan were done to detect distant metastasis, and when suspecting a local tumor recurrence, MRI was required.

The Musculoskeletal Tumor Society (MSTS) scoring system [12] for the lower extremities was used for evaluation of the functional outcome at the last follow-up visit.

The oncologic outcome was categorized as no evidence of disease (NED), alive with disease (AWD), or dead of disease (DOD). Complications and local recurrences were recorded. Recurrence was confirmed by histopathological evaluation.

2.4. Statistical analysis

Statistical analysis was performed using SPSS v.20.0 (SPSS Inc., Chicago, IL). Statistical analysis of data focused on the functional outcome, complications, and recurrence rates. Continuous variables (e.g., MSTS functional scores) were compared utilizing the Student's t-test. Potential differences between proportions of occurrences were assessed utilizing Chi-square analysis or the Fisher Exact test, as appropriate. Differences were considered statistically significant for p value < 0.05.

3. Results

3.1. Epidemiological characteristics

This study included 7 males (38.9%) and 11 females (61.1%) with a mean age of 29.2 (range, 10–60) years at the time of diagnosis. Nine patients (50%) presented to our center following previous surgeries performed elsewhere and were considered as recurrent cases. Pain was the primary presenting symptom in 11 patients (61.1%), mass was in 4 patients (22.2%), and pain and mass in 3 patients (16.7%).

3.2. Tumor characteristics

The tumor locations were forefoot in 7 patients (38.9%) (Figs. 1 and 2), hindfoot in 4 patients (22.2%), hindfoot and midfoot in 3 patients (16.7%), forefoot and midfoot in 2 patients (11.1%), and hindfoot and ankle in 2 patients (11.1%) (Fig. 3).

The histopathologic diagnoses in this series were synovial sarcoma in 7 patients (38.9%), Ewing's sarcoma in 3 patients (16.7%), and one case (5.6%) for each of liposarcoma, osteosarcoma, neurofibrosarcoma, myxofibrosarcoma, giant cell tumor (GCT) of the bone, fibromatosis, malignant peripheral nerve sheath tumor (MPNST), and GCT of the soft tissue (Table 1).

The tumor staging for sarcomas according to Enneking was stage IB (1 patient), IIB (12 patient) and IIIB (1 patient).

3.3. Surgical management

Limb-salvage surgery and wide resections (including ray resections)

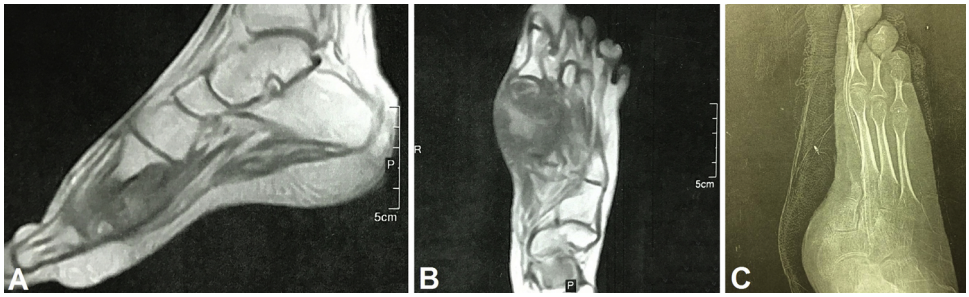

Fig. 2. A case of female patient 16 years old with Ewing's sarcoma of the forefoot. A) Preoperative MRI, sagittal view. B) Preoperative MRI, coronal view. C) Two-months postoperative X-ray after resection of the tumor with the medial 2 rays showing no recurrence.

