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**Original Research Article**

# Functional outcome in reconstructions with fibula autograft in tumors of appendicular skeleton

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## ABSTRACT

**Background:** Resection by a limb-sparing surgery and restoration of bone and soft tissues makes a successful limb salvage. Several reconstructive procedures that maintain limb length and provide acceptable cosmetic and functional results include endoprosthetic reconstruction, use of allografts and/or autografts like vascular or avascular fibula graft. The objective of the study was to assess and compare the preoperative and postoperative functional and radiological outcome in patients treated with wide resection of tumors of the appendicular skeleton followed by reconstruction with fibula graft.
**Methods:** This retrospective and prospective comparative study was conducted in 17 patients in Amrita Institute of Medical Sciences, Kerala. The patients were followed up for a minimum of 9 months ranging to 65 months. Functional and radiological assessments were done. Wilcoxon signed ranks test was done to assess significant differences between preoperative and postoperative functional scores. The SPSS software was used to analyze the data collected.
**Results:** There was statistical significance as well as improvement in the postoperative functional scores (p=0.004) when compared to the preoperative status. There was no significance (2 tailed test) in postoperative functional scores between vascular and avascular fibula graft (p=1.000).
**Conclusions:** Fibula grafting after resection of appendicular tumors offers a wonderful technique in filling bony defects. It provides good functional outcome and better bony union. Even though the postoperative outcome is significant, there is no significant difference between vascularized and avascular fibula in terms of functional outcome, bony union and graft hypertrophy.

**Keywords:** Appendicular skeleton, Fibula autograft, Limb-sparing surgery, Reconstructions, Vascularized fibula graft

## INTRODUCTION

The concept of limb-sparing surgery or limb salvage has gradually evolved over the past few decades.[1] Determining the correct level at which to perform an amputation, was the major challenge in surgical oncology for the extremities and over the years all tumor surgeons are looking at salvaging the limb whenever possible. Resection by a limb-sparing surgery and restoration of bone and soft tissues makes a successful limb salvage.[2]

Recent advances in the treatment of tumors of the appendicular skeleton including improved diagnostic staging, neo-adjuvant chemotherapy and in some cases

radiotherapy have made limb salvage a viable option in the majority of patients.[3] A wide range of reconstructive procedures which have the potential to maintain limb length while producing an acceptable functional and cosmetic result are available. These include endoprosthetic reconstruction, use of allografts and/ autografts in various forms.[4] There are lot of factors which determine the type of surgery required. Those include location and size of tumor and also patient related factors.

Several anatomical sites can be used as donors for the bone graft. While a range of bones including the ilium, scapula, radius, and rib are used as donor grafts, the fibula has become favoured by surgeons because of its good structural advantages, blood supply and low donor site morbidity. This cortical structure has allowed the fibula to be successfully grafted into defects of up to 30 cm. Fibular transfer is probably the most suitable for a large defect in a long bone, because of its length, geometrical shape and mechanical strength.[5] fibula grafting is ideal for extremity reconstruction because the size and straight configuration of the fibula match the forearm bones and fit into the medullary canal of the femur and tibia.

The continued development of surgical techniques has made the use of fibula bone grafting a promising option in reconstructing large meta/diaphyseal defects after tumor resections. The two methods include the use of either vascular or avascular fibula graft.[6] These procedures have risk of complications like infection, aseptic loosening, implant failure, donor site morbidity etc.

The objective of the study is to assess and compare the preoperative and postoperative functional and radiological outcome in patients treated with wide resection of tumors of the appendicular skeleton and reconstruction with fibula graft. It involves the evaluation and comparison of both vascularized and avascular fibula autograft.[7]

## METHODS

This retrospective and prospective comparative study was conducted in Amrita Institute of Medical Sciences, Kochi, Kerala, India from January 2012 to January 2014 on patients where fibula reconstruction was done after resection of appendicular musculoskeletal tumors. Prospective study was done in 12 patients and 5 patients were studied retrospectively. Data collection was done by interview of patients and through electronic medical records, case file details and imaging. All information like resection and fibula length, bone grafting and graft fixation, intraoperative and postoperative complications, resurgery, chemo and radiotherapy, donor site morbidity and refracture details were recorded. The patients were followed up regularly and a comparison was done between vascularized and avascular fibula regarding the functional and radiological outcome. The study was conducted in six patients with giant cell tumor, osteosarcoma (five patients), two with Ewing's sarcoma and one case each of chondrosarcoma, osteoid osteoma, fibrous dysplasia and metastasis from thyroid carcinoma. Two patients had tumor in radius, six in humerus, seven people had in femur and one each in metatarsal and tibia. The chondrosarcoma and one case of giant cell tumor were cases of recurrence (Figure 1).

