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Long Term Outcome Of Vascularized Fibular Graft In Paediatric Large Bone Defects

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Abstract

Limb salvage procedures in children are challenging in orthopaedics, when dealing with sequel of severe bone infections and malignant tumours. Various surgical techniques of limb salvage procedures have their own merits and demerits. The constant problem with most of these reconstructs are the inability to cope with growth of the child and failure of the reconstruction. In this article, we share our experience on dealing large bone defects (>7 cm) using vascularized fibula graft in 3 children aged (5-6 years) due to malignant tumors in 2 cases and infection in another case. In all these 3 cases there is union with good incorporation with no recurrence of infection , tumour or metastasis. None of the patients had graft non-union , graft fracture or donor site morbidity.

Keywords: Vascularized fibula graft, large bone defect reconstruction, bone loss in younger children

Introduction

Large bone defects are not uncommon in limb salvage procedures for malignant bone tumor and gap-non unions occurring as a sequel of infection (pandiaphyseal osteomyelitis) [17]. Surgical options are allograft [5, 11], autograft [1,2,3,4,9], induced membrane technique (Masquelet technique) , bone transport with external ring fixator and endo prostheses for the reconstruction of the defects. In this article, we will discuss this challenging problem of large bone defects [6] (more than 7 cm) in children with its long term clinic radiological outcome following vascularized Fibular bone graft.

Case Study 1 :

18 months old girl had a closed injury to her right arm for which she underwent indigenous splinting- and developed multiple blisters over the arm. Multiple humeral debridement procedures were done elsewhere over a period of 3 years for her meta diaphyseal osteomyelitis with septic arthritis of her shoulder and elbow joint. She presented to us at 5 years of her age with deformity over the right arm. On evaluation, she had a nonfunctional right shoulder and elbow joint with a “Large gap non-union” of her humerus due to post septic and debridement sequalae’ – (missing humerus). After ruling out active infection, we reconstructed the right humerus with vascularized fibular graft taken from ipsilateral fibula. The free vascularizedgraft was fixed proximally to the residual stump using an intramedullary thick-wireand then blood vessels were anastomosed using microvascular technique. Distal

part of the graft was left free to allow non-anatomical jointformation between the graft and the forearm bones. On 13 years follow-up, the graft survived with hypertrophy and the pseudo humerus contributed for the development of arm musculature. There were no graft related issues such as non-union, graft fracture, recurrence of infection or graft resorption She can do her daily activities like eatingand writing using her hypoplastic right upper limb but with arm length shortening of 10 cm. Her shoulder ROM were abduction- 70^0; flexion- 70^0; external rotation-60^0; internal rotation- 70^0 with active elbow ROM (at pseudoarthrosis site)- flexion-0-$110^{0.}$ [Figure 1, Figure 2].

