Available online at www.sciencedirect.com
SCIENCE DIRECT®
The Knee 11 (2004) 489–496
THE KNEE
www.elsevier.com/locate/knee

Treatment of proximal fibular tumors with en bloc resection

Kaan Erler*, Bahtiyar Demiralp, M. Taner Ozdemir, Mustafa Basbozkurt

Gülhane Military Medical Academy, Department of Orthopedics and Traumatology, 06018 Etlik, Ankara, Turkey

Received 20 April 2003; received in revised form 24 June 2003; accepted 31 October 2003

Abstract

Proximal fibular tumor resection has always been a challenge to an orthopedic surgeon due to the proximity of two major structures; the peroneal nerve and anterior tibial artery. Extra-articular resection of the proximal tibiofibular joint, sacrificing of peroneal nerve and split resection of lateral tibial wall are major points of debate. Malawer described two types of resection for aggressive benign and malignant tumors of the proximal fibula, type I for benign and type II for malignant tumors. Between 1992 and 2002, nine male patients with proximal fibula tumors were treated by en-bloc resection as described either by Malawer and or by one of two new resection techniques. Of the nine tumors, six were diagnosed as giant cell tumor (one of them recurrent), two as osteosarcoma and one as benign fibrous histiocytoma. The mean age of the patients was 23.6 (20–48) years. The mean follow up period was 42.8 months (15–117). There were no complications leading to a secondary surgical procedure+no local recurrence. Tumor volume was over 250 ml in two GCT cases, so the deep peroneal nerve was sacrificed to provide a wide margin. Iatrogenic peroneal nerve palsy developed in two patients. Late tendon transfers were performed for the management of drop foot. Our results indicate that if tumor is recurrent or has a large volume, wide resection (including deep peroneal nerve) should be done. Despite satisfactory tumor management, functional outcomes turned out to be variable, therefore precise ligament and muscle reconstruction is recommended.

Keywords: Proximal fibula; Resection type; Tumor volume; Bone tumor; Knee stability

1. Introduction

As the fourth compartment of the knee, proximal tibiofibular joint (PTFJ) and its muscular-ligamentous attachments deserves much attention in any anatomical and functional consideration of the knee joint. Recent studies suggest that PTFJ plays an important role on knee stability, particularly as the lateral collateral ligament and biceps femoris tendon are the main lateral stabilizators of the knee. Only 2.5% of primary bone tumors are found in the fibula [9], and those requiring wide resection are usually localized in proximal part. At this site, common tumors are osteosarcoma, Ewing's tumor and giant cell tumor (GCT). The incidence of giant cell tumor and osteosarcoma in the proximal fibula is 2.8–8% and 2.3%, respectively [5,14]. Close relation of common peroneal nerve and anterior tibial artery to the proximal fibula are major challenges in surgical resection of tumors at this location. Concurrently, sacrifice of PTFJ and lateral stabilizators of the knee may cause various degrees of knee instability. Although two detailed types of resection technique for malignant and aggressive benign proximal fibular tumors have been described by Malawer in 1984, there are not many studies in the literature where different types of resection are described and variable clinical outcome is reported [5,8,9,11]. These reports focus mainly on preserving the peroneal nerve, resection of lateral tibial wall and resection type of proximal tibiofibular joint. In these few reports, where different resection techniques were used, local recurrence was rarely reported [5]. This study describes a review of the therapeutic outcomes of seven benign and two malignant bone tumors localized in the proximal fibula managed according to Malawer's resection types. Two modifications of Malawer's resection methods were made by us: (1) Tumor volume calculation was included in the surgeon's decision process to determine the resection type and (2) If the joint was not invaded by the tumor in MR images and if there was at

* Corresponding author. Tel.: +90-532-292-2878; fax: +90-312-4427607.
E-mail address: kaanerler@hotmail.com (K. Erler).