6 patients had history of trauma before presentation. 8 patients had tumor on the left side. Pain had been the presenting complaint for all of them although only 8 of them presented with swelling. Except the patient with metatarsal fibrous dysplasia, all of them underwent MRI scan.

Reconstruction was done in 13 of them and arthrodesis was done in 4 patients. Avascular fibula grafting was done in eight patients and rest of them were grafted with vascular fibula.

Patients were assessed functionally through clinical examination and through use of the self-assessed Musculoskeletal Tumor Society (MSTS) scoring system.[8] In the MSTS system, numerical values (0–5) are assigned to each of six categories for upper limb: ''emotional acceptance,'' ''function,'' ''pain,'' ''manual dexterity,'' ''lifting ability, ''and ''hand position.'' and six categories for lower limb ''emotional acceptance,'' ''function,'' ''pain,'' "supports", "walking" and "gait". A total score between 0 and 30 is calculated, with 30 as the best outcome possible. Functional assessment was performed at most recent follow-up. Radiographs were assessed by the surgeon for evidence of bony union, resorption, implant failure and other complications.

Wilcoxon signed ranks test was done to assess significant differences between preoperative and postoperative MSTS scores in both vascularized and avascular fibula grafts. Mann-Whitney test was used to assess the difference in postoperative MSTS scores between vascularized and avascular fibula graft as well as the union time between vascular and avascular fibula graft. The level of significance was set at p value 0.05. The SPSS software was used to analyze the data collected.

## RESULTS

Out of the 17 subjects 5 were female and 12 were Male. The mean age of the subject was 24.06 and standard deviation 13.96 and ranged from seven to fifty eight. The distribution of the gender and the age is given in Figure 2.

The length of resection ranged from six to nineteen cm with a mean of 11.76 cm and the length of fibula ranged from seven to twenty four cm with a range of 13.94 cm. The graft was fixed with implants like plate, screws, nails, external fixation or K-wire.

Allograft augmentation (5 patients) or autograft from Iliac crest (8 patients) or proximal tibia (3 Patients) was done along with reconstruction. Skin grafting was done in 4 patients.[9]

***Intraoperative issues***

One patient with osteosarcoma had popliteal artery injury which was repaired during surgery. One patient with GCT femur had cartilage breach and tumor erosion to patella articular surface and another patient with fibrous dysplasia of metacarpal had cortical breach.

The proximal/distal margin was free of tumor in sixteen patients and only one patient had evidence of tumor in proximal margin on microscopic examination. However this patient has not had any local recurrence after 30 months of follow up. Appropriate postoperative immobilization was given to patients based on the regions operated. (Shoulder spica, plaster of Paris slab, wrist brace, foot drop splint, crutches).

