Foot sarcomas: Factors affecting oncological and functional outcomes

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Abstract. Oncological and functional prognostic factors for patients with foot sarcomas have yet to be clarified. This study was undertaken to identify the prognostic factors for oncological and functional outcomes and the significance of adjuvant radiotherapy in achieving local control in patients with foot sarcomas. We reviewed 31 consecutive patients with soft tissue (24), and bone (7) sarcomas arising in the foot and analyzed the impact of patient characteristics on the functional and oncological outcomes. There were seven cases with clear cell or epithelioid sarcomas. Two of the 31 cases experienced local recurrence despite the fact that only two cases received adjuvant radiotherapy. Sixteen out of 18 cases of soft tissue sarcomas with limb salvage surgery underwent reconstructive procedures for soft tissue defects. Amputation required as a surgical treatment (p=0.002) was a poor prognostic factor. Larger size (p=0.029) and bone reconstruction (p=0.018) were poor prognostic factors for local recurrence-free survival, and amputation (p=0.001) and bone reconstruction (p=0.008) for metastasis-free survival in patients with soft tissue sarcomas. No significant factors were derived in patients with bone sarcomas. Larger size (p=0.021), amputation (p=0.016) and bone reconstruction (p=0.03) were poor prognostic factors affecting function in patients with soft tissue sarcomas, and hindfoot site (p=0.028) and amputation (p=0.028) were poor prognostic factors affecting function in patients with bone sarcomas. Surgery with a negative operative margin and reconstructive procedures achieved good local control and function. Patients that had tumors with larger size, necessitating amputation or bone reconstruction, required novel multimodal treatment in order to improve their outcomes.

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Introduction

Primary foot sarcomas of bone and soft tissue tumors are rare. Malignant tumors of the foot account for approximately 2% of tumors that occur in the entire body (1). Papagelopoulos *et al* proposed that fewer than 5% of all malignancies of bone and soft tissues originate in the foot (2). The pathology series of the Mayo Clinic on 5124 bone sarcomas found that approximately 1.2% of malignant bone tumors in the body occur in the foot (3). Approximately 2.2% of cases of 4496 soft tissue sarcomas (STS) originated in the foot in patients diagnosed at the Memorial Sloan-Kettering Cancer Center (MSKCC) between 1982 and 2000 (4). Due to the rarity of this disease, few reports have described the prognostic factors correlating with the clinical outcome in patients with bone and STS of the foot.

Recently, owing to multidisciplinary advances in excision, reconstruction and adjuvant therapy, limb salvage procedure has become the technique of choice for lower extremity sarcoma, particularly with adjuvant radiotherapy. The usefulness of radiotherapy for local control of sarcomas has been well demonstrated in patients with foot sarcomas (5). Since radiotherapy has been indicated for sarcoma patients with positive microscopic margins in our institutions, only a small number of such patients have received radiotherapy. This makes it possible to analyze the significance of radiotherapy for local control in patients with foot sarcomas. Another crucial issue for limb salvage surgery is advances in plastic reconstructive procedures (5), although few studies have demonstrated the importance of flaps.

Even successful limb salvage surgery may occasionally not be associated with a functional limb. Postoperative function in patients with foot sarcoma has not been reported in detail. Due to the lack of fascial boundaries and the proximity to neurovascular and complex structures, the tumor should be resected with safe and wider margins (6), leading to difficulty in preserving the function of the affected limb. In cases with limb salvage surgery and amputation, postoperative function should be evaluated to determine the indication of operative procedures.

The aims of this study were to clarify i) prognostic factors in patients with sarcomas arising in the foot, ii) rate of local control (mostly without radiotherapy), iii) feasibility of limb salvage surgery and iv) postoperative function.

Patients and methods

Patients. This was a retrospective study of 31 patients with bone (7) or soft tissue (24) sarcoma arising in the foot between 1986 and 2008 at the Nagoya University Hospital and affiliated cancer centers (Japan). Patient information was collected from our database. Patients included 17 males and 14 females, with an average age of 43 years of age (range 11-76). The study was approved by an institutional review board and informed consent was obtained from all patients.