0968-0160/$ - see front matter © 2003 Elsevier B.V. All rights reserved.
doi:10.1016/j.knee.2003.10.005

Fig. 1. Anteroposterior X-ray of the GCT. Note that cortical destruction, marked expansion of proximal fibula with uncertain marginal zone (Case IX).

least 2 cm fibular segment free of tumor, preservation of PTFJ was performed. Knee stability after different resection methods is also discussed.

2. Patients and method

Between April 1992 and January 2002, nine male patients with proximal fibular tumors were treated surgically at our institution. The mean age of the patients was 23.6 (20–48) years. In the preoperative period, patients were evaluated with bone and chest X-ray, bone scintigraphy, CT and MRI (Figs. 1 and 2). Histopathological diagnoses were obtained by fine needle biopsy. Surgical stages of nine lesions were as follows; six grade III (benign aggressive) giant cell tumor of bone (GCT) and one grade III benign fibrous histiocytoma of bone (BFH) and two grade IIB (high grade malignant, extracompartmantal) osteosarcomas [15]. Induction chemotherapy was given to the patients with osteosarcoma. A pathological fracture after minor trauma was noted at the time of admission to our hospital in one of the patients who had an osteosarcoma (case VI). One patient with GCT was referred us with recurrence after two intralesional curettages.

Type I–III–IV resections were performed for benign lesions and type II resection for malign lesions according to Malawer with minor modifications (Fig. 3a–b). Brief descriptions of resections are as follows; Type I (marginal) includes resection of proximal fibula with 1–2 cm normal diaphysis and a thin muscle cuff in all dimensions while preserving the peroneal nerve and all motor branches. Type II (wide intracompartmental) includes resection of proximal fibula with 3 cm normal diaphysis with anterior and lateral muscle compartments, peroneal nerve, anterior tibial artery and proximal tibiofibular joint (extra-articular) and gastrocnemius flap reconstruction. (Fig. 4). Type III; type I resection+resection of deep peroneal nerve (in benign tumors, volume over 250 ml) Type IV; Type I resection but PTFJ and 2–3 cm fibular segment is preserved.

Tumor volume calculation was performed according to Sorensen et al. by using diameter method with MRI scans [13]. Lesions were assessed as ellipsoid. After evaluation of axial, coronal and sagittal T1 weighted images, volume was calculated with the formula V=4/3pi ($a \times b \times c$) (where a, b, c indicates that half of the diameters). We divided the patients into two groups according to tumor volume; over 250 ml (case I and IX) and less than 250 ml (cases II–VIII).

Extra-articular proximal tibiofibular joint resection was performed in four cases (two osteosarcomas and two GCT). In the case of BFH and one GCT, proximal tibiofibular joint (PTFJ) was preserved with a proximal metaphyseal segment of 2–3-cm long (type IV resection) (Fig. 5). After preoperative volume calculation and intraoperative verification, in patients with a tumor volume over 250 ml, the superficial branch of peroneal nerve was

Fig. 2. Axial CT image revealed detailed cortical destruction and large volume of the lesion, typical appearances of grade III GCT (Case IX).