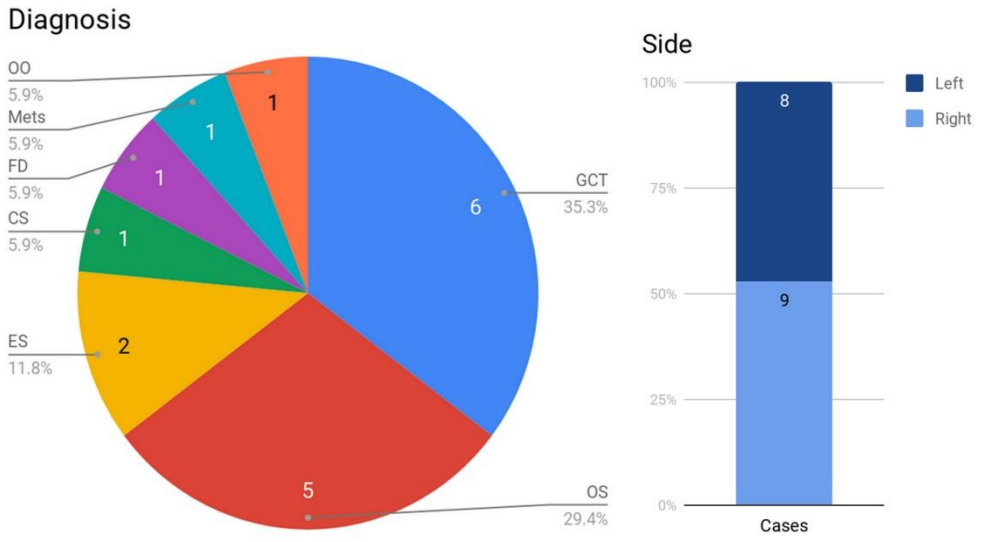


**Figure 1: Diagnosis and side.**


**Figure 2: (A) Gender distribution; (B) sex distribution of the subjects (n=17).**

Superficial skin edge necrosis was seen in six patients of which 2 had vascular and 4 had avascular grafts. Out of them two required only dressings and antibiotics. Debridement was done in rest of the patients in one week (2 patients), 3 weeks (1 patient) and 2 months (1 patient). One patient had a non healing ulcer at the surgical site (vascularized graft) after 10 months which was treated with cleaning and dressing.

The patients were followed up for a minimum of 9 months ranging to 65 months (Mean - 30.3 months). 2 patients in the study had died due to recurrence in the distant site. One patient had local recurrence in the soft

tissue near primary site. Resurgery was done in 9 patients. (Figure 3) Radiotherapy was given for two patients. One was for a primary thyroid follicular carcinoma patient who had distal femur solitary metastasis and second was for metastasis of Proximal humerus osteosarcoma. The second patient later died of the illness (Figure 4-8).

| | | |
|---|---|---|
| Case 1 | 5 Months | Proximal screw removal |
| Case 2 | 1 Day | Venous thrombosis, kinked vein:- reexploration |
| | 3 Months | Fixator removed after 3 months |
| Case 3 | 1 Day | Reexploration |
| | 4 Days | Paddle DCIA flap |
| | 5 Days | Debridement, hemisoleus cover |
| Case 4 | 1 Day | End to end repair of popliteal injury |
| | 1 Month | Wound debridement |
| | 2 Months | Flap and split skin grafting |
| | 3 Months | Reexploration and debridement of flap |
| Case 5 | 1 Month | Debridement |
| Case 6 | 1 Year 5 Months | Excision of soft tissue recurrence adjacent to primary site. |
| Case 12 | 2 Year 3 Months | Implant revision, bone grafting. |
| Case 13 | 1 Day | Reexploration |
| | 1 Week | Skin edge necrosis- excision, suturing |
| Case 14 | 3 Weeks | Exploration & readjustment of distal locking |
| | 1 Year 10 Months | Bone grafting |