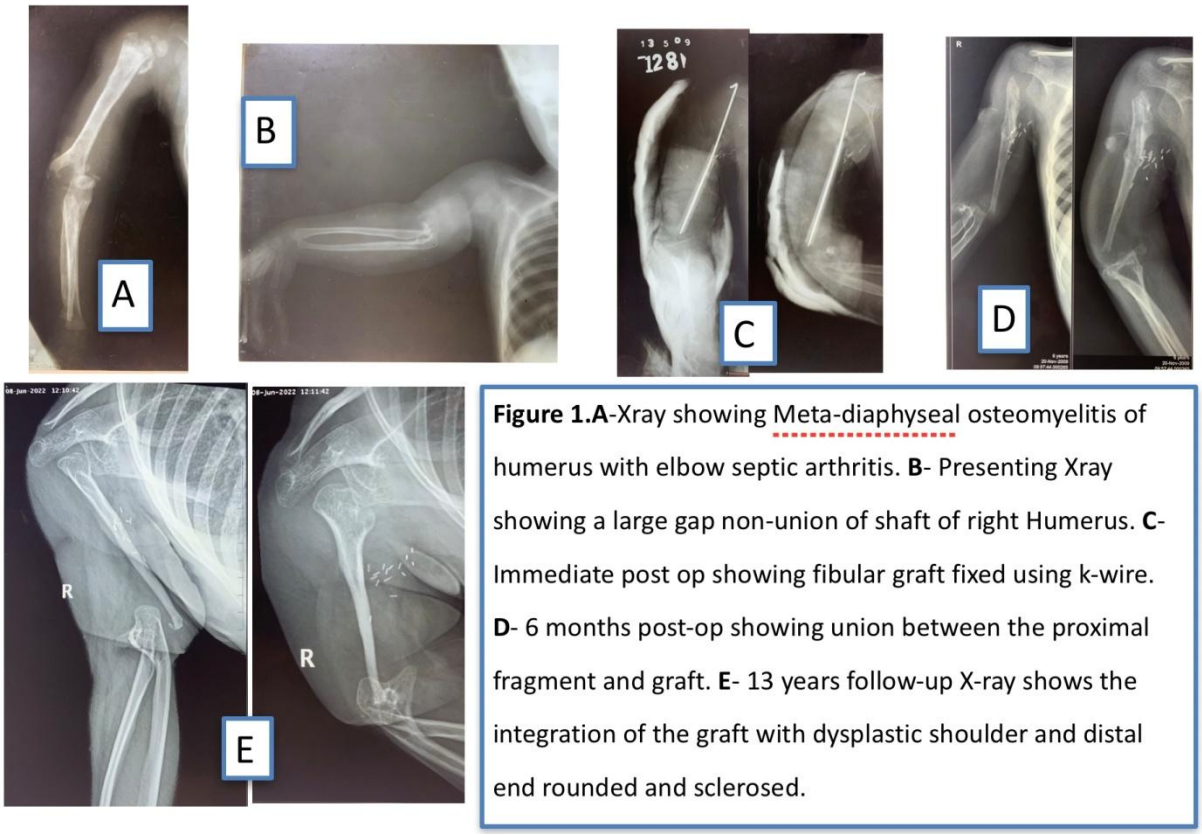

Figure 1.A-Xray showing Meta-diaphyseal osteomyelitis of humerus with elbow septic arthritis. **B**- Presenting Xray showing a large gap non-union of shaft of right Humerus. **C**- Immediate post op showing fibular graft fixed using k-wire. **D**- 6 months post-op showing union between the proximal fragment and graft. **E**- 13 years follow-up X-ray shows the integration of the graft with dysplastic shoulder and distal end rounded and sclerosed.

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Figure 2- Clinical pictures

Case Study 2:

5 years old girl presented with pain and swelling in herleft arm following a trivial trauma. On evaluation she had proximal humerus pathological fracture witha highly expansile metaphyseal osteolytic lesion with soft tissue extension. In view of the pathological fracture,she had further evaluations and finally an open biopsy that confirmed the diagnosis ofosteosarcoma of left proximal humerus(not involving the blood vessels). After a multidisciplinary team discussion, she was given4 cycles of neoadjuvant chemotherapy. After which she underwent wide local resection of the tumor and reconstruction of left humerus with free vascularized fibular auto graft. The proximal epiphyseal part of the fibula graft (with its residual growth potential) was included to form the pseudo shoulder. Distally the graft was fixed to the residual humerus with a plate osteosynthesis and then completed the microvascular anastomosisof the graft.Post-operatively plannedcycles of chemotherapy were completed. At 5 year follow-up, there is no recurrence of tumor or metastasis nor graft related complications such as non-union, fracture or infection. Although active movements of shoulder are absent, Passive range of movements remain pain free and full. Active functional Elbow movements are available despite the limb length discrepancy of 8 cm[Figure 3].

