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Nonvascularized fibular grafts in the reconstruction of bone defects in orthopedic oncology

Ortopedik onkolojide kemik defektlerinin onarımında vaskülarize olmayan fibula greftleri

Kerem BASARIR,[1] Hakan SELEK,[2] Yusuf YILDIZ,[1] Yener SAGLIK,[1]

[1]Ankara University Medicine Faculty, Orthopedics and Traumatology Department;
[2]Gazi University Medicine Faculty, Orthopedics and Traumatology Department

Amaç: Ortopedik onkolojide tümör rezeksiyonu veya küretajı sonrası meydana gelen kemik defektlerinin yapısal fibula grefti ile rekonstrüksiyonu sık kullanılan ve başarılı bir yöntemdir. Bu çalışmada vaskülarize olmayan otogreft ve allogreftlerin klinik ve radyografik sonuçları karşılaştırıldı.

Çalışma planı: Çalışmaya, tümör rezeksiyonu sonrası fibula allogrefti veya otogrefti kullanılarak rekonstrüksiyon yapılan 57 hasta (30 erkek, 27 kadın; ort. yaş 22.8; dağılım 5-57) alındı. Yirmi yedi hastada allogreft, 30 hastada otogreft kullanıldı. Defektlerin 24'ü segmenter, 33'ü kaviter idi. Segmenter rekonstrüksiyonlarda, hastaların biri dışında tamamına internal fiksasyon yapıldı. Femur rekonstrüksiyonu yapılan bir olguda internal fiksasyona ek olarak monolateral eksternal fiksatör uygulandı. Hastalar kaynama ve süresi ve komplikasyonlar açısından değerlendirildi. Ortalama izlem süresi 46 aydı; allogreft ve otogreft gruplarında sırasıyla ort. 48.4 ve 42.3 ay).

Sonuçlar: Radyografik olarak 46 hastada (80.7%) ortalama 5.9 ayda kaynama sağlandı (20 otogreftte ort. 6.8 ay; 26 allogreftte ort. 5.1 ay). Dördü allogreft, yedisi otogreft grubunda olan 11 hastada (19.3%) kaynama olmadı. Kaynama bakımından allogreft ve otogreft grupları arasında anlamlı fark bulunmadı. Tamamı küçük travmalar sonucu olmak üzere, altı hastada greft kırığı saptandı. Bu hastaların beşi otogreft, biri allogreft grubundandı. Üçü geçici peroneal sinir hasarı, ikisi el bileği subluksasyonu, ikisi enfeksiyon, biri Madelung deformitesi olmak üzere sekiz hastada (%14) komplikasyon görüldü.

Çıkarımlar: Segmenter veya kaviter kemik defektlerinde otojen veya allojen kaynaklı vaskülarize olmayan fibula grefti ile rekonstrüksiyon başarı oranı yüksek olan güvenilir bir yöntemdir.

Anahtar sözcükler: Kemik kisti/cerrahi; kemik neoplazileri/cerrahi; kemik transplantasyonu/yöntem; küretaj; fibula/transplantasyon; ekstremite kurtarma; transplantasyon, otolog; transplantasyon, homolog.

Objectives: Bone defects after resection or curettage of musculoskeletal tumors are commonly reconstructed with the use of structural fibular autografts or allografts with considerable success. In this study, we compared the clinical and radiographic results of nonvascularized autografts and allografts.

Methods: Fifty-seven patients (30 males, 27 females; mean age 22.8 years; range 5 to 57 years) underwent reconstruction with a structural fibular autograft (n=30) or allograft (n=27) following tumor resection. Of the tumor defects, 24 were segmental and 33 were cavitary. All the patients who had segmental reconstruction were treated with internal fixation, except for one patient who had internal fixation and monolateral external fixator for femoral reconstruction. The results were evaluated with respect to union, time to union, and complications. The mean follow-up period was 46 months; 48.4 and 42.3 months in the allograft and autograft groups, respectively).