Bone and soft tissue sarcomas arising in the foot were defined as those distal to the ankle joint. Bone tumors arising in the tibia and fibula were omitted, while soft tissue tumors occurring in the bilateral malleolus were included in our study. The foot was subdivided into the forefoot and hindfoot at the level of Lisfranc. Radiography, computed tomography (CT) and magnetic resonance imaging (MRI) were used to diagnose and examine all body systems. Tumors histologically diagnosed as sarcomas were classified according to World Health Organization (WHO) criteria (7). This series excluded grade Ia chondrosarcoma, all metastases, carcinoma, lymphoma, melanoma, Kaposi's sarcoma and well-differentiated liposarcoma. According to the Fédération Nationale des Centres de Lutte Contre le Cancer (FNCLCC; National Federation of French Cancer Centres), grade 1 was defined as low grade and grades 2 and 3 as high grade. Disease staging was carried out according to the American Joint Committee on Cancer Staging System (AJCC) (9).

The patients had undergone either limb salvage surgery or amputation. Goals of surgery for all remaining sarcomas were tumor excision with microscopically negative operative margin and limb salvage if tumors were resectable and there was good preservation of postoperative function. Patients with unplanned excision in the pre-referral hospital underwent additional excision aimed at obtaining a negative operative margin in our institution. 'Unplanned resection' has been termed as an operation on a presumed benign soft tissue mass without appropriate preoperative imaging or prior biopsy with excision of the lesion, without attention to the operative margins (10,11).

Patients with toe and ray amputations were included in the limb salvage group. We performed bone reconstruction of the bone defects after resection in selected cases in which instability of the operated foot was predicted. Reconstructive methods were defined as a vascularized osteocutaneous fibula flap or an arthrodesis.

Methods. Margin status after the final surgery was classified as microscopically negative or positive. According to the treatment modality of our institutions, radiotherapy was commonly administered to patients with positive microscopic margins and chemotherapy on a case-by-case basis. In general, ifosfamide and doxorubicin were used in cases of spindle cell soft tissue sarcoma when measuring >5 cm and when deeply located, whereas vincristine, actinomycin D, ifosfamide and doxorubicin (VAIA) were utilized in patients with small round cell sarcoma and Ewing's sarcoma. Combinations of cyclophosphamide, vincristine, doxorubicin and actinomycin D (CYVADACT) or cisplatin, methotrexate, doxorubicin and ifosfamide were applied for one case each of bone sarcoma. Overall survival (OAS) was defined as the time from surgery to death or latest follow-up visit. Local recurrence-free survival (LRFS) and metastasis-free survival (MFS) were defined as the time from surgery to recurrence and metastasis or the latest follow-up visit, respectively.

Functional outcome at the last follow-up was scored according to the International Society of Limb Salvage (ISOLS) scoring system (12) in all 31 patients, which is a modification of the initial Musculoskeletal Tumor Society (MSTS) score (6). The MSTS system is based on six items (pain, function, emotional acceptance, use of supports, ability to walk and gait) for the lower extremities. Each item was assigned a value from zero to five points. In this study, five items were evaluated (0-25 points), with the exception of emotional acceptance.

Statistical analysis. Survival probabilities over time were determined by the Kaplan-Meier method (13). The effect of each prognostic variable was analyzed using the log-rank test. The analyses were performed using SPSS statistics version 17.0 software (SPSS Inc., Chicago, IL, USA). Differences in functional outcome between groups were analyzed by the Mann-Whitney U-test. $P<0.05$ was considered to be statistically significant.

Results

Patient characteristics. From the 1040 patients with STS and 470 patients with bone sarcomas treated in our hospital and an affiliated cancer center, 17 male and 14 female patients (average age, 43 years; range 11-76) were identified with such lesions in the foot. Excluding the patients who succumbed to the disease, the duration of patient follow-up ranged from 24 to 276 months (mean 68). Table I shows characteristics of the tumors and AJCC staging.