**Figure 3: Resurgery details.**

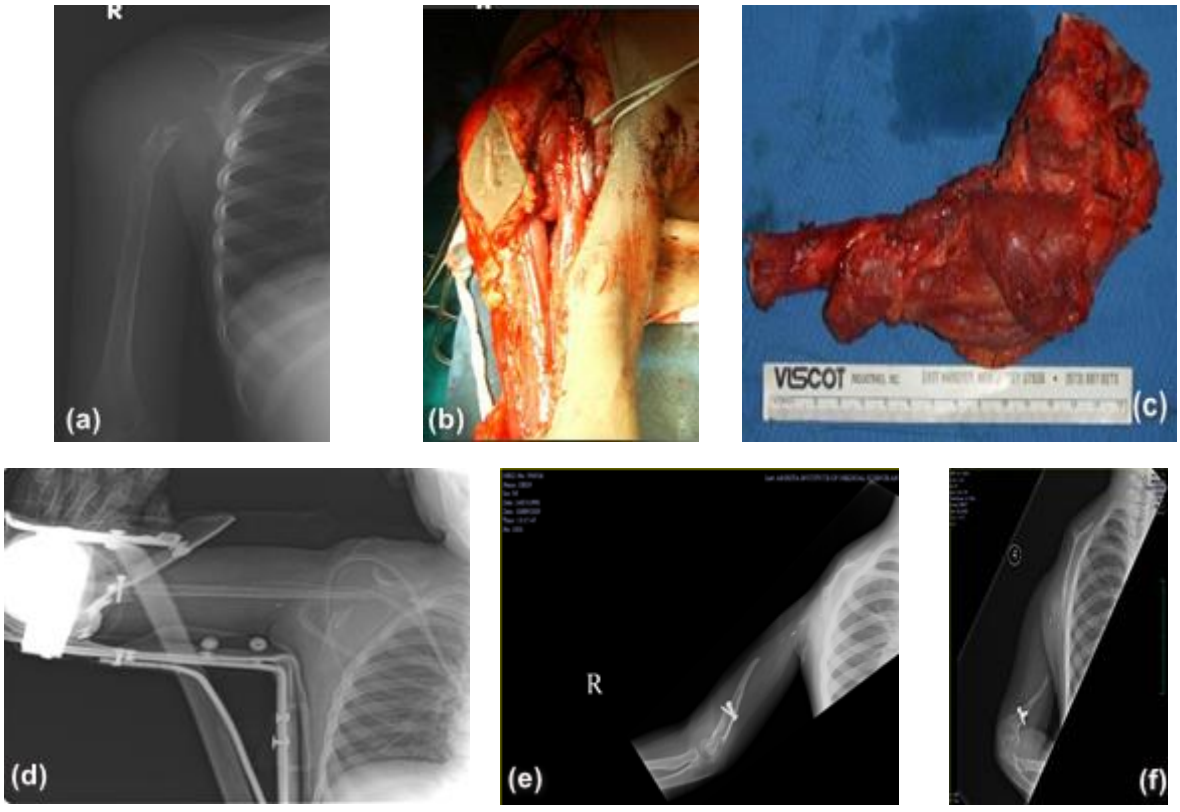


**Figure 4: Case 5 - Ewing's sarcoma of proximal humerus treated with resection and reconstruction with avascular fibula. He had improvement in the function despite resorption of the graft (retrospective study). (a) Preop, (b, c) introp, (d) immediate post op, (e) post op 2 years, (f) post op 3 years.**

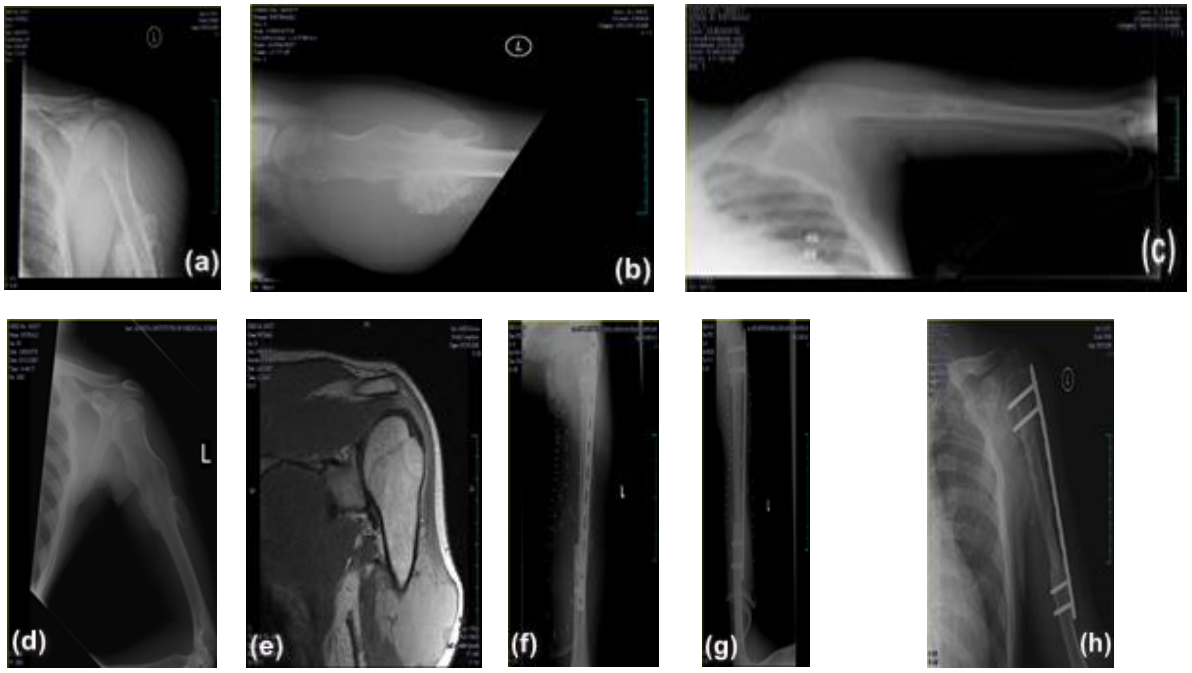


**Figure 5: Case 6 - recurrent secondary Chondrosarcoma humerus treated with excision and reconstruction with vascular fibula and fixed with plates and screws (prospective study): (a, b) Preop, (c) initial resection, (d,e) recurrence, (f, g) immediate post op, (h) post op 1 year.**