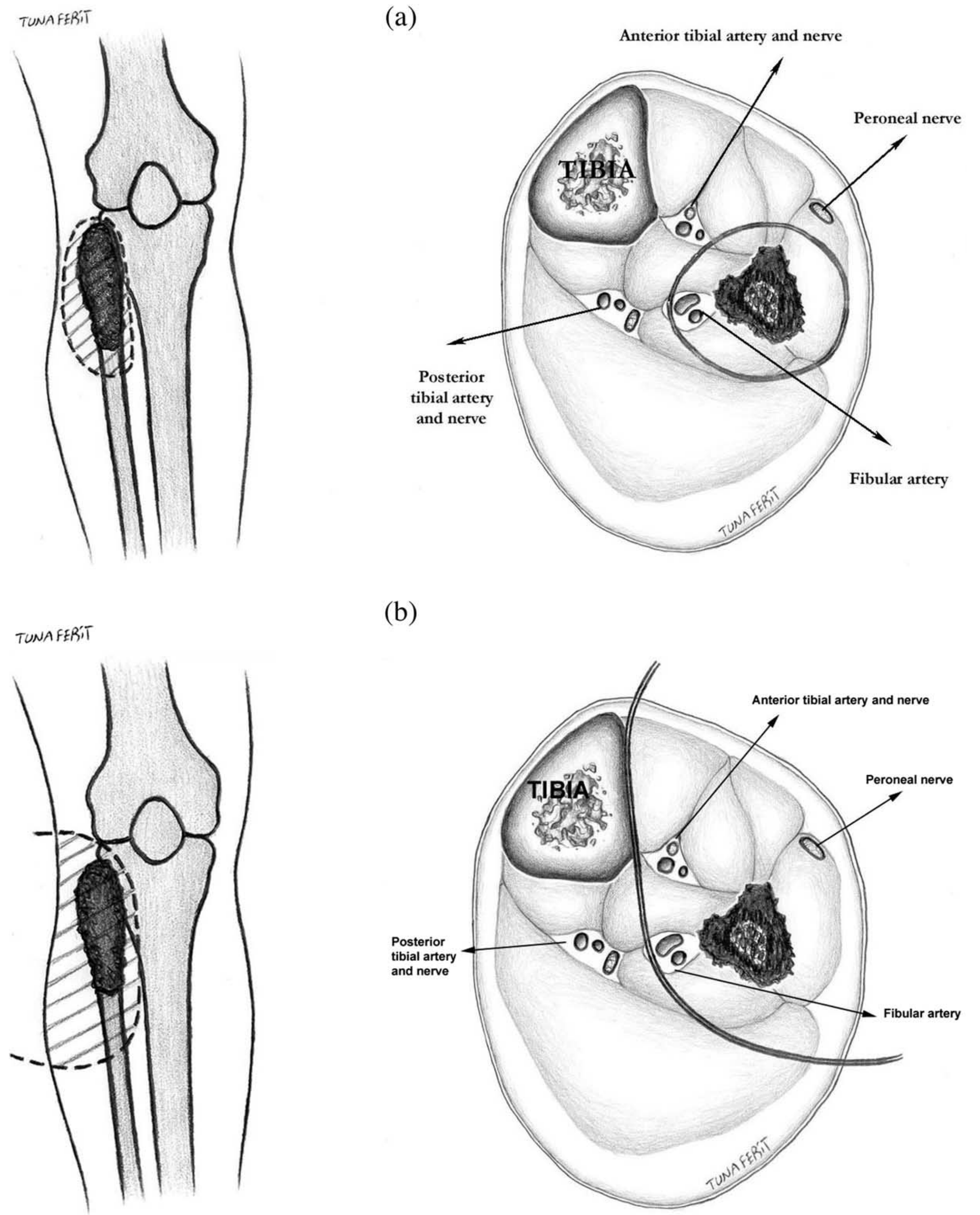

Fig. 3. (a) Schematic illustration of type I resection according to Malawer. (b) Schematic illustration of type II resection according to Malawer.

preserved but the deep peroneal nerve was sacrified in order to obtain safe surgical margins (type III resection) (Fig. 6a,b). Also, primary repair of anterior tibial artery and saphenous vein grafting was performed in case I. Great care was taken for proper reconstruction of lateral collateral ligament and reinsertion of biceps femoris tendon on the lateral condyle of tibia in order to prevent knee instability.

Postoperatively, the affected limbs were immobilized with a splint allowing 30° flexion for 2 weeks for type