Treatments. All 31 patients received operative treatment (Table II). Margin status was microscopically negative in 30 patients. A total of 10 out of 30 patients underwent primary amputation. Only one case with a synovial sarcoma arising in the soft tissue of the medial hindfoot showed a microscopically positive margin. In that case, the patient received postoperative chemotherapy and radiation, but developed local recurrence at 14 months after surgery. All 10 patients with unplanned excision had soft tissue sarcomas and received additional excision aimed at a negative operative margin in our institutions.

Of the 21 patients who underwent limb salvage surgery, 17 required soft tissue and/or bone reconstruction, which included 6 pedicle cutaneous flaps and 11 free flaps (6 lateral thigh fasciocutaneous flaps, 2 latissimus dorsi muscle flaps, 1 scapula cutaneous flap and 2 vascularized osteocutaneous fibula flaps). Partial flap necrosis and subsequent local infection occurred in 3 patients following reconstruction with free flaps. Two of the 3 patients required skin grafts, and the other patient only debridement. The wound complications of the 3 patients were completely resolved.

Two patients with soft tissue sarcoma, one with a microscopically positive margin (synovial sarcoma), received postoperative radiotherapy. A total of 15 patients had adjuvant chemotherapy. A total of 11 out of 24 patients (6 synovial

Table I. Characteristics of the 31 cases with foot sarcomas.

	Soft tissue sarcomas (n=24)	Bone sarcomas (n=7)
Age (years)	43	42
Gender		
Male	12	5
Female	12	2
Site		
Forefoot	4	3
Hindfoot	20	4
Size		
<5 cm	14	4
≥5 cm	8	2
Unknown	2	1
Histology		
Synovial sarcoma	7	
Clear cell sarcoma	4	
Epithelioid sarcoma	3	
MPNST	2	
DFSP	2	
MFH	2	
Myofibroblastic sarcoma	1	
Myxoid liposarcoma	1	
Small round cell sarcoma	1	
Leiomyosarcoma	1	
Chondrosarcoma		3
Angiosarcoma		1
Adamantinoma		1
Ewing/PNET		1
Not classified		1
Tumor grade (FNCLCC)		
G1	5	1
G2/3	19	6
Stage (AJCC)		
IA	5	
IB	1	1
IIA	1	
IIB	11	6
IIC	1	
III	1	
IV	3	
Unknown	1	
Unplanned excision		
Yes	10	0
No	14	7

MPNST, malignant peripheral nerve sheath tumor; DFSP, dermatofibrosarcoma protuberans; MFH, malignant fibrous histiocytoma; PNET, primitive neuroectodermal tumor; AJCC, American Joint Committee on Cancer Staging System; FNCLCC, Fédération Nationale des Centres de Lutte Contre le Cancer (National Federation of French Cancer Centres).

Table II. Treatment for 31 cases.

	Soft tissue sarcomas (n=24)	Bone sarcomas (n=7)
Operative procedures		
Limb salvage	18	3
Amputation	6	4
Margin status after final surgery		
Negative	23	7
Positive	1	0
Flap		
Yes	17	1
No	7	6
Reconstruction (bone)		
No	10	0
Yes	6	1
Radiotherapy		
Yes	2	0
No	22	7
Chemotherapy		
Yes	11	4
No	13	3
Disease recurrence		
Local recurrence	2	0
Metastasis	8	1

sarcomas, 2 clear cell sarcomas, 1 small round cell sarcoma, 1 MFH and 1 epithelioid sarcoma) with soft tissue sarcomas received chemotherapy (4 preoperative, 3 postoperative and 4 both). A total of 4 out of 7 cases with bone sarcoma received chemotherapy (1 preoperative, 2 postoperative and 1 both).