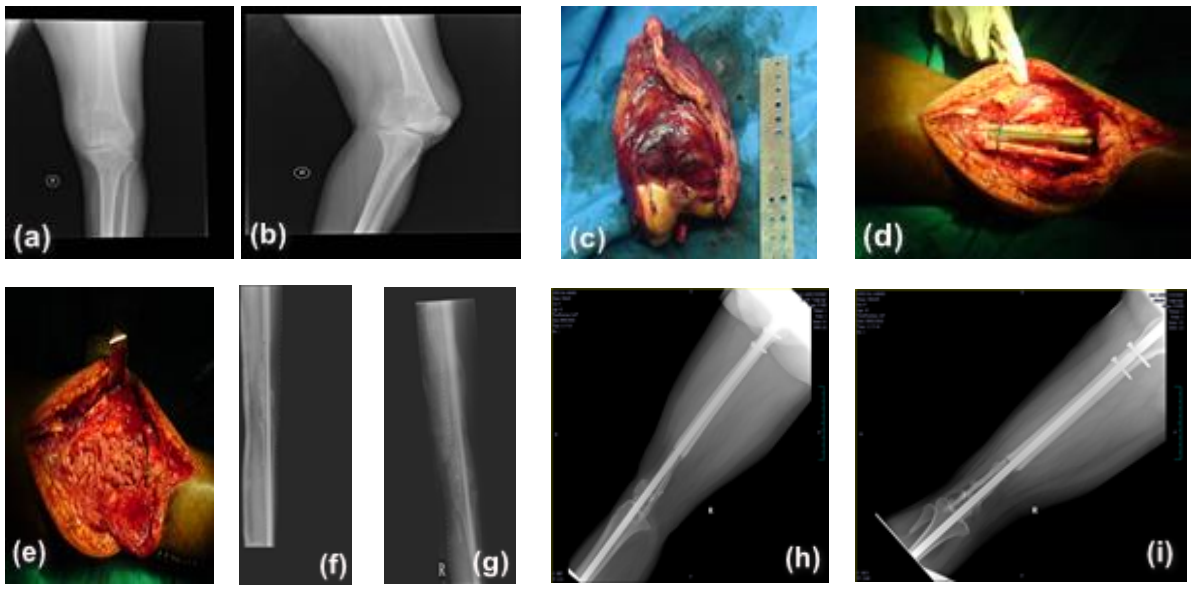


**Figure 6: Case 9 – resection with reconstruction arthrodesis using avascular fibula graft augmented with intramedullary nail in case of giant cell tumor of distal femur (prospective study). (a, b) Preop, (c-e) Intraop, (f, g) immediate post op, (h, i) post op 2 yrs.**

Chemotherapy was given for six patients and among them, two patients died of distant metastasis of which one patient had discontinued chemotherapy.

***Functional outcome***

Excluding the two patients who died of distant metastasis, the mean preoperative musculoskeletal tumor society score for the remaining 15 patients was 72.22 and the mean postoperative musculoskeletal tumor society score was 88.44.

MSTS score improved in 11 patients. In two patients, it went down and in two others, it remained the same. The difference between preoperative and postoperative MSTS scores was significant (p=0.004) (Table 1). The mean

preoperative musculoskeletal tumor society score for patients with vascularized fibula graft was 78.09 and the mean postoperative musculoskeletal tumor society score was 89.04. Even though the score showed improvement, the significance was borderline (p=0.058) (Table 2) which could be attributed to the less sample size.