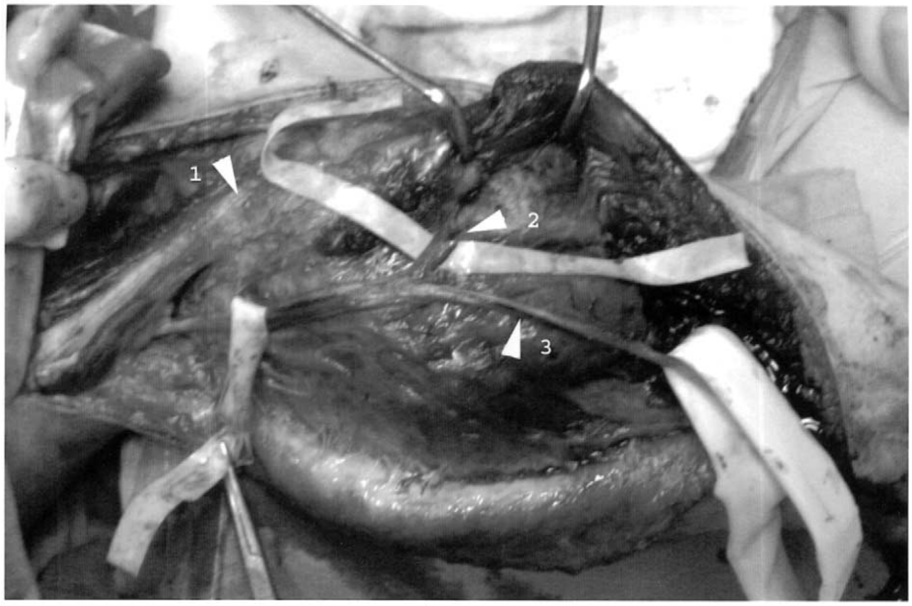

Fig. 4. Intraoperative appearance. (1) Biceps femoris tendon and its insertion (2) Deep peroneal nerve, enters to the lesion (unable to dissect) (3) Superficial peroneal nerve, explored (Case IX).

I–III–IV and 3 weeks for type II resections. Full weight bearing was allowed after splint immobilization. All patients were examined at 3 months intervals during the first postoperative year and twice a year thereafter. Clinical outcome was assessed according to Enneking's scoring system at the last follow up (Table 1) [4]. Knee stability was evaluated by patient's history, clinical examination and valgus-varus stress radiographs.

3. Results

Three type I, two type II, two type III and two type IV fibular resections were performed. In all of the resections, negative surgical margins were obtained at surgery. None of our patients required a secondary surgical procedure. The mean follow up period was 42.8 months (15–117). Mean en-bloc resection length was 11.2 cm (9.5–14).

The results were determined as excellent and/or good in three patients, fair in three patients and poor in three patients according to Enneking's functional scoring system. Only two patients have healed completely without any complication (case IV–VII). Two patients who underwent type II resection and one patient who underwent type III resection began to use foot-ankle orthosis for peroneal nerve palsy. After type I and IV resections, two iatrogenic peroneal nerve palsy developed and two more at type III (one of these patients also had anterior tibial artery repair). Calf atrophy of approximately 3 cm developed in the patients with peroneal nerve palsy. In two patients (case V and IX) with peroneal nerve palsy, split posterior tendon transfer (SPTT) was performed 7–9 months after resection. Percentages of tumor necrosis after chemotherapy in two osteosarcoma patients were 50 and 100% (case VI and VIII). Lung metastasis was determined in both osteosarcoma patients 14 (12–15) months after the operation and treated with metastectomy–chemotherapy protocol. One patient, who had 50% of tumor necrosis, died 25 months after surgery because of multiple metastases (case VI). One patient is still alive with disease at his last follow up (case VIII). Histological interpretation of the specimen of case five revealed secondary aneurysmal bone cyst components of GCT. Surgical margins were reported as clear in all cases (Table 2).

Physical and radiological examination revealed no knee instability by manual varus and valgus stress tests and on varus-valgus stress radiographs. None of our patients complained of knee instability symptoms. No secondary surgical procedure was performed because of local complications or recurrence.

4. Discussion

Marcove performed first limb salvage attempt in proximal fibular osteosarcoma by total resection of fibula in 1977 [10] and Malawer described two detailed different resection types in 1984 [9]. We describe two more resection types of proximal fibula to Malawer's classification. Type I (marginal), type II (wide intracompartmental), type III (wide

Fig. 5. Type IV resection; proximal tibiofibular joint is preserved with metaphyseal portion of proximal fibula (Case IV).

intracompartmental, preserving superficial peroneal nerve), type IV (PTFJ preserved).