Survival. Local recurrence occurred in two cases. All 5 patients who succumbed to the disease had soft tissue sarcomas. The 5-year OAS, LRFS and MFS of soft tissue sarcomas were 79, 91 and 66%, respectively (Table III). The 5-year OAS, LRFS and MFS of bone sarcomas were 100, 100 and 67%, respectively. As expected, with the numbers available, size (cut-off 5 cm) affected LRFS (p=0.029), and MFS (p=0.018) and stage affected MFS (p<0.001) in patients with soft tissue sarcomas (Table III). Patients with unplanned excision had a favorable prognosis of OAS (p=0.047) and MFS (p=0.044) compared with those with planned excision. Patients undergoing amputation had a significantly poor prognosis for OAS (p=0.002) and MFS (p=0.001). Patients requiring bone reconstruction after excision had a significantly poor LRFS (p=0.041) and MFS (p=0.008) with the numbers available. Given that 23 out of 24 patients had a microscopically negative margin, the margin status did not reach significance on analysis. Throughout the analysis, no factors had a significant impact on survival in patients with bone sarcomas.

Table III. OAS, LRFS and MFS at 5 years in patients with soft tissue sarcomas.

	5-year OAS (%)	P-value	5-year LRFS (%)	P-value	5-year MFS (%)	P-value
	79		91		66	
Site						
Forefoot (4)	100	ns	100	ns	100	ns
Hindfoot (20)	74		89		59	
Size						
<5 cm (14)	93	ns	100	0.029	86	0.018
≥5 cm (8)	60		66		31	
Grade (FNCLCC)						
G1 (6)	100	ns	100	ns	100	0.06
G2/3 (18)	71		87		55	
Stage (AJCC)						
I (6)	100	ns	100	ns	100	<0.001
II (13)	76		82		68	
III (1)	50		100		0	
IV (3)	50		100		0	
Unplanned excision						
Yes (10)	100	0.047	89	ns	89	0.044
No (14)	64		93		50	
Operative procedures						
Limb salvage (18)	94	0.002	89	ns	83	0.001
Amputation (6)	33		100		17	
Reconstruction (bone)						
No (10)	100	ns	100	0.041	100	0.008
Yes (6)	83		67		50	
Flap						
Free (11)	91	ns	88	ns	72	ns
Local (6)/none (6)	100		100		100	
Margin status after final surgery						
Negative (23)	78	ns	96	ns	65	
Positive (1)	100		0		0	

AJCC, American Joint Committee on Cancer Staging System; FNCLCC, Fédération Nationale des Centres de Lutte Contre le Cancer; OAS, overall survival; MFS, metastasis-free survival; LRFS, local recurrence-free survival; ns, not significant.

Functional scores. The mean ISOLS functional scores were 18.3 and 18.4 in patients with soft tissue and bone sarcomas, respectively (Table IV). The ISOLS scores of the limb-sparing group were found to be significantly better than those of the amputation group in both soft tissue sarcomas (p=0.016) and bone sarcomas (p=0.028). Larger size (p=0.021) had an impact on lower ISOLS scores for soft tissue sarcoma patients. Patients with soft tissue sarcomas requiring bone reconstruction had significantly less function (p=0.03), whereas those with bone sarcomas did not exhibit reduced function. Tumor location in the hindfoot was a significantly poor prognostic factor (p=0.028) for function in patients with bone sarcomas.

Discussion

Fewer than 10% of soft tissue sarcomas arise in the foot and ankle (14,15). Studies have described the management of soft tissue sarcomas arising at this site (5,16,17). However, few studies have analyzed the prognostic factors involved due to the small number of such cases. Sarcomas of the distal extremity are associated with improved survival rates as compared to sarcomas located elsewhere in the body. For example, Zeytoonjian *et al* showed an overall death rate from all sarcomas of 26.6% in contrast to 10.3% for those in the foot and ankle (15). This improved prognosis is attributable to the fact that even small lesions in the foot and ankle are likely to

Table IV. Comparison of functional outcomes.