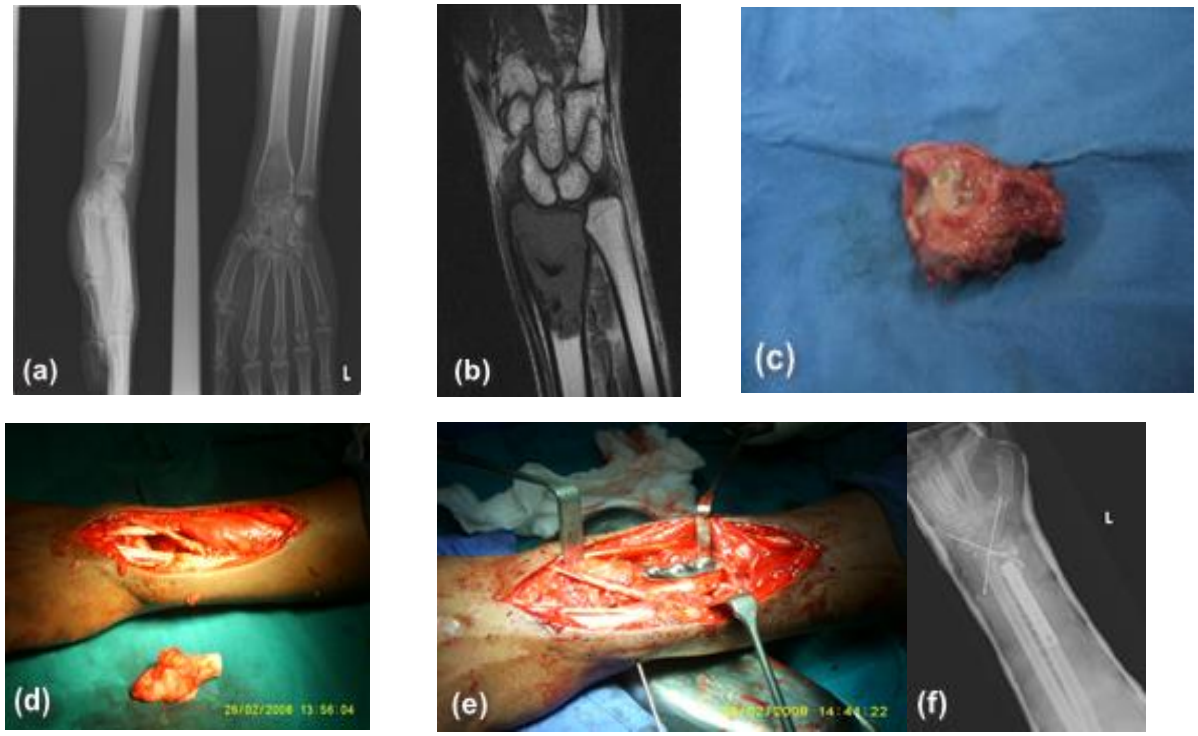


**Figure 7: Case 10– resection and reconstruction with avascular fibula augmented with plate, screws and wire in case of giant cell tumor of distal radius (prospective study): (a, b) preop, (c-e) intra op, (f) post op.**