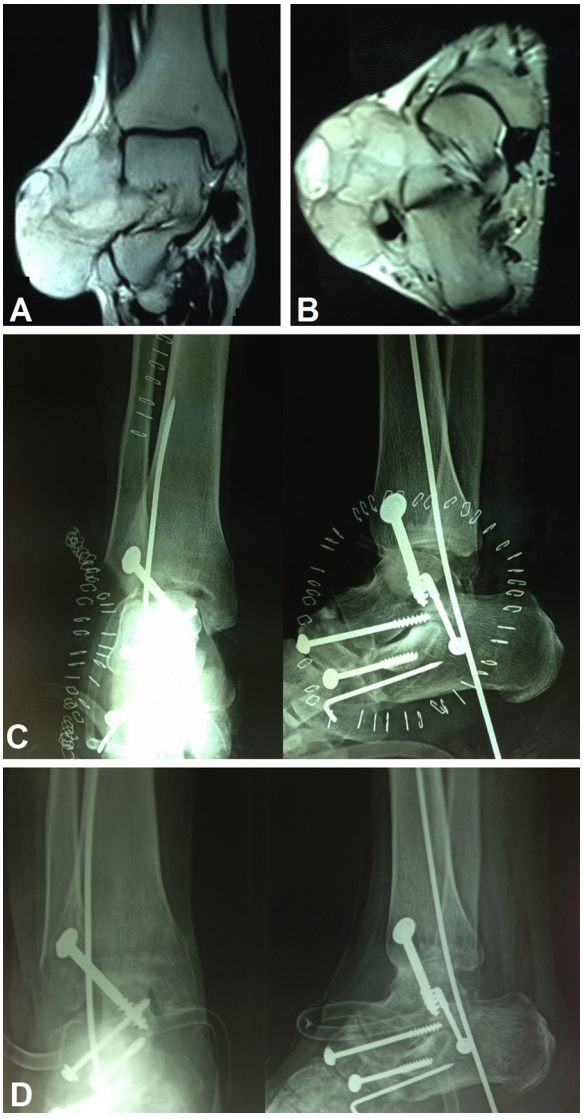

Fig. 3. A case of male patient 25 years old with synovial sarcoma of the hindfoot and ankle. MRI showing the mass is lying on the calcaneus and talus with extension into the subtalar joint; A) coronal view, B) axial view. Resection included the outer part of talus, calcaneus and distal fibula. C) Immediate post-operative X-rays showing pan-talar fusion by screws and K-wires. D) Four months postoperative X-rays showing ankle and subtalar fusion with no recurrence (N.B. the tube is the suction tube of the wound vacuum system).

were planned for all the 18 patients included in this study. To achieve a wide margin of resection, 13 patients underwent a variable degree of tendons and small muscles of the foot excision, peeling of the periosteum from bone, and sometimes excision of chips or margins of bone or complete bone excision, while the other 5 cases underwent ray resection. The final surgical margins were wide in 15 patients (83%), wide-contaminated in one patient (5.6%), and marginal in two patients (11.1%).

After resection, soft tissue reconstruction and wound coverage were done by soft tissue flaps in 4 patients (22.2%); revesed sural flaps in 3 patients (16.7%), and supramaleolar fasciocutaneous flap in one patient (5.6%). Three out of those 4 patients had undergone previous surgical intervention.

Postoperatively, no adjuvant treatment was administered for 11 (61.1%) patients, while 4 patients (22.2%) received chemotherapy only, one patient (5.6%) received radiotherapy only, and two patients (11.1%) received both chemotherapy and radiotherapy as adjuvant treatment.

3.4. Functional and oncologic outcomes

The mean follow-up period was 44.2 (range, 6–222) months, with a minimum follow-up of 2 years for surviving patients. The mean MSTS functional score was 27.5 (range, 22–30). Patients who underwent previous surgeries had a mean MSTS score of 27.8, while patients with no previous surgeries had a mean MSTS score of 27.2 (p value = 0.34).

The most common complication was wound problems which occurred in 7 patients (38.7%). In 5 of them, wound was healed by repeated dressing, while the remaining 2 patients required vacuum-assisted closure (VAC) therapy for 4 weeks to achieve healing. Moreover, one patient (5.6%) developed valgus deformity.

Regarding recurrence, 4 patients (22.2%) developed local recurrence. The recurrent lesions were located in the forefoot in 2 patients, and hind foot and mid foot in the other 2 patients (p value = 0.21). Two pateints who developed local recurrence got adjuvant treatment, while the other two patients did not get it (p value = 0.42). The types of recurrent tumors were synovial sarcoma in 2 patients, MPNST in 1 patient, and fibromatosis in 1 patient (p value = 0.37). Three patients had wide margins, and only one had a wide-contaminated margin (p value = 0.13). One of those 4 patients developed metastasis and died of disease, and the other 3 patients underwent below knee amputations, and at the last follow-up, they were alive with no evidence of disease. The four patients who developed local recurrence were originaly presented as recurrent cases (4 out of 9 patients) while no local recurrence has occurred in do novo patients, which was statistically significant (p value = 0.02) (Table 2).