	Soft tissue sarcomas			Bone sarcomas		
	MSTS (point)	(%)	P-value	MSTS (point)	(%)	P-value
	18.3	73		18.4	74	ns
Site						
Forefoot	21.5	86	ns	24.0	96	0.028
Hindfoot	17.7	71		14.3	57	
Size						
<5cm	20.1	80	0.021	21.3	85	ns
≥5cm	16.8	67		13.0	52	
Unplanned exicision						
Yes	19.7	79	ns			
No	17.3	69				
Operative procedures						
Limb salvage	20.1	80	0.016	24.0	96	0.028
Amputation	12.8	51		14.3	57	
Reconstruction (bone)						
No	21.3	85	0.03			
Yes	17.2	69				
Flap						
Yes	18.6	74	ns			
No	22.4	90				

MSTS, Musculoskeletal Tumor Society.

be observed early. Although patients with foot sarcomas have a more favorable prognosis, prognostic factors should be clarified to determine the most appropriate treatment modality for such patients.

The current study showed that size (>5 cm) (LRFS and MFS), amputation as a operative procedure (OAS and MFS) and bone reconstruction (LRFS and MFS) had a significant adverse impact on prognosis. Thacker *et al* reported that no factors including tumor grade, size (5 cm), site, planned vs. unplanned excisions, radiotherapy and amputation vs. limb salvage, had a significant impact on the local control of tumors (18). Talbert *et al* reported that the size of the primary tumor correlated with total tumor-free survival, whereas no factors correlated with local control (19). Considering the characteristics of foot anatomy, including the lack of abundant muscle and subcutaneous structures, large tumors easily invade adjacent tissue, with more cases thus requiring amputation or bone reconstruction following resection. Taken together, correlation of factors derived from the current study, such as larger size, amputation and bone reconstruction, may occur. Another possible explanation for the poor prognosis of patients with amputation is attributed to the histological type. The treatment modality of operative treatment in our institutions has shown a trend towards amputation for patients with epithelioid and clear cell sarcomas. Of the 5 patients who succumbed to the disease, 3 had either epithelioid or clear cell sarcomas and all 3 patients received amputation. Analysis with larger cohorts of patients may lead to the omission of amputation from the poor prognostic factors with multivariate analysis, including histological type.

Few reports have described bone sarcoma of the foot. Chou *et al* reported 17 bone sarcomas with an equal proportion of osteosarcoma and chondrosarcoma (1). Another study reported that chondrosarcoma occurs three times more often than osteosarcoma (20). However, these studies did not describe the oncological outcome or postoperative function. Prognostic factors for patients with bone sarcomas were not derived in the current study either, probably due to the small number of cases and/or heterogeneity of histological types (Table I).

Given that benign lesions outnumber malignant ones by a ratio of 100:1 (7), unplanned excision is a relatively common occurrence in soft tissue sarcomas of the foot and ankle. Temple *et al* (14) and Cribb *et al* (5) observed that 51 and 56% of the foot and ankle tumors they studied had unplanned excisions at other institutions, respectively. These patients required more complicated surgery, had more perioperative complications and were more likely to be treated with adjuvant radiotherapy; however, there were no differences between the oncological outcomes (14). The current study had 10 (42%) cases of unplanned excision with soft tissue sarcoma, which are comparable to the rates noted in previous studies. Of note, patients with unplanned excisions had a significantly improved prognosis (OAS and MFS) as compared with patients with planned excisions. As previously reported (12), unplanned

excisions tended to be performed in patients with superficial and small tumors. In this study, tumors undergoing unplanned excisions were smaller (3.3 cm) than those (4.0 cm) subjected to planned excisions.

Although 2 of the 24 patients with soft tissue sarcomas received radiotherapy in this series, only 2 (8%) had local recurrence. Talbert *et al* reported a 19% local recurrence rate in 39 cases with soft tissue sarcomas of the foot and ankle (19). Thacker *et al* reported that the local recurrence rate was 13.5% in their series of 52 cases (18). In these studies, 100 and 35% of the patients received radiotherapy, respectively, in contrast to only 8% in the current study. Given that amputation was performed in 6 (25%) of the 24 patients in the current study, comparable with the 24% (18) and 18% (19) of previous reports, limb salvage surgery with a microscopically negative margin (94%; 17 of 18 cases) is capable of preventing local recurrence without adjuvant radiotherapy. Moreover, considering that major wound complications (i.e., delayed wound healing or need for operative intervention) reportedly occur in approximately 17% of patients following operative resection with postoperative radiotherapy (21), these complications may be mitigated if radiotherapy is omitted.

The next issue considered in this study involved whether limb salvage surgery is feasible for patients with foot sarcomas, as well as the benefits thereof. Given the excellent functional results that are obtained with below-the-knee amputation, the benefits of time-consuming operative reconstruction are often questionable. Comparisons of the quality of life between limb salvage and amputation for sarcomas of the lower extremity show little difference (22,23), but these studies were not specific for the distal part. A recent study revealed that limb salvage is capable of achieving good functional results, assessed with Toronto Extremity Salvage Score (TESS) score (5), which is consistent with our results that ISOLS scores in the limb salvage group were significantly better than those of the amputation group. In cases in which a safe margin can be achieved, limb salvage surgery is indicated in patients with sarcomas of the foot and ankle. To achieve limb salvage surgery, reconstruction by plastic surgery is required. Recent advances in plastic operative reconstruction have rendered such limb salvage surgery possible. In this study, 17 out of 18 patients with soft tissue sarcomas required free or local flaps. In terms of local control, the low recurrence rate (8%) was attributed to a negative operative margin, resulting in larger defects following excision. These extensive defects were successfully reconstructed by plastic and reconstructive surgery.

The present study showed that the function of the patients with limb salvage surgery was better than that of those with amputation, which was not consistent with a previous report in which the MSTS functional scores did not differ between limb salvage and amputation (18). The current study included 7 cases (29%) with clear cell or epithelioid sarcoma. Epithelioid sarcoma has a high risk of regional lymph node metastasis, and 'local metastasis' at some distance from the primary tumor (24). Considering the high 'regional metastasis' of these diseases, it is occasionally preferable to amputate at higher levels. Two cases with an epithelioid sarcoma and a clear cell sarcoma underwent below-the-knee amputation and hip disarticulation for the foot primary tumor, respectively, in this study. Cases with amputation at higher levels caused the low ISOLS scores in the amputation group. Patients with larger tumors had significantly lower scores. Moreover, reconstruction procedures with free flap tended to have lower functional scores, suggesting that larger defects after excision correlate with poorer functional outcome.

One of the limitations of this study was the small number of cases, particularly those with bone sarcomas. Due to the heterogeneous nature of these lesions, treatment modalities also markedly differed. Particular patterns of invasion and metastasis by the tumors, particularly clear cell and epithelial sarcomas, affected the range of excision. Another limitation was the indication of chemotherapy for patients with foot sarcomas. However, given that the modality of chemotherapy has not been well-defined for patients with soft tissue sarcomas, and that soft tissue sarcomas in foot include both relatively responsive (synovial sarcoma) and non-responsive (clear cell and epithelioid sarcomas) tumors, the significance of chemotherapy should be analyzed independently according to histological type.

In conclusion, although the anatomical features of the foot include insufficient barriers against sarcomatous spread, primary resections or additional resections after unplanned excisions with microscopically negative margins are able to achieve local control without radiotherapy. Plastic reconstructive procedures permit limb salvage and well-preserved limb function. However, patients with larger tumors, requiring amputation or bone reconstruction require novel treatment strategies to improve their oncological and functional outcomes.

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References

1. Chou LB, Ho YY and Malawer MM: Tumors of the foot and ankle: experience with 153 cases. Foot Ankle Int 30: 836-841, 2009.
2. Papagelopoulos PJ, Mavrogenis AF, Badekas A and Sim FH: Foot malignancies: a multidisciplinary approach. Foot Ankle Clin 8: 751-763, 2003.
3. Unni KK: General aspects and data on 10,135 cases. In: Dahlin's Bone Tumors. 6th edition. Lippincott Williams & Wilkins, Philadelphia, PA, pp1-224, 2010.
4. Brennan MF: Diagnosis and management of soft tissue sarcoma. Martin Dunitz, London, 2002.
5. Cribb GL, Loo SCS and Dickinson I: Limb salvage for soft-tissue sarcomas of the foot and ankle. J Bone Joint Surg 92: 424-429, 2010.
6. Enneking WF, Dunham W, Gebhardt MC, Malawar M and Pritchard DJ: A system for the functional evaluation of reconstructive procedures after surgical treatment of tumors of the musculoskeletal system. Clin Orthop Relat Res 286: 241-246, 1993.
7. Fletcher C, Unni K and Mertens F: World Health Organization Classification of Tumours Pathology and Genetics of Tumours of Soft Tissue and Bone. IARC Press, Lyon, 2002.
8. Guillou L, Coindre JM, Bonichon F, *et al*: Comparative study of the National Cancer Institute and the French Federation of Cancer Centers Sarcoma Group grading systems in a population of 410 adult patients with soft tissue sarcoma. J Clin Oncol 15: 350-362, 1997.