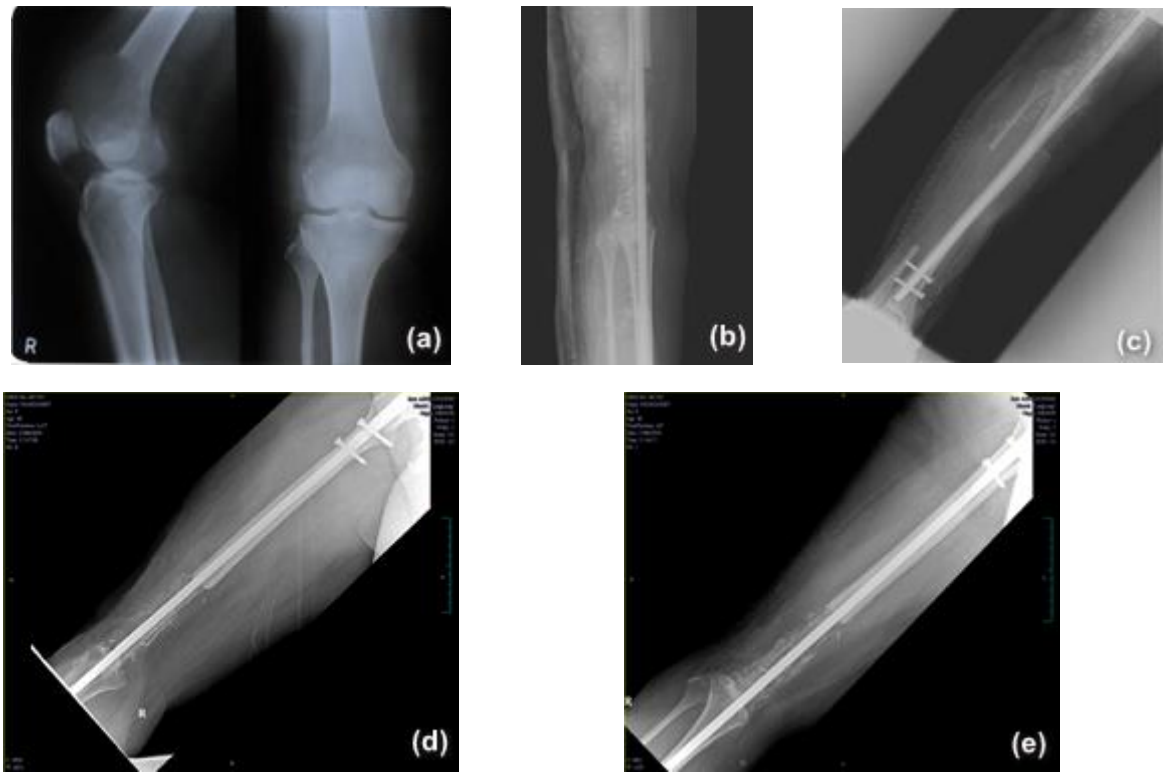


**Figure 8: Case 14 – resection arthrodesis of giant cell tumor distal femur with avascular fibula, nail and allograft (prospective study): (a) Preop, (b,c) immediate post op, (d,e) post op 1 year.**

**Table 1: Preoperative and postoperative MSTS Scores.**

| Group | Number | Mean | SD | Min | Max | P value (2-tailed test) |
|---|---|---|---|---|---|---|
| **Preop MSTS** | 15 | 72.2180 | 17.84765 | 23.33 | 93.33 | **0.004**** |
| **Postop MSTS** | 15 | 88.4407 | 8.89576 | 70.00 | 96.66 | |

Statistical test used is Wilcoxon Signed Ranks test. **Significant at p<0.01

**Table 2: Preoperative and postoperative MSTS scores in Vascularized fibula graft**

| Group | Number | Mean | SD | Min | Max | P value (2-tailed test) |
|---|---|---|---|---|---|---|
| **Preop MSTS** | 7 | 78.0914 | 11.36345 | 63.33 | 93.33 | **0.058$** |
| **Postop MSTS** | 7 | 89.0443 | 7.86725 | 76.66 | 96.66 | |

Statistical test used is Wilcoxon Signed Ranks test. $Not significant.

**Table 3: Preoperative and postoperative MSTS scores in Vascularized fibula graft**

| Group | Number | Mean | SD | Min | Max | P value (2-tailed test) 0.028* |
|---|---|---|---|---|---|---|
| **Preop MSTS** | 8 | 67.0788 | 21.48753 | 23.33 | 86.66 | |
| **Postop MSTS** | 8 | 87.9125 | 10.22419 | 70.00 | 96.66 | |

Statistical test used is Wilcoxon Signed Ranks test. *Significant at p<0.05

**Table 4: Postoperative MSTS scores between vascular and avascular fibula.**

| Group | Number | Mean | SD | Min | Max | P value (2-tailed test) |
|---|---|---|---|---|---|---|
| **Vascular** | 7 | 89.0443 | 7.86725 | 76.66 | 96.66 | **1.000$** |
| **Avascular** | 8 | 87.9125 | 10.22419 | 70.00 | 96.66 | |

Statistical test used is Wilcoxon Signed Ranks test. $Not significant.

The mean preoperative musculoskeletal tumor society score for patients with avascular fibula graft was 67.08 and the mean postoperative musculoskeletal tumor society score was 87.91. There was statistical significance (0.028) (Table 3) as well as improvement in the scores. There was no significance (2 tailed test) in postoperative MSTS scores between vascular and avascular fibula graft (p=1.000) (Table 4).

***Graft union***

Among the total 17 patients, 13 patients had solid union with a mean union time of 7.15 months with a range of 3 months to 12 months. Eight were vascularized and five were avascular fibula. One vascular fibula graft united only at proximal site. Two grafts which were avascular united only at the distal site. One patient had a graft resorption. However he had improvement in the functional score compared to the preoperative status (Figure 4).

***Donor site morbidity***

Regarding the donor site, 2 patients had occasional pain which had subsided in the latest follow up. Two patients had foot drop of which one recovered by one year. Both of them had avascular fibula grafting.

***Refracture***

There was one case where the fibula graft and all fixation screws were broken after 27 months of surgery. Implant revision with bone grafting was done and fracture united after 2 months of second surgery. In another patient, fibula graft had resorbed and later fractured five months after surgery. However no further surgical interventions were done.