Surgical treatments of benign aggressive tumors are based on tumor grade, anatomical localization and local recurrence rate. For GCT of distal radius, even aggressive wide resection is recommended for permanent local control of disease [6]. In benign tumors of the fibula, intralesional or marginal resections of tumor mass and intraarticular PTFJ resection, local recurrences may occur [5]. Thus we consider that for some grade III GCTs localized to proximal fibula — especially if the tumor volume is high and soft tissue component is present, marginal resection can be inadequate and primary wide resection with deep peroneal nerve sacrifice (type III) will be indicated. Great care must be taken to avoid inadequate surgical margins, while trying to preserve the peroneal nerve and other important anatomical structures [11].

MRI (especially post contrast axial-coronal T1 weighted images) is an essential step in assessing the resectability of the tumor, describing the relationship with major neurovascular structures, calculating the tumor volume and determining the involvement of PTFJ. Tumor volume calculation must be involved in surgeon's decision making process. 250 ml tumor volume can be considered as the limit for resection of deep peroneal nerve in benign lesions. If PTFJ and 2 cm of fibular metaphyseal segment is found out to be clear in MR images, they can be preserved. This will abolish the need for biceps femoris and lateral collateral ligament repair and prevent the risk of knee instability. If they cannot be preserved, an intraarticular PTFJ resection will also provide local control of disease, because intraarticular PTFJ resection in our series resulted in a 0% recurrence rate. Tumor resection of the tibial side is still controversial. Both subperiostal dissection from the lateral tibial wall [5,9,11] and resection of tibial wall is recommended [8]. We performed subperiostal resection in our cases.

Resection of proximal fibula brings serious functional problems like peroneal loss [2,9,11]. Peroneal nerve palsy leading to a lush stepping gait, permanent use of an ankle-foot orthosis (AFO), muscle atrophy and parasthesiae all of which will decrease the Enneking score. Split posterior tibial tendon (SPTT) transfer is a appropriate alternative for compensation of peroneal loss and eliminates the use of an AFO. Improvement of extremity function with this reconstructive surgery gives better Enneking scores (poor to fair) as in our series (case V, IX).

The fibula and PTFJ play an important role in the biomechanics of the knee and leg [2,12,16]. Its major roles are load transfer between knee and ankle, acting at the site of origin for muscles and dissipation of lateral tibial bending moments. Thus any difference in resection types such as resection length of fibula, PTFJ preservation, ligamentous repair and gastrocnemius flap procedure will affect both knee and ankle in gait.

Bozkurt et al. proved that PTFJ, anatomically and clinically is a part of the knee. Their cadaveric study demonstrated that there is a clear communication between the PTFJ and the knee in 64.3% of dissections [1]. Thus we may consider proximal fibular resection as removing an important structure of the knee. Varus stabilization of the knee is mainly provided by the lateral collateral ligament, biceps femoris and the anterior tibiofibular ligament [2,16]. If the proximal fibula is resected, the lateral collateral ligament and biceps femoris tendon should be meticulously reattached. Contrary to the consensus in the literature [2,8,9] Eionder and Choong did not perform any reconstruction of these structures. Although they reported that the knee remained stable in their series for 4 years of follow up, 1 cm joint space widening was detected in two cases [3]. This degree of instability of the knee may result in osteoarthritis in long-term follow-up [2]. Thus if a proximal fibular resection is planned, where the patients are usually young, recon-

(a) (b)

Fig. 6. (a) Clinical appearance of the patient who had recurrent GCT. Large soft tissue swelling is visible in the posterolateral compartment of the leg (Case I). (b) Lateral X-ray of the lesion revealed that tumor destructed bony structure and expanded in to soft tissue (Case I).

struction of the lateral instability is essential for prevention of knee osteoarthritis.