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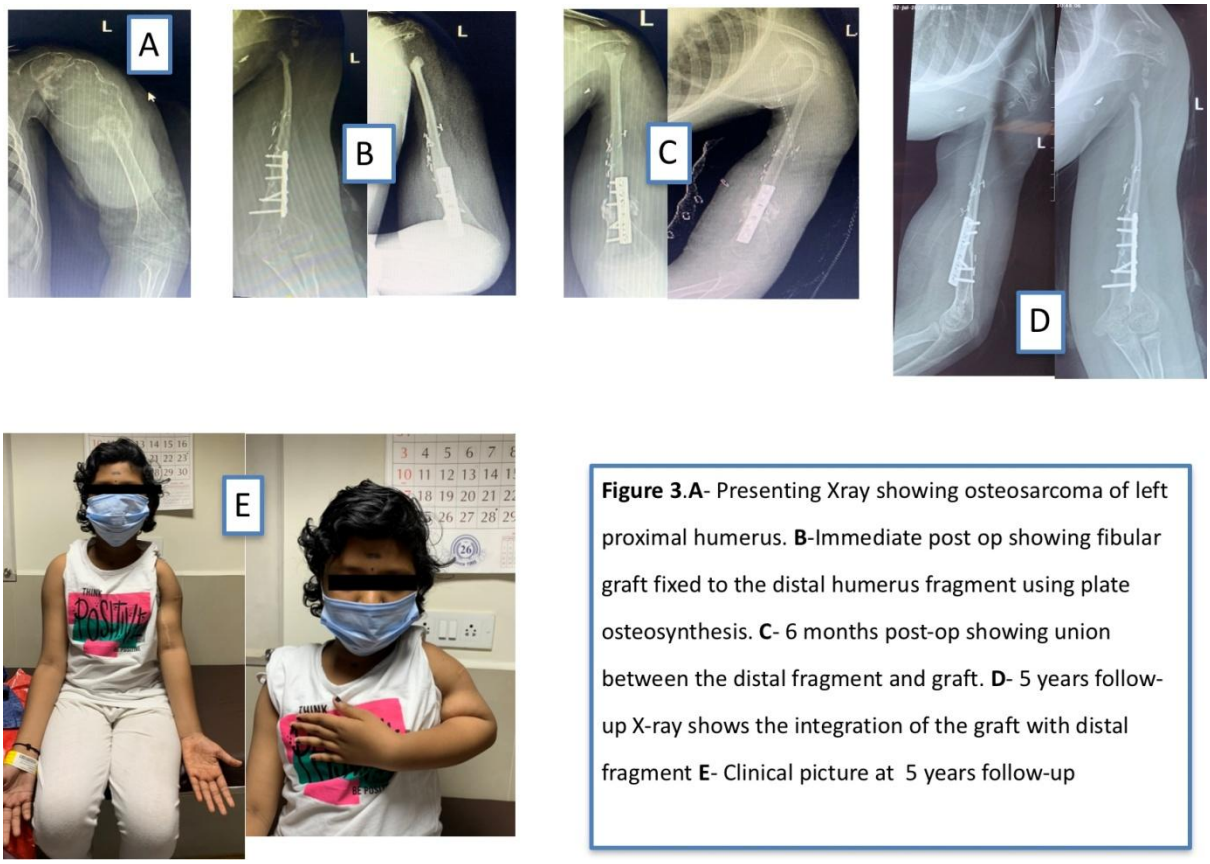

Figure 3.A- Presenting Xray showing osteosarcoma of left proximal humerus. **B**-Immediate post op showing fibular graft fixed to the distal humerus fragment using plate osteosynthesis. **C**- 6 months post-op showing union between the distal fragment and graft. **D**- 5 years follow-up X-ray shows the integration of the graft with distal fragment **E**- Clinical picture at 5 years follow-up

Case Study 3:

6 years old girl presented with pain and swelling of her right knee for amonth . She had no trauma or history suggestive of any infection. Xray's showed an expansile bone tumor in theproximal tibial metaphyseal area. After further necessary evaluations an open biopsy confirmed the diagnosis of osteosarcoma of right proximal tibia Enneking's stage IIB(not involving the blood vessels) After 4 cycles of neoadjuvant chemotherapy, She underwent en- bloc wide local resection(inclusive of 14 cm tibia with 12 cm fibular length) and knee joint arthrodesis. An Intramedullary transfer of vascularized fibular graft from opposite side(19cmlong)spanned across the knee with 1cm medullary insertion on either ends. The peroneal artery of the fibular graft was anastomosed to the anterior tibial artery and the venae comittants to the tibial vein. Additional femoro tibial extra medullary stabilization was done using plate osteosynthesis. Post-operatively 6 cycles of chemotherapy were given. On 4 year follow-up there is no recurrence of tumour, metastasis, graft non-union , fracture or infection. Child is walking with a knee-ankle-foot orthosis without pain but with intact distal sensations. She had residual Limb shortening of 7 cm [Figure 4].