At the last follow-up, there were 14 patients (77.8%) with no evidence of disease (NED), 2 patients (11.1%) alive with disease (AWD), and 2 patients (11.1%) dead of disease (DOD); one of them had both local recurrence, and distant metastasis and the other patient had only distant metastasis. The overall patient survival was 88.9% (16/18) to the last follow-up period.

Table 1
Patient details.

No.	Age	Sex	Recurrent case	Site	Pathology	Adjuvant treatment	Local recurrence	MSTS score
1	13	M	No	Hindfoot	Neurofibrosarcoma	No	No	29
2	30	F	Yes	Forefoot	Fibromatosis	No	Yes	28
3	29	F	Yes	Hindfoot and midfoot	Synovial sarcoma	No	Yes	27
4	10	M	Yes	Hindfoot and midfoot	Synovial sarcoma	Chemotherapy	Yes	26
5	59	F	Yes	Hindfoot	GCT soft tissue	No	No	30
6	40	M	No	Forefoot	Liposarcoma	No	No	29
7	60	M	Yes	Forefoot	MPNST	Chemotherapy + radiotherapy	Yes	29
8	25	F	Yes	Forefoot and midfoot	Ewing sarcoma	Chemotherapy	No	27
9	35	M	Yes	Hindfoot and ankle	Myxofibrosarcoma	No	No	27
10	36	F	No	Forefoot and midfoot	Synovial sarcoma	No	No	30
11	25	M	No	Hindfoot and ankle	Synovial sarcoma	No	No	30
12	28	M	No	Forefoot	Synovial sarcoma	No	No	30
13	16	F	No	Forefoot	Ewing sarcoma	Chemotherapy	No	24
14	17	F	No	Hindfoot	Ewing sarcoma	Chemotherapy	No	27
15	19	F	No	Hindfoot	Osteosarcoma	No	No	24
16	34	F	No	Forefoot	GCT bone	No	No	22
17	18	F	Yes	Forefoot	Synovial sarcoma	Chemotherapy + radiotherapy	No	28
18	32	F	Yes	Hindfoot and midfoot	Synovial sarcoma	Radiotherapy	No	28

GCT giant cell tumor, *MPNST* malignant peripheral nerve sheath tumor, *MSTS* Musculoskeletal Tumor Society.

Table 2
Relation between tumor location, history of previous intervention, adjuvant treatment, and the occurrence of local recurrence.

Data	Local recurrence				p Value
	Yes (n = 4)		No (n = 14)		
	No.	%	No.	%	
Site:					
Forefoot (n = 7)	2	50	5	35.7	0.21
Hindfoot (n = 4)	0	0	4	28.6	
Hindfoot and midfoot (n = 3)	2	50	1	7.1	
Forefoot and midfoot (n = 2)	0	0	2	14.3	
Hindfoot and ankle (n = 2)	0	0	2	14.3	
History of previous intervention:					
De Novo (n = 9)	0	0	9	64.3	**0.02***
Recurrent (n = 9)	4	100	5	35.7	
Adjuvant treatment:					
Yes (n = 7)	2	50	5	35.7	0.42
No (n = 11)	2	50	9	64.3	

* $p < 0.05$ is significant.

4. Discussion

Limb-salvage surgery for foot and ankle tumors aims to obtain a wide surgical margin and to maintain a sensate, plantigrade and functional foot [5,6]. Depending on the tumor extent and location, and if limb-salvage surgery cannot be achieved, amputation may be necessary [6,13,14].

If limb salvage can be achieved with good oncologic outcomes, it has more social, psychological, and physical benefits in contrast to amputation [1,5,15,16]. Foot and ankle patients generally demonstrate some of the best functional scores among sarcoma survivors for all anatomic regions [16,17]. However, one review of 124 patients with lower extremity sarcoma found no difference in the quality of life between survivors with amputation versus limb salvage [18].