Proximal fibular resection with ligamentous reattachment causes gait abnormalities and even knee instability [2,16]. Draganich et al. reported increased anterior and anteroposterior translation of knee at flexion, varus-valgus rotations at 20° flexion and several abnormalities in ground reaction forces [2]. Draganich suggested that these disorders can be minimized by proper reattachment of lateral collateral ligament and biceps tendon at their new insertion site. Youdas et al. reported moderate changes in the knee after removal of fibular diaphyseal segment with intact PTFJ (like type IV resection), such as transverse motion of the knee and late stance sagittal motion of the knee [16]. These changes are due to alterations in load transmission through the fibula and loss of origin of the muscles. Thus when fibular resection is performed with preservation of PTFJ and a short metaphyseal segment (type IV resection), knee stability might be less disturbed.

In type II resection gastrocnemius flap is used for soft tissue reconstruction. This procedure itself brings additional mechanical problems. Kramers et al. noted that after a gastrocnemius flap procedure the knee develops a compensatory mechanism during the swing phase of the gait, by increasing peak knee flexion but knee motion remains normal in the stance phase [7].

We propose that satisfactory clinical results can be achieved by careful interpretation of MRI and appropriate selection of four different resection techniques. Also, wide surgical margins can be obtained in tumors with large volume by resection of the deep peroneal nerve. Removing of PTFJ will require reconstruction of lateral stability of the knee. However, in our series all knees were clinically stable and no complaints were detected. The preservation of proximal tibiofibular joint and its effect on knee instability requires further study with more objective and quantitative methods. This study provides a different perspective to the orthopedic surgeon for the resection of proximal fibular tumors by means of tumor volume calculation and preservation of PTFJ.

Acknowledgments

We thank Safdhar N. Khan, MD at the Hospital For Special Surgery, New York, USA for critically reviewing the manuscript, Emre Tomin, BS at the Hospital For Special Surgery, New York, USA for preparation of this manuscript

Table 1
Enneking scoring sytem for lower extermity

Number	Age/Sex	Surgical margin	Diagnosis	Resection type	Resection length and PTFJ	Complication	Follow-up period	Enneking score
Case I	48/M	Clear	Recurrent GCT, volume 510 ml	Type III	14 cm Extraarticular	Peroneal nerve palsy, AFO, A.tibialis anterior grafting.	27 months	Fair
Case II	20/M	Clear	GCT	Type I	11 cm Intraarticular	Peroneal nerve palsy, partially resolved after 6 months.	117 months	Poor
Case III	21/M	Clear	GCT	Type IV	11 cm Intraarticular, (PTFJ preserved)	Peroneal nerve palsy, resolved after 6 months.	32 months	Good
Case IV	20/M	Clear	Benign fibrous Histiocytoma	Type IV	13 cm Intraarticular, (PTFJ preserved)	None	74 months	Excellent
Case V	21/M	Clear	GCT, secondary ABC	Type I	10 cm Intraarticular	Peroneal nerve palsy, SPTT.	18 months	Fair
Case VI	21/M	Clear	Osteosarcoma (pathological fracture)	Type II	9.5 cm Extraarticular,%50 necrosis	Peroneal nerve palsy, lung metastasis, AFO.	25 months (Dead)	Poor
Case VII	22/M	Clear	GCT	Type I	10 cm Intraarticular	None.	48 months	Excellent
Case VIII	20/M	Clear	Osteosarcoma	Type II	13.5 cm Extraarticular,% 100 necrosis	Peroneal nerve palsy, lung metatasis, AFO.	34 months	Poor
Case IX	20/M	Clear	GCT, volume 276 ml	Type III	13 cm Extraarticular	Peroneal nerve palsy, SPTT.	15 months	Fair

PTFJ, Proximal tibiofibular joint; AFO, Ankle foot orthosis; SPTT, Split posterior tibial tendon transfer; ABC, Aneurismal bone cyst; GCT, Giant cell tumor.