Results: Radiographically, union was obtained in 46 patients (80.7%) within a mean of 5.9 months (6.8 months in 20 autografts, and 5.1 months in 26 allografts). Nonunion (19.3%) occurred in four allografts and seven autografts. No significant difference was found between the two fibular grafts in terms of union ($p>0.05$). Graft rupture was detected in six patients (5 autografts, 1 allograft) all of which were due to minor traumas. Complications were encountered in eight patients (14%) including transient peroneal nerve injury (n=3), wrist subluxation (n=2), infection (n=2), and Madelung's deformity.

Conclusion: Reconstruction of cavitary and segmental bone defects with autogenous or allogenous nonvascularized fibular grafts is a reliable method, with high success rates.

Key words: Bone cysts/surgery; bone neoplasms/surgery; bone transplantation/methods; curettage; fibula/transplantation; limb salvage; transplantation, autologous; transplantation, homologous.

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Correspondence to: Dr. Yener Sağlık. Ankara University Medicine Faculty, Orthopedics and Traumatology Department, 06100 Samanpazarı, Ankara.
Phone: +90 312 - 310 33 33 Fax: + 90 312 - 311 25 22 e-mail: kerembasarir@hotmail.com

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Autogenous and allogenous bone grafts are widely used for reconstruction of bone defects in a variety of situations. Resection or curettage of bone tumors, osteolysis in major joint replacement and infection are the most common situations.[1,2] Successful use of adjuvant treatment with better imaging modalities and evolving surgical techniques increase limb sparing surgery. These defects should be reconstructed in order to obtain an acceptable outcome. Autogenous bone grafting was first described by Walther in tumor resection by replacing radius with fibula and since then it has been used for more than 90 years.[3,4] Fibula is the strongest autogenous bone graft available when compared to other cortical autograft donor sites such as iliac crest and anterior tibial shaft.[4] There is little donor site morbidity after resection of fibula.[5] Single fibular graft is not sufficient to replace segmental bone defects in large tubular bones. The results were unsatisfactory due to nonunion or stress fracture of the graft.[6] Additionally proximal fibula is used for reconstruction of distal radius resection with its articular cartilage.[7] Although autogenous bone seemed superior to allografts many authors report satisfactory results with usage of allografts in reconstruction of bone loss.[8,9,10] Allograft usage has its own advantages such as avoidance of donor site morbidity, unlimited supply and availability in different sizes.

This study reports a retrospective analysis of the outcome of non-vascularised fibular auto and allografts used in orthopaedic oncologic practice.

Material and method

A survey of records of the Orthopaedic Oncology Section of Ankara University School of Medicine between June 1986 and January 2004 uncovered 65 cases (35 men, 30 women; mean age 23.3: range 5-67) who have been treated by the use of fibular allo- and autografts. The defects were reconstructed with autogenous grafts in 35 and allografts in 30 patients. The mean length of the fibular graft was 9.2 cm (range 4-16 cm). Additional bone graft from iliac wing was used in % 66.6 allografts and % 48.5 of autografts. Proximal fibula was used as an osteochondral graft in nine cases. All of the allografts were used were freeze dried. They were kept at room temperature and bathed in warm Ringer's lactate just before usage. For application of cavity filling snug fit placement of fibular graft was performed. In case of structural reconstruction internal fixation was performed by screws, plates and additional external fixation was used in one case because of extra length of fibular graft (16 cm) and removed at 3 months postoperatively. The patients with at least 6 months follow up are included in this study. There were totally 57 patients (30 men, 27 women; Mean