Previous excisions or biopsies may compromise outcomes and complicate the treatment of patients suitable for limb salvage [5,19,20]. All lesions should undergo appropriate preoperative imaging prior to biopsy or excision, and any unplanned excisions should be avoided [21]. Also, early referral of all potential malignancies, appropriate biopsy techniques at a specialty center, and avoiding marginal excision of indeterminate lesions are mandatory [20,21].

During limb salvage for tumors of the foot and ankle, wide tumor resection should take the first priority. Adequate margins must be achieved since failure to do so may result in subsequent metastases and death [6,9]. Soft tissue coverage is a unique challenge after limb-salvage surgery of foot and ankle tumors. Vascularized tissue flaps allow wider resection margins and decrease potential wound complications and hence achieve more success of limb-salvage surgery [22,23].

In the present series, soft tissue flaps were used in 4 patients (22.2%), and patients with previous interventions required more tissue transfers (3 out of four flaps).

Adjuvant therapies represent a critical component of the local control and systemic treatment of patients with sarcoma [1,9,24]. Particularly for high-grade lesions, limb salvage without chemotherapy or radiation may result in a high rate of local recurrence and relapse [5,9,24].

In our study, the mean MSTS functional score after limb-salvage surgery was 27.5, with a mean follow-up period of 44.2 months, which was comparable to prior series in the literature. Talbert et al. [25] reported that 54% of cured patients had normal or near normal function, while Selch et al. [16] found good or excellent function in 86% of 14 patients. Gerrand et al. [17] reported mean MSTS scores of 84.2% in 7 patients with foot and ankle sarcomas.

The most important surgical goal for limb-salvage surgery is to achieve local tumor control [3,5]. In a series of both benign and malignant foot and ankle tumors, Ozdemir et al. [26] reported local recurrence in 9.3% of 140 surgical cases. Selch et al. [16] reported two (10%) recurrences in 19 patients, while Talbert et al. [25] reported 23% local recurrence in 39 cases of soft tissue sarcoma of the foot and ankle.

The local recurrence rate in our series was 22.2%. All local recurrences occurred in patients with previous biopsy or resections with local recurrence rate of 44.4% (4 out of 9), but did not significantly affect mean patient functional score. The patient with fibromatosis presented to us with intractable pain after previous intervention in another center with local recurrence of the lesion. Wide margin excision was attempted but local recurrence occurred. No local recurrence observed in patients undergone amputation for treatment of local recurrence. The location of the tumor or the adjuvant treatment did not correlate with an increased recurrence rate. Three Patients with local recurrences needed a transtibial amputation.

In our study, initiation of adjuvant therapy after limb-salvage surgery for foot and ankle tumors was difficult, with improper wound healing and wound complications being the major limitations. Three of our patients received post-operative radiotherapy; two of them suffered from edema and pain that required analgesics for 3 months in one patient and 4 months in the other patient.

In this series, the overall patient survival was 88.9% (16/18) to the

last follow-up period. Selch et al. [16] reported 83% actuarial and 63% disease-free survival rates at 3 years in 20 patients. Talbert et al. [25] reported actuarial 5 and 10-year survival rates of 80% and 69% in 78 patients with soft tissue sarcoma of the distal upper and lower extremities.

In a series of 175 distal lower extremity sarcomas of either soft tissue or bone, Zeytoonjian et al. [27] found a death rate of only 10% at a minimum follow-up of 2 years, in contrast to a death rate of 27% for the same tumors at other sites.

Careful preoperative planning based on appropriate preoperative imaging studies, coupled with judicious use of adjuvant radiotherapy, facilitates limb salvage via function-preserving wide excision within the anatomic limits of the foot in most patients with foot and ankle tumors [10,21,28].

This study had some limitations. The present series was a retrospective analysis of data and was therefore susceptible to the same limitations and biases of all retrospective studies. Moreover, it reported a relatively small number of patients with heterogeneous pathology, making analysis of oncologic and functional outcomes difficult. Adjuvant treatment was not uniform throughout the series, due both to a case chronology spanning more than two decades.

5. Conclusion

Limb salvage is a good option for patients with salvageable tumors of the foot and ankle. In order to avoid compromising oncologic outcomes, patients subjected to limb-salvage surgery must be critically indicated, aggressively treated with combined modalities, and carefully observed for tumor recurrence.

Conflicts of interest

No conflicts of interest.

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