9. Greene FL, Page DL and Flemming FD: American Joint Committee on Cancer: Cancer Staging Manual. 6th edition. Springer, New York, NY, pp157-164, 2002.
10. Arai E, Nishida Y, Tsukushi S, Wasa J and Ishiguro N: Clinical and treatment outcomes of planned and unplanned excisions of soft tissue sarcomas. Clin Orthop Relat Res 11: 3028-3034, 2010.
11. Giuliano AE and Eilber FR: The rationale for planned reoperation after unplanned total excision of soft-tissue sarcomas. J Clin Oncol 10: 1344-1348, 1985.
12. Schwab JH, Agarwal P, Boland PJ, Kennedy JG and Healey JH: Patellar complications following distal femoral replacement after bone tumor resection. J Bone Joint Surg Am 88: 2225-2230, 2006.
13. Kaplan EL and Meier P: Nonparametric-estimation from incomplete observations. J Am Stat Assoc 53: 457-481, 1958.
14. Temple HT, Worman DS and Mnaymneh WA: Unplanned surgical excision of tumors of the foot and ankle. Cancer Control 8: 262-268, 2001.
15. Zeytoonjian T, Mankin HJ, Gebhardt MC and Hornicek FJ: Distal lower extremity sarcomas: frequency of occurrence and patient survival rate. Foot Ankle Int 5: 325-30, 2004.
16. Colterjohn NR, Davis AM, O'Sullivan B, Catton CN, Wunder JS and Bell RS: Functional outcome in limb-salvage surgery for soft tissue tumours of the foot and ankle. Sarcoma 1: 67-74, 1997.
17. Selch MT, Kopald KH, Ferreiro GA, Mirra JM, Parker RG and Eilber FR: LIMB salvage therapy for soft-tissue sarcomas of the foot. Int J Radiat Oncol Biol Phys 19: 41-48, 1990.
18. Thacker MM, Potter BK, Pitcher JD and Temple HT: Soft tissue sarcomas of the foot and ankle: impact of unplanned excision, limb salvage, and multimodality therapy. Foot Ankle Int 29: 690-698, 2008.
19. Talbert ML, Zagars GK, Sherman NE and Romsdahl MM: Conservative surgery and radiation-therapy for soft-tissue sarcoma of the wrist, hand, ankle, and foot. Cancer 66: 2482-2491, 1990.
20. Murari TM, Callaghan JJ, Berrey BH and Sweet DE: Primary benign and malignant osseous neoplasms of the foot. Foot Ankle 10: 68-80, 1989.
21. O'Sullivan B, Davis AM, Turcotte R, *et al*: Preoperative versus postoperative radiotherapy in soft-tissue sarcoma of the limbs: a randomised trial. Lancet 359: 2235-2241, 2002.
22. Refaat Y, Gunnoe J, Hornicek FJ and Mankin HJ: Comparison of quality of life after amputation or limb salvage. Clin Orthop Relat Res 397: 298-305, 2002.
23. Zahlten-Hinguranage A, Bernd L, Ewerbeck V and Sabo D: Equal quality of life after limb-sparing or ablative surgery for lower extremity sarcomas. Br J Cancer 6: 1012-1014, 2004.
24. Weiss SW and Goldblum JR: Enzinger and Weiss's soft tissue tumors, 4th edition. Mosby, St. Louis, MO, pp1191-1203, 2001.