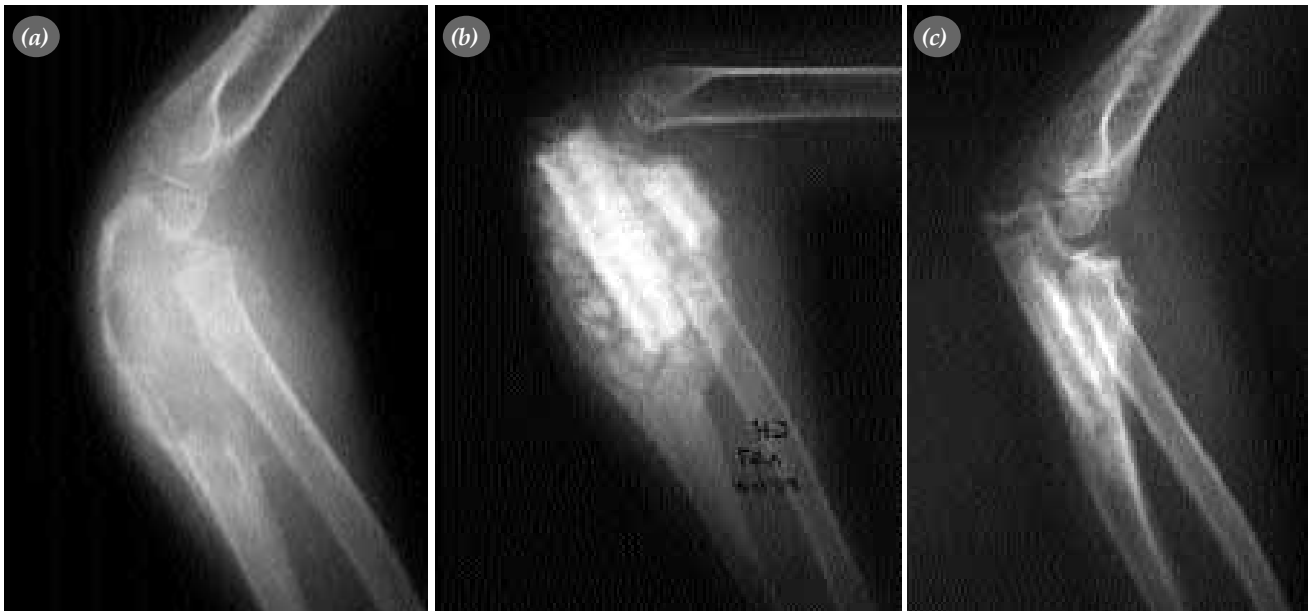

Figure 1. (a) Aneurysmal bone cyst of ulna in a seven year old boy **(b)** Reconstruction of the cavitary defect with allograft fibula and autogenous iliac bone graft after curettage **(c)** Anteroposterior radiograph reveals radiological bone incorporation at seven months follow up.

age 22.8 range 5-57) 27 in allograft group and 30 cases in autograft group with adequate follow up. The following data were considered age, sex, pathological diagnosis, anatomical site, length of the graft used, type of the stabilization method, complications, time for union and follow up time.the mean follow up time was 46 months (allograft 48.4, autograft 42.3).

The results were analyzed with Mann-Whitney U test, Spearman's correlation analysis and chi-square test using SPSS 11.0 program.

Results

All but one patient in the segmental bone defect group had internal fixation. In one patient with a long segmental defect, additional external fixation was used and removed at three months postoperatively in wards (Figure 2a,b). In the follow up of the patient the graft was replaced with new bone by creeping substitution and adapt femur due to mechanical stresses (Figure 2c-e).

Primary bone union detected by radiological incorporation was observed in a total number of 46

Figure 2. (a) Preoperative x-ray shows aneurysmal bone cyst of femur in an eight year old girl **(b)** Additonal external fixator was observed in immediately postoperative Anteroposterior radiogram. **(c)** The graft was replaced with viable bone by creeping substitution observed ant anteroposterior radiogram at one year follow up. **(d, e)** Full radiological bone incorporation and remodelization was observed at seven years follow up. **(f)** Clinical result at seven years postoperatively.

patients (80.7%) at a mean of 5.9 months (20 autograft 6.8 months, 26 allograft 5.1 months). Of 11 pseudoarthroses 4 were observed in the allograft group and 7 in autograft group. They were treated surgically with more rigid internal fixation and autografting bone union was achieved in 5 cases (1 allograft, 4 autograft). Six patients had established and resistant nonunion despite of second operation but functional result was satisfactory in these patients and they were followed up without any other intervention. The mean age in pseudoarthrosis group was 31.5 (39.7 autograft, 17 allograft).

Fracture of the graft was seen in 6 cases, all with minor trauma. Of the six cases five were in autograft and one was in allograft group. All patients underwent open reduction, internal fixation and additional autogenous bone graft from iliac wing. Bone union was achieved in three patients. Two patients were followed up without any additional treatment because of their satisfactory functional status however in one case vascularised fibula was used because of symptomatic nonunion. Infection was observed in one patient. She underwent repeated debridements and was lost secondary to her progressing primary disease. Although there were radiological signs of carpal collapse and distal radioulnar dissociation, most of the patients have the capacity of daily work without any significant functional limitation. (Figure 3). Six patients stated that they were satisfied with the functional result. Of these six patients one had resistant nonunion, one had Madelung deformity and two had wrist subluxation.

Infection was observed as a complication in two patients. Internal fixation was used in one of them. Surgical debridement of the wound was performed because drainage resisted despite oral antibiotics. Staphylococcus aureus was cultured. After parenteral antibiotics clinical and laboratory signs of infection was subsided. other patient underwent autogenous fibular proximal humeral reconstruction with the diagnosis of osteosarcoma. In the opsteoperative period nonunion was observed and treated with rigid internal fixation and autogenous iliac bone grafting. Infection developed during chemotherapy period. Wound drainage persisted despite parenteral antibiotics. She was recovered from infection after two surgical debridements and intravenous antibiotic administration; however she was lost secondary to progression and lung metastasis secondary to her primary sarcoma.

Figure 3. (a) Anteroposterior x-ray of a 29 year old woman revels giant cell tumor at distal radius. **(b, c)** Reconstruction of the defect after resection with proximal fibular graft observed in anteroposterior and lateral radiograms.

Local recurrence was observed in one patient. Distant metastasis was observed in two patients one of whom was Ewing sarcoma and other was osteosarcoma. Transient peroneal nerve palsy was observed in three patients all of which recovered in four months.

Excluding oncologic complications, the overall complication rate was 14 % (8/57), including three transient peroneal nerve palsy, two wrist subluxation, two infections and one Madelung deformity.

There were no significant relationship was found between age and radiological bone incorporation in allograft and autograft groups ($p>0.05$). There was also no significant relationship between the graft length, location of the reconstruction and fixation method and union ($p>0.05$). When cavitary and segmentary reconstruction was compared there were no significant difference in union rate and union time ($p>0.05$). The bone incorporation rate was higher in the cavitary defect group. There was no significant difference between allograft and autograft group in bone incorporation.

Discussion

The progress in radiology, chemotherapy and radiotherapy allows more accurate evaluation and decision making in treatment.[11] Improvements in diagnosis, evaluation and treatment of musculoskeletal tumors resulted in treatment of malignant tumors by limb salvage without compromising the oncological result. The procedures used in limb saving surgery resulted in bone defects which have to reconstructed in order to achieve an acceptable functional result. Although there are several alternative procedures, ideally the defect should be reconstructed with a bone that is similar in size, shape and antigenicity.[12]

Fibula is the most suitable bone to transfer for a large defect in a tubular bone because of its established length, geometrical shape and strength [13,14] In addition to its strength both fibulas can be used when required.[15,16] Despite of its strength there were several reports about fibular graft fracture when used alone for defects in large tubular bones.[2,6,17]

In our study we have used single fibula in reconstruction of segmental defects. There were six graft fracture observed in our study in proximal humerus (4 cases), distal radius and distal tibia. The fracture incidence was similar when compared with fibular grafts in large tubular bones.

There were stress fractures reported with similar incidence in vascularised grafts and nonvascularised grafts. Prolonged immobilization and usage of cancellous bone graft with proper stable internal fixation were stated to have a role in this result.[18] Fracture of the graft was observed in 5 cases autograft group and 1 case in allograft all were pseudoarthrosis and after fracture all underwent internal fixation and autologous grafting. In three patients radiological incorporation was observed. In one patient vascularised fibular grafting was performed and the other one had minimal symptoms although radiological incorporation could not be achieved. In other patient an infection was observed during chemotherapy which continued despite two debridements. This patient was lost because of her primary disease.

Reconstruction with non-vascularised fibula is a well-known and easy to perform procedure.[19] Allograft fibulas are composed of dead bone sterilized either by radiation, freezing or both. They have the potential for antigenicity which is reduced by cryopreservation, storage and processing.[12,20] No appreciable immune response was observed in our patients either local or systemic. Allografts have the advantage of unlimited supply without donor site morbidity and the disadvantage of high cost. Despite allografts even non vascularised bone grafts are biologically active and capable of remodelling in order to adapt the new anatomical site and mechanical stresses.[4,21,22] Additionally autografts include stimulants for bone growth including growth factors and bone morphogenic proteins and they are non-antigenic.[4] Vascularised fibula graft was first used because of potential advantage of relatively earlier bone union providing earlier rehabilitation by Taylor in 1975.[23] The time consuming method and technically difficult method of obtaining bone graft is usually reserved for resistant problems with insufficient blood supply.[18]

Proximal fibula can be used for reconstruction of defects in distal radius as an osteochondral graft. It provides considerable amounts of wrist motion and forearm rotation when compared with grafts

from ilium, tibia or wrist prosthesis.[7] We have satisfactory results in our series of distal radial reconstruction using nonvascularised autograft proximal fibula in 9 patients. Radiologic bone incorporation was achieved in eight patients. In one patient asymptomatic fibrous union was observed, nonunion despite of secondary internal fixation and autologous cancellous grafting in another patient. Madelung deformity was observed in one patient and subluxation in two cases. An acceptable functional result which permits moderate activities was achieved in all patients.

In the treatment of cystic lesions Glancy et al. reported 86 % complete healing and 80 % radiological bone incorporation in small cysts in children.[23] Nonunion for filling of cystic cavities was similar in the allograft group and autograft group %12 vs %16 respectively. Sethi et al. has reported no major difference between auto and allografts in filling up cavities.[24]

The time required for bone graft incorporation depends on many factors such as age and local blood flow as reported by several authors. There has been various values reported in the literature varying between 3 and 15 months.[24,25] Sethi et al reported a mean of 6-9 months in children and 9-15 months in adults. They also stated that there were no significant remodelling after 2 years of time. In an experimental model bone incorporation was found to occur within 3 months in %40 and 6 months in %90 of the experimental models.[6] In our series radiological incorporation of the graft was detected in %80 of the patients at a mean of 5.9 months which was in concordance with the literature (range; 2 - 16 months).

Infection was a complication in 2 cases. Both of these patients had internal fixation at the primary operation. In one patient Staphylococcus aureus was cultured. It did not respond to antibiotics and were treated surgically. Infection resolved with 10 days parenteral antibiotic course after debridement. Other patient who had a diagnosis of osteosarcoma was treated with autologous fibular graft initially. She had psedoarthrosis and fracture of the graft. Internal fixation and autogenous iliac wing grafting was performed. On the postoperative period while was taking chemotheraphy, she had persistent discharge despite antibiotic treatment and a second debridement was required. Her infection resolved after aggressive debridement and parenteral antibiotic treatment. However her disease progressed, she had died 2 years after the resection with lung metastasis.

Obtaining fibular autograft had very low donor site morbidity.[5] However well- known donor side defects can be seen such as transitory walking weakness due to peroneal nerve lesion. It was seen in 3 of our patients and all of them resolved in 4 months time. Electromyographic examination revealed normal result in two and subacute lesion in one patient.

Reconstruction with non vascularised autograft is relatively cheap, simple procedure which can be performed without special training with good results. Allografts have the advantages of unlimited supply and absence of donor site morbidity and they can also be used with considerable success. We conclude that autograft or allograft fibula can be successfully used in the reconstruction of defects observed after resection or curettage in orthopedic oncology. Techniques requiring special equipment and training should be reserved for resistant cases with disrupted local vascularity.

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