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Figure 4.A- Presenting Xray showing osteosarcoma of right proximal tibia. **B**-Immediate post op showing arthrodesis of knee joint with fibular strut graft, fixed using plate osteosynthesis. **C**- 6 months post-op Xray **D**- 4 years follow-up X-ray shows the integration of the graft with distal femur and proximal tibia. **E**- Clinical pictures at 4 years follow-up

Discussion:

Skeletal reconstruction in children after massive bone loss following tumor resections andinfections, remains a challenge with regard to stability, survivorship of the reconstruct and ability to lengthen with growth. Options for reconstructionof bone loss includes biological and Endoprostheses. Even with expandable endo prosthesis the concerns are longevity of the implant, Loosening, Trunnionosis and pseudo-tumors with long term prostheses survival [12]. Options for biological reconstruction includes allograft [5,11], autograft [1,2,3,4,9], induced membrane (Masquelet technique).

Bone transport with external ring fixatorprovides the advantage of restoring and lengthening. Physeal preserving metaphyseal resections allows distraction osteosynthesis [19] but the option is limited when tumor principles follow wide excision to prevent joint contamination with extra articular resections.

Allograft and non-vascularized autograft were other biological reconstruction options. They have weak osteointegration potential and high complication rates such as infection, nonunion, delayed union, and fractures in upto 20% cases [2]. Allografts heals by creeping substitution and slow revascularization [2, 11,14] and hence makes their use limited to defects which are less than 8cm.

Vascularized autografts are superior to other biological reconstructions, as they have osteogenic cells and proteins with higher osteointegration potential. They heal and incorporates by primary union, and have the capability to hypertrophy in response to load[13]. Since they do not depend on the re-vascularizationphenomenon from the peripheries of the graft, larger defects can be managed by this[2, 9, 10]. Because of these reasons, they are better options even in large defects secondary to infective sequel.[4,6,7,8]

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Taylor et al. [15] was the first to describe free fibular graft in two patients with limb-threatening lower extremity trauma in 1975. In 1977, Weiland et al. [16] reported the first reconstruction of long bones with vascularized fibula after tumor resection. Manfrini et al attempted to use metaphysis and epiphysis of the fibula in vascularized fibula graft in 2003. Fibula is the preferred donor site for Free vascularized autografts because of the rich blood supply (endosteal nutrient artery and multiple periosteal arteries) and lesser donor site morbidity[6], but with the risk of associated peroneal nerve injury.

The isolated vascularized fibular transfer biomechanically remains a weak construct for the knee joint stabilization.Capanna technique [14] combines cortical allograft with vascularised fibula graft to overcome this failure.It is recommended in cases with anticipated leg length discrepancy of less than 4 cm and should be joint sparing after wide resection.

In case of osteomyelitis thorough debridement before the involucrum formation results in bone loss. The residual hypovascular bone bed fails to incorporate conventional non-vasculacularized bone grafts. Vascularized bone grafts improves the vascularity and increases the incorporation rates. In short case series of 14 patients (2 with humerus) bone loss due to osteomyelitis were managed with vascularized fibula graft with overall good outcome of 92%[18].

Osteosarcoma although is the commonest malignant bone tumor, occurs between the age of 10 -20 years and its incidence under 10 yrs is uncommon. Although limb amputation is considered as a choice to cure, the neoadjuvant chemotherapy has made limb salvage a gold standard surgical option after osteosarcoma tumor resection The physeal resection and joint arthrodesis results in progressive limb length discrepancy despite oncological cure. Hence it makes the limb salvage less optimal in children but amputation related disability and mobility can be avoided. Literatures on vascularized fibular graft in younger children under 10 years of age is uncommon, although Grimer et al mentioned the theoretical benefits following osteosarcoma resection and reconstruction.

Conclusion:

In our experience with limb reconstruction using vascularized fibula graft, in younger children there is no recurrence of infection , tumour or metastasis. None of the patients had graft non-union , graft fracture or donor site morbidity. Vascularized fibula graft is a viable option to be considered for reconstruction of bone loss in younger children secondary to infection and tumour.

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