Table 2
Demographics and results of patients

Score	Pain	Function	Emotional acceptance	Supports	Walking	Gait
5	None	No restriction	Enthused	None	Unlimited	Normal
4	Intermadiate	Intermadiate	Intermadiate	Intermadiate	Intermadiate	Intermadiate
3	Modest	Restriction in recreational activities	Satisfied	Brace	Limited	Minor Cosmetic
2	Intermadiate	Intermadiate	Intermadiate	Intermadiate	Intermadiate	Intermadiate
1	Moderate	Partial disability	Accepts	One cane or crutches	Household	Minor Handicap
0	Severe	Total disability	Dislikes	Two crutches	Unable, unaided	Major handicap

and Tuna Ferit Hidayetoglu, Gazi University, Ankara, TURKEY for the illustrations.

References

[1] Bozkurt M, Yilmaz E, Atlihan D, Tekdemir I, Havitcioglu H, Gunal I. The proximal tibiofibular joint. An anatomic study. Clin Orthop 2003;406:136–40.
[2] Draganich LF, Nicholas RW, Shusther JK, Sathy MR, Chang AF, Simon MA. The effects of resection of the proximal part of the fibula on stability of the knee and on gait. J Bone Joint Surg [Am] 1991;73A(4):575–83.
[3] Einoder PA. Choong PFM. Tumors of the head of fibula. Acta Orthop Scand 2002;73(6):663–6.
[4] Enneking WF, Dunham W, Gebhardt MC, Malawar M, Pritchardt DJ. A system for the functional evaluation of reconstructive procedures after surgical treatment of tumors of the musculoskeletal system. Clin Orthop 1991;286:241–6.
[5] Farooque M, Biyani A, Adhikari A. Giant cell tumors of the proximal fibula. J Bone Joint Surg 1990;72-B(4):723–4.
[6] Johnston JO. Giant cell tumor of bone. In: Menendez L.R., editor. Orthopaedic knowledge update musculoskeletal tumors72-B. Pennsylvania: American Academy of orthopaedic Surgeons; 2002. p. 113–8.
[7] Kramers De Quervain IA, Lauffer JM, Kach K, Trentz O, Stussi E. Functional donor site morbidity during level and uphill gait after a gastrocnemius muscle flap procedure. J Bone Joint Surg 2001; 83A(2):239–46.
[8] Lushiku HB, Gebhart M. Osteosarcoma of the proximal fibula: report of 3 cases. Acta Chir Belg 1997;97(5):260–3.
[9] Malawer MM. Surgical management of aggressive and malignant tumors of the proximal fibula. Clin Orthop 1983;186:172–81.
[10] Marcove RC, Jensen MJ. Radical resection for osteogenic sarcoma of fibula with preservation of the limb. Clin Orthop 1976; 125:173–6.
[11] Ozaki T, Hilmann A, Linder N, Winkelmann W. Surgical treatment of bone sarcomas of the fibula. Arch Orthop Trauma Surg 1997;116: 375–9.
[12] Parker VT, Urbaniak JR. Donor site morbidity with use of vascularized autogenous fibular grafts. J Bone Joint Surg 1996;78A(2): 204–11.
[13] Sorenson AG, Patel S, Harmath C, Bridges S, Synnott J, Sievers A, Yoon YH, Lee EJ, Yang MC, Lewis RF, Harris GJ, Lev M, Schaefer PW, Buchbinder BR, Barest G, Yamada K, Ponzo J, Kwon HY, Gemmete J, Farkas J, Tievsky AL, Ziegler RB, Salhus MR, Weisskoff R. Comparison of diameter and perimeter methods for tumor volume calculation. J Clin Oncol 2001;19(2):551–7.
[14] Unni KK. Dahlin bone tumors: general aspects and data on 11.087 cases19. Illinois: Lippincott-Raven; 1996. p. 172,264.
[15] Wolf RE, Enneking WF. The staging and surgery of musculoskeletal neoplasms. Orthop Clin North Am 1996;27(3):473–81.
[16] Youdas JW, Wood MB, Cahalan TD, Chao EY. A quantitative analysis of donor site morbidity after vascularized fibula transfer. J Orthop Res 1988;6(5):621–9.