## DISCUSSION

Limb salvage surgery for tumors of the appendicular skeleton is well established. Limb salvage after tumor resection in the extremities is a preferable procedure to amputation; provided that safe margins are left after all pathologic tissue is removed.[9] Reconstruction using endoprosthesis is a regularly used technique which produces good functional results. However, the use of endoprosthesis may be problematic, with complications including subluxation, bone loss as a result of stress-shielding, implant failure and deep infection.[1] Difficulties may also occur with poorly vascularized, contracted, or deficient overlying soft tissue. Biological reconstruction technique should always be considered whenever possible. These techniques have several advantages including a reduced soft tissue requirement and viable bone healing.

Non-vascularised autogenous bone grafts have been used for the past 100 years, particularly for reconstruction after resection of a bone tumor. Fibula provides the most practical graft for bridging large defects in the diaphyseal portions of the bone. Disability after removing fibula graft is less compared to other larger grafts. The use of avascular grafts is a relatively simple and less expensive

technique. Advantage includes donor site remodelling. Reduced biological activity and resorption would be the drawbacks of avascular grafts.[10]

For larger defects, free vascularized bone graft has a great potential to maintain good functional ability in the affected limb, a factor which is particularly important in younger patients.[5]

Peroneal artery is used as the vascular pedicle in vascularized fibula graft that has endosteal as well as periosteal vascularity. Reconstruction of large tibial defects by vascularized graft was first reported by Taylor et al. in 1975. Free fibular vascularized grafting has an advantage of ability to hypertrophy. It can be used in case of diaphyseal defects with poor soft tissue coverage and also after failed endoprosthetic or allograft reconstructions. However, this method is not free from surgical site complications like infections, graft fracture or nonunion, hardware problems donor site complications like peroneal nerve palsy.[11]

In this particular study there was improvement in the postoperative functional outcome when compared to the preoperative status in both vascularized and avascular fibula. No significant difference was found in the postoperative functional outcome when these 2 groups were analyzed.

Fibula bone grafting is a good reconstruction option after intercalary resections of the femoral or tibial diaphysis. It is a very reliable technique, when the diaphyseal resection is close to the epiphysis.[12] This is particularly advantageous in children where epiphysis or epiphyseal plate can be spared thereby conserving the growth potential of the segment. In our study 6 patients had undergone intercalary resection. The overall postoperative functional outcome as per the MSTS score for these patients had improved. The vascularity of the fibula was compromised in one patient, who required multiple salvage procedures. This subsequently led to graft site infection, which was managed with debridements and antibiotics. All patients showed good radiographic union with fibular hypertrophy. One of the disadvantages of fibula grafting when compared to endoprosthetic reconstruction is that the loading capacity of the graft after surgery is relatively low and so patients have to be immobilized for a longer period.

Increased operative complexity of free vascularized fibula graft is another disadvantage compared to other surgical techniques.[13] Highly skilled micro vascular expertise is needed for the same. This will also reflect in the expense of the surgery also. The operative time is more which can cause more blood loss and the anaesthetic time is also more which increases the postoperative morbidity. The use of avascular fibula graft has its own beneficial effects.[14] Graft harvesting time is drastically reduced when compared to that of vascular grafts. The help of a surgeon with micro vascular skills is also not necessary. The surgical expense of avascular bone grafting is also less. After harvesting the avascular fibula, the periosteal sleeve is repaired on a gel foam scaffold. So, the chance of regeneration of new bone is a major advantage when compared to vascularized graft.

The postoperative morbidity was also compared between the vascular and avascular fibula grafting methods. Out of the 7 patients who had surgical site necrosis/ulcer, 4 had avascular fibula grafting. The two patients who developed foot drop had avascular fibula grafting. Two patients had graft fracture of which one was vascular and the other avascular. In our study, there has been only a very minor difference in the postoperative morbidity when avascular and vascularized bone grafting was compared. Krieg et al has reported a higher incidence of donor site morbidity in vascularized fibula grafting.[15] But in our study, the overall donor site complication rate was 11% of which all cases were avascular fibula grafting.

***Drawbacks***

The patients were divided into the two groups, vascular and avascular fibula. The significance in the functional outcome was borderline which can be attributed to the less sample size. Longer follow up would have given clear and significant results.

## CONCLUSION

Fibula grafting after resection of tumors of the appendicular skeleton offers a wonderful technique in filling bony defects. It provides good functional outcome and better bony union. Even though the postoperative outcome is significant, there is no significant difference between vascularized and avascular fibula in terms of functional outcome, bony union and graft hypertrophy.

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