



Comparison of Various Modalities to Treat Long Tibial Segmental Bone Defects

KEYWORDS

fibular transport, segmental defect, vascularized graft, Ilizarov, tibialization of the fibula.

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ABSTRACT As large segmental bone defects of the tibia is a challenging problem in the field of orthopaedic surgery, this study describes comparison of different patients with large tibial segmental bone loss associated with a soft tissue injury, which also required a plastic surgery for coverage. 12 patