Use of vascularised free fibula in limb reconstruction (for non-malignant defects)

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Abstract

The case series was conducted at the Department of Plastic Surgery, Combined Military Hospital, Rawalpindi, from June 2009 to May 2011, and comprised 19 patients in whom free fibula flap was performed for upper and lower limb reconstruction, using SPSS 16. Results showed that flap survival was 100%. One (5.2%) flap was re-explored for venous congestion and was salvaged. One (5.2%) patient of congenital pseudoarthrosis of tibia had a fracture of the fibula and was treated with external fixation. Average follow up was 8 months. Mean union time and full weight-bearing was 6.5±1.34 months (range3-8 months) and 9 months, respectively. No recurrence of pseudoathrosis was observed until the last follow up, with only a 1.5cm length discrepancy in one patient. The results proved that a microvascular free fibular flap heals rapidly, causes early functional recovery and it can be raised as an osteocutaneous flap.
Keywords: Pseudoarthrosis, Trauma, Free flap.

Introduction

Reconstruction of large defects (>6cm) in long bones of the limbs poses a challenge to the reconstructive surgeon with regards to limb length preservation, function and cosmesis. There can be multiple causes of these defects e.g. trauma, infection with osteomyelitis and oncologic resection which in turn can be with or without soft tissue loss.

Various reconstruction modalities are present, each having its own benefits and drawbacks. The two most acceptable techniques for large long bone defects include the use of massive bony allografts and free composite tissue flaps.

Non-vascularised allografts provide a biological spacer with strong cortical bone and can be accurately matched to conform to the configuration of a bony defect. The use of allograft has fewer host/donor-site morbidity.[1] Allografts, however, have many disadvantages, including their lack of blood supply, lack of osteogenic cells, and potential for immunologic reaction, slow, superficial and incomplete healing, high non-union rate and pre-disposition to infection and fracture.[2-8]

With the advent of microvascular surgical reconstruction, techniques using free vascularised bone have become well-described and well-established.[9,10]

Potential donor site for osteocutaneous free flaps is the vascular system supplied by the subscapular artery, where a lateral or medial segment of the scapula can be included in composite grafts.[11,12] Other flaps, such as the lateral arm flap and the radial forearm flap, can also be modified as an osteofasciocutaneous flap when a bone segment from the lateral and distal humerus or from the radius is included.[13,14] Another potential donor site for microvascular bone segments is the iliac crest, but its curvature limits reconstruction of long diaphyseal bone or requires multiple osteotomies.[15]

Probably the most popular possibility for bone-only and free composite tissue harvest is the free fibula transplantation. The first microvascular fibula transfer was performed by Ueba and Fujikawa in 1973 and Taylor et al. in 1974.[16,17] In 1977, Weiland et al. reported the first reconstruction of long bones with vascularised fibula after tumour resection.[18] This option offers good available length of bone, good pedicle size, minimal donor site morbidity, shortened union time compared with the allograft and the possibility of using its proximal end for joint restoration. The composite free fibula flap can provide a skin paddle, soft tissue and muscle to reconstruct complicated defects.

Vascularised free fibula is also a treatment modality for congenital pseudoarthrosis of tibia.[19] It is a rare disease which usually becomes evident within a child's first year of life, but may be undetected up to the age of 12 years.[20] It is characterised by segmental osseous weakness, resulting in anterolateral angulation of the bone. The osseous dysplasia leads to tibial fracture and non-union. Tibial bowing and reduced growth in the distal tibial epiphysis may result in shortening.

Our unit has previously published results of salvage of the upper limb using vascularised fibula flaps.[21] Here we describe our results with free fibular flaps for limb salvage in patients with defects resulting from non malignant conditions and congenital pseudoarthrosis of tibia.

Patients and Methods

A total of 58 free fibular flaps were performed at the Plastic Surgery Department of the Combined Military Hospital, Rawalpindi, over a two-year period from June 2009 to May 2011. Thirtytwo free microvascular fibular flaps were performed in upper and lower limbs out of which 19 were performed for upper and lower limb reconstruction due to defects arising from non-malignant conditions. Out of these, 11 were oseocutaneous flaps while the rest were bone-only flaps.

Fourteen patients had bone loss due to trauma (most of these patients were serving soldiers injured during combat) and 5 patients had Congenital Pseudoarthrosis of the tibia.

The type of psuedoarthrosis was evaluated according to Crawford classification.[22] (Figure-1).

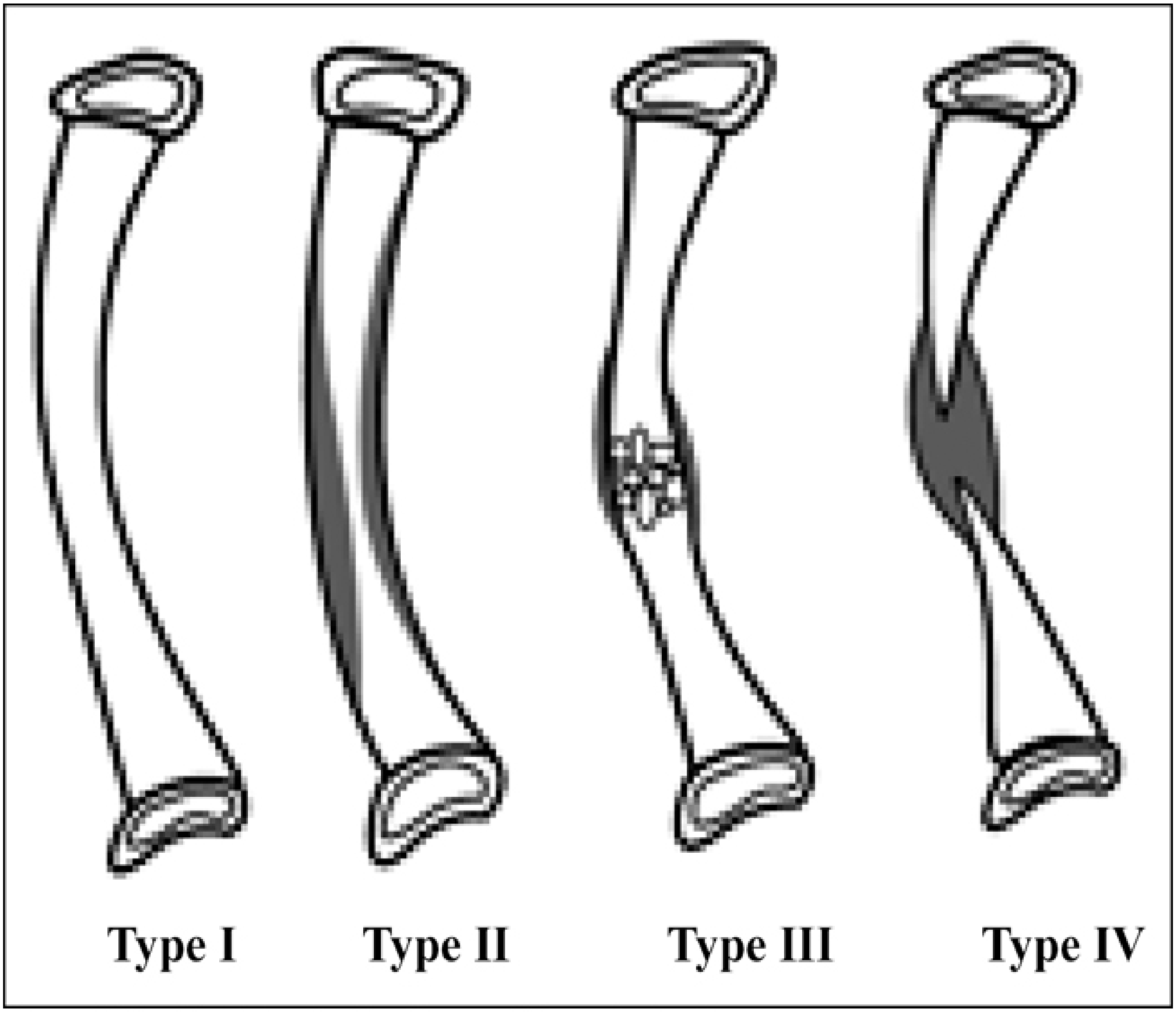

Figure-1: Crawford's classification of congenital pseudarthrosis.

Three patients had Type III and 2 had Type IV psuedoarthrosis.
Reconstruction was done in 8 Upper limbs and 11 lower limbs (Table).

Table: Summary of demographic data.

Patient	Reconstructed bone	Age	Gender	Cause of defect	Length of fibula	Type of flap
1	Tibia	7	F	congenital Pseudoarthrosis of the tibia type III	7 cm	Osseous
2	Tibia	9	M	congenital Pseudoarthrosis of the tibia type III	8	Osseous
3	Tibia	6	M	congenital Pseudoarthrosis of the tibia Type III	8	Osseous
4	Tibia	7	F	congenital Pseudoarthrosis of the tibia type IV	9	Osteocutaneous
5	Tibia	13	F	congenital Pseudoarthrosis of the tibia type IV	8	Osteocutaneous
6	Humerus	37	M	Gunshot wound	12	Osseous
7	Elbow	29	F	Gunshot wound	12	Osseous
8	Wrist	40	M	Blast Injury	9	Osteocutaneous
9	Humerus	35	M	Gunshot wound	14	Osteocutaneous
10	Tibia	27	M	Blast Injury	18	Osteocutaneous
11	Tibia	45	F	Road Traffic Accident	16	Osseous
12	Tibia	43	F	Road Traffic Accident	14	Osseous
13	Ulna	21	M	Gunshot wound	12	Osteocutaneous
14	Radius	24	M	Gunshot Wound	11	Osteocutaneous
15	Tibia	32	M	Blast Injury	16	Osteocutaneous
16	Humerus	41	M	Gunshot wound	8	Osteocutaneous
17	Tibia	47	M	Road Traffic Accident	9	Osseous
18	Humerus	26	M	Gunshot wound	13	Osteocutaneous
19	Tibia	27	M	Gunshot Wound	16	Osteocutaneous

A pedicled latissimus dorsi flap was done for soft tissue coverage of elbow defect in one patient three months after which free fibula flap was done. Another patient underwent radial nerve transfer for radial nerve injury four months prior to an osseocutaneous free fibula for humerus reconstruction.

The orthopaedic team performed the resection. The reconstructive effort was started simultaneously with the raising of the fibula. In all patients whom osteocutaneous fibula was done, perforators were marked before general anaesthesia with a Huntleigh SD2 healthcare hand-held Doppler. The right fibula was harvested in all except 4 patients who underwent reconstruction of defects in the tibia as the lesions were on the right side.

Fibular dissection was done through a lateral approach under tourniquet control. Any variation in blood supply was noted. Length of the fibula required was pre-operatively assessed by measuring the defect on the X-ray, taking into account the disparity in size between the X-ray and actual defect. Per-operatively the bone defect created by the resection was measured by the orthopaedic surgeon and the length of the fibula required was communicated. The maximum length was harvested to ensure the maximum possible length of the pedicle.

After resection was complete the patient was given 5000 international units of heparin intravenously (IV) and the fibular pedicle was divided The fibula was handed over to the orthopaedic team with one member of the plastic surgery team working with them for insetting of the bone and protecting the pedicle throughout the insetting/fixation of the bone. All anastamosis were done in a non-traumatised area under loupe magnification (x4). In the recipient site, the fibular graft was inserted into the medullary canal of the long bone. Additional stability was provided by cortical screws or locking plates. All free flaps with a skin paddle were monitored clinically by colour, temperature, capillary refill and pattern of bleed on scratching. To monitor bone-only fibular flaps, three-phase bone scan was done within the first 48 hours after surgery. For the donor lower limb an above-knee plaster of Paris (POP) slab was given for 4 weeks after which partial weight-bearing was started at 6 weeks. In cases of lower limb reconstruction partial weight-bearing was started at 12 weeks after consultation with an

orthopaedic surgeon.
Aeroplane splint slab was used for arm immobilisation when reconstruction of humerus was done.
Osseous union was defined as described by Gebert et al. and included attenuation or absence of osteotomy line, presence of external bridging callus, or bony trabeculae spanning the osteosynthesis site.[23]
Statistical analysis was done using SPSS 16.0. Continuous variables were expressed as mean ± standard deviation, whereas frequencies and percentages were shown for nominal variables.
Drawings illustrate Crawford's classification of congenital pseudarthrosis of tibia. Patients with all types present with anterolateral bowing of tibia. In type I, the medullary canal is preserved. Cortical thickening might be observed. Type II is defined by presence of thinned medullary canal, cortical thickening, and tabulation defect. The dominant finding in type III is a cystic lesion, which may be fractured. In type IV, pseudarthrosis is present with tibial and possibly fibular non-union.

Results

Out of the 19 patients in the study, 6 (32%) were females the rest (13, 68%) were males. The mean age for patients with congenital pseudoarthrosis was 8.4±2.79 years, and for rest of the patients was 33.86±8.43 years.
The average raising time of the free fibula was 75-90 mins for bone-only flap. Osteocutaneus flaps took a little longer to raise compared to bone-only flaps (90-105 mins). Total Operating time including the orthopaedics team and reconstruction time was 6-11 hours with mean 6.15±1.67 hours. Maximum length of the fibula was 22cm for tibia and minimum length of fibula was 7cm (for congenital pseudoarthrosis of the tibia).
Flap survival was 100%. One Flap was re-explored for congestion 20 hours post-operatively; a venous clot was found intra-operatively. The flap was salvaged. One patient of congenital pseudoarthrosis of tibia had a fracture of the fibula and was treated with external fixation.
Average followup was 8 months. All patients had achieved bone union on their last followup visit, including patients of pseudoarthrosis. Mean union time was 6.5±1.34 months (range: 3-8 months) as determined clinically and radiologically by evidence of bridging of three of the four cortices on plain radiographs.
The mean time to full weight-bearing was 9 months, and all patients were pain-free and able to walk without supportive devices.
At final followup there was no recurrence of pseudoathrosis until the last followup, with only a 1.5cm length discrepancy in one patient.
Three of the cases are described here individually:
Case-1
A 13-year-old female with type IV pseudoarthrosis operated previously at another hospital (Figure-2).

Figure-3: a) Scar of previous surgery. b) X ray showing segmental loss of ulna. c,d) Flap insetting showing fixation by bridging plate and skin paddle. e) Early post op X-ray.

Case-2

A young soldier with segmental loss of ulna due to gunshot wound was treated. He was subjected to 9cm free osteocutaneous fibula flap. Anastamosis was done with the ulnar artery and its 2 vena commitments (Figure-3).

Figure-3: a) Scar of previous surgery. b) X ray showing segmental loss of ulna. c,d) Flap insetting showing fixation by bridging plate and skin paddle. e) Early post op X-ray.

Case-3

A young soldier with gunshot wound resulting in segmental loss of humerus right and radial nerve injury was also treated. Radial nerve transfer was done. After four months, free fibula osteocutaneous flap was done (Figure-4).

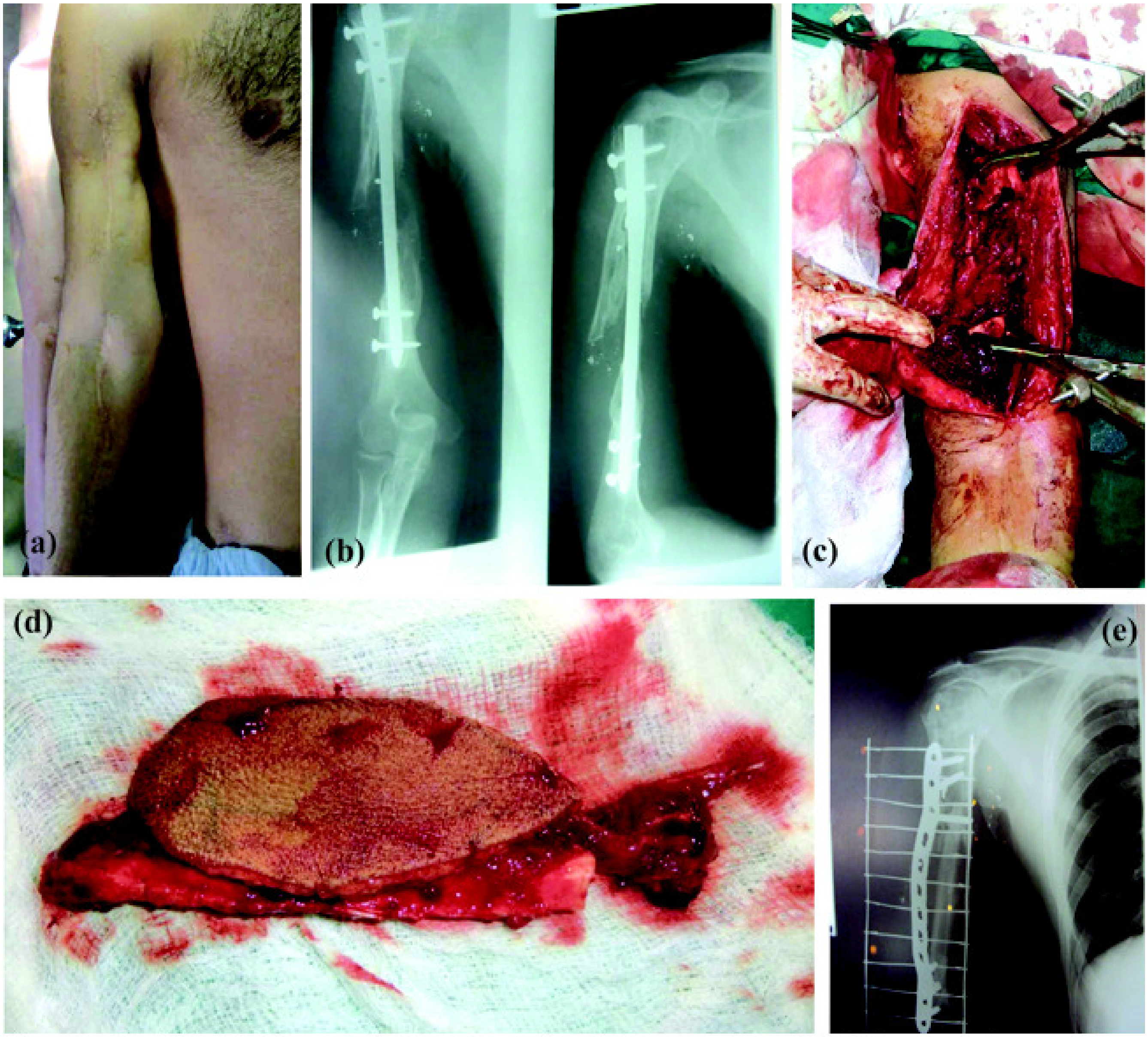

Figure-4: a) Scar of previous surgery and radial nerve transfer. b) Bony defect seen on X-ray with Intramedullary Nail. c) Defect to be reconstructed. d) Harvested flap with skin paddle. e) Early post-op X-ray with bridging plate.

Discussion

Free Fibula has been extensively used for reconstruction of limb defects post-tumour resection. Studies of it as a viable option for reconstruction of long bone defects due to other causes remain scarce and hard to find especially in local literature.

Since Taylor et al, numerous studies have demonstrated that microvascularised transfer of bone can be effective for the reconstruction of large skeletal defects, including those due to trauma, resection of a tumour, infection and congenital tibial pseudarthrosis.[24-26]

Worldwide, the free vascularised fibular graft (FVFG) has become the most commonly transferred vascular autograft for reconstructing segmental bone defects.[27]

Microvascular transplantation of an osteocutaneous fibula graft includes the advantage of a diaphyseal bone that is sufficient in length and stability for reconstruction of upper extremity as well as lower extremity bone defects.[28,29] In addition, the vascular pedicle of the graft is of sufficiently large diametre to facilitate microvascular anastamosis.

Also the advantages of use of vascularised grafts as compared with use of non-vascularised grafts have been demonstrated experimentally and clinically in skeletally mature individuals. These advantages include skeletal healing without creeping substitution of the graft from the surrounding host bone; more rapid incorporation and union; lower rates of fracture, infection, resorption, and non-union; the option of using the grafts for the treatment of established infections and segmental defects larger than five centimetres; greater initial strength; remodelling in a manner similar to that of viable bone; the ability to respond to biomechanical loading physiologically; increased hypertrophy; and a decreased duration of immobilization after implantation.[30]

Jupiter et al. demonstrated that after secondary reconstruction procedures, mature vascularised fibular grafts respond in a manner similar to normal cortical bone.[31] Fibulas will hypertrophy through a process of pressure transport, microfracture and callus formation. We have also seen this in long-term followup of our patients.

Reconstruction using vascularised fibula graft alone takes as early as three months to unite.[32] In other studies, an average time of three to five months is needed for union.[33] Ninety per cent of the patients achieved union at average of 7.6 months in a study conducted by Hsu et al,[34] which is similar to the time the fibula took to achieve union in our patients (6.5 months).

We also used it as an osteocutaneous flap in 11 cases. Other studies have also shown advantages of using a skin paddle. They show that monitoring of graft perfusion is clinically possible when a skin paddle is left attached to the fibula.[35]

We have also observed that primary closure (without using a split thickness skin graft) becomes easier once a skin paddle is used, as usually the recipient skin and soft tissue consists of scar tissue.

The complication rate after composite tissue transplantation is low, but the difficulty and length of the procedures may be disadvantageous.

In the past, some authors thought that the FVFG could only be done at specialised centres and was time-consuming. These grafts took years to hypertrophy and often fractured one or more times before re-modelling was complete. The grafts often failed to unite to the recipient osseous tissue at one or both ends.[36]

However, in our study, only one fracture and no non-union of the vascularised fibular grafts were encountered, which is similar to the study conducted by Sun et al[37] (although the defects were post osteomyelitis).

Recent studies show that donor-site morbidity after harvest of a free osteocutaneous fibula segment is low.[38,39] The most frequent complaints are pain, dysesthesia, and a feeling of ankle instability. There was no morbidity at the donor site in our study.

The interpretation of our results of reconstruction for congenital pseudoarthrosis need to be consolidated with a longer followup till skeletal maturity and with a larger no of patients.

Conclusion

Microvascular free fibular flaps heal more rapidly with fewer complications. There is earlier functional recovery than conventional non-vascularised grafts and it can be raised as an osteocutaneous flap. It provides a dynamic option to the plastic surgeon for 3 dimensional reconstruction of large complex defects located in poorly vascularised wound beds.

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Refrences

1. Moran SL, Shin AY, Bishop AT. The use of massive bone allograft with intramedullary free fibular flap for limb salvage in a paediatric and adolescent population. Plast Reconstr Surg 2006; 118: 413-9.
2. Stevenson S. Biology of bone grafts. Orthop Clin North Am 1999; 30: 543-52.
3. Ortiz-Cruz E, Gebhardt MC, Jennings L, Springfield DS, Mankin HJ. The results of transplantation of intercalary allografts after resection of tumors: A long-term follow-up study. J Bone Joint Surg Am 1997; 79: 97-106.
4. Cara JA, Lacléríga A, Cañadell J. Intercalary bone allograft: 23 tumor cases followed by 3 years. Acta Orthop Scand 1994; 65: 42-6.
5. Makley JT. The use of allograft to reconstruct intercalary defects of long bone. Clin Orthop Relat Res 1985; 197: 58-75.
6. Berry BHJr, Lord CF, Gebhardt MC, Mankin HJ. Fractures of allografts: Frequency, treatment and end-results. J. Bone Joint Surg Am 1990; 72: 825-33.
7. Brunelli G, Brunelli G. Free microvascular fibular transfer for idiopathic femoral head necrosis: Long-term follow-up. J Reconstr Microsurg 1991; 7: 285-95.
8. Weiland AJ. Current concepts review: vascularized free bone transplant. J Bone Joint Surg 1981; 63: 166-9.
9. Gebert C, Hillman A, Schwappach A, Hoffmann Ch, Hardes J, Kleinheinz J et al. Free vascularised fibular grafting for reconstruction after tumor resection in the upper extremity. J Surg Oncol 2006; 94: 114-27.
10. Gherlinzoni F, Picci P, Bacci G, Campanacci D. Limb sparing versus amputation in osteosarcoma.Correlation between local control, surgical margins and tumor necrosis: Istituto Rizzoli experience. Ann Oncol 1992; 3(Suppl 2): 3-7.
11. Smith RB, Henstrom DK, Karnell LH, Chang KC, Goldstein DP, Funk GF. Scapula osteocutaneous free flap reconstruction of the head and neck: impact of flap choice on surgical and medical complications.Head Neck 2007; 29: 446-52.
12. Sauerbier M, Erdmann D, Bickert B,Whitteman M, GermannG.[Defect coverage of the hand and forearm with a free scapula-parascapular flap].Handchir Mikrochir Plast Chir 2001; 33: 20-5.
13. Karamürsel S, Ba?datlý D, Markal N, Demir Z, Celebio?lu S. Versatility of the lateral arm free flap in various anatomic defect reconstructions.J Reconstr Microsurg 2005; 21: 107-12.
14. Militsakh ON, Werle A, Mohyuddin N, Toby EB, Kriet JD, Wallace DI, Girod DA, Tsue TT. Comparison of radial forearm with fibula and scapula osteocutaneous free flaps fororomandibular reconstruction. Arch Otolaryngol Head Neck Surg 2005; 131: 571-5.
15. Serafin D. The groin-iliac crest-deep circumflex iliac artery flap. In: Serafin D (ed.) Atlas of Microsurgical Composite Tissue Transplantation. Philadelphia: Saunders; 1996; pp 525-35.
16. Ueba Y, Fujikawa S. Nine years follow up of a vascularized fibular graft in neurofibromatosis: a case report and literature review. Jpn J Orthop Trauma Surg 1983; 26: 595-600.
17. Taylor GI, Miller GD, Ham FJ. The free vascularised bone graft. A clinical extension of microvascular techniques. Plast Reconstr Surg 1975; 55: 533-44.
18. Sowa DT, Weiland AJ. Clinical applications of vascularized bone autografts. Orthop Clin North Am 1987; 18: 257-73.

19. Choi IH, Cho TJ, Moon HJ. Ilizarov Treatment of Congenital Pseudarthrosis of the Tibia: A Multi-Targeted Approach Using the Ilizarov Technique. Clin Orthop Surg 2011; 3: 1-8. doi: 10.4055/cios.2011.3.1.1.
20. Delgado-Martinez AD, Rodriguez-Merchan EC, Olsen B. Congenital pseudarthrosis of the tibia. Int Orthop 1996; 20: 192-9.
21. Rashid M, Hafeez S, Zia ul Islam M, Rizvi ST, ur Rehman S, Tamimy MS, et al. Limb salvage in malignant tumours of the upper limb using vascularised fibula. J Plast Reconstr Aesthet Surg 2008; 61: 648-61.
22. Crawford AH. Neurofibromatosis in children. Acta Orthop Scand Suppl 1986; 218: 1-60.
23. Gebert C, Hillman A, Schwappach A, Hoffmann Ch, Hardes J, Kleinheinz J, Gosheger G. Free vascularised fibular grafting for reconstruction after tumor resection in the upper extremity. J Surg Oncol 2006; 94: 114-27.
24. Ridha H, Bernard J, Gateley D, Vesely MJ. Reconstruction of large traumatic segmental defects of the femur using segmental allograft with vascularized fibula inlay. J Reconstr Microsurg 2011; 27: 383-90.
25. Bach AD, Kopp J, Stark GB, Horch RE. The versatility of the free osteocutaneous fibula flap inthe reconstruction ofextremities after sarcoma resection. World J Surg Oncol 2004; 2: 22. doi: 10.1186/1477-7819-2-22.
26. Iamaguchi RB, Fucs PM, Carlos da Costa A, Chakkour I, Gomes MD. Congenital pseudoarthrosis of the tibia - results of treatment by free fibular transfer and associated procedures - preliminary study. J Pediatr Orthop B 2011; 20: 323-9.
27. Gebert C, Hillmann A, Schwappach A, Hoffmann Ch, Hardes J, Kleinheinz J, Gosheger G. Free vascularised fibular grafting for reconstruction after tumor resection in the upper extremity.J Surg Oncol 2006; 94: 114-27.
28. Zaretski A, Amir A, Meller I, Leshem D, Kollender Y, Barnea Y, et al. Free fibula long bone reconstruction in orthopedic oncology: A surgical algorithm for reconstructive options. Plast Reconstr Surg 2004; 113: 1989-2000.
29. Heitmann C, Erdmann D, Levin LS. Treatment of segmental defects of the humerus with an osteoseptocutaneous fibular transplant. J Bone Joint Surg Am 2002; 84: 2216-23.
30. Shea KG, Coleman SS, Coleman DA. Growth of the proximal fibular physis and remodeling ofthe epiphysis aftermicrovascular transfer. A case report. J Bone Joint Surg Am 1997; 79: 583-6.
31. Jupiter J B, Palumbo MA, Nunley JA, Aulicino PL,Herzenberg JE. Secondary reconstruction after vascularised fibular transfer. J Bone and Joint Surg Am 1993; 75: 1442-50.
32. Imran Y, Zulmi W, Halim AS. Skeletal Union Following Long Bone Reconstruction Using Vascularised Fibula Graft. Singapore Med J 2003; 44: 286-7.
33. Weiland AJ, Moore JR, Daniel RK. Vascularised bone autografts. Experience with 41 cases. Clin Orthop Relat Res 1983; 174: 87-95.
34. Hsu RW, Wood MB, Sim FH, Chao EY. Free vascularised fibular grafting for reconstruction after tumor resection. J Bone Joint Surg Br 1997; 79: 36-42.
35. Giessler GA, Bickert B, Sauerbier M, Germann G. [Free microvascular fibula graft for skeletal reconstruction after tumor resections in the forearm: Experience with five cases]. Handchir Mikrochir Plast Chir 2004; 36: 301-7.
36. Green SA, Jackson JM, Wall DM, Marinow H, Ishkanian J. Management of segmental defects by Ilizarov intercalary bone transport method. Clin Orthop Relat Res 1992; 280: 136-42.
37. Sun Y, Zhang C, Jin D, Sheng J, Cheng X, Liu X, et al. Free vascularised fibular grafting in the treatment of large skeletal defects due to osteomyelitis. Int Orthop 2010; 34: 425-30.doi: 10.1007/s00264-009-0761-x.
38. Tang CL, Mahoney JL, McKee MD,Richards RR, Waddell JP, Louie B. Donor site morbidity following vascularised fibular grafting. Microsurgery 1998; 18: 383-6.

39. Vail TP, Urbaniak JR. Donor-site morbidity with use of vascularised autogenous fibular grafts. J Bone Joint Surg Am 1996; 78: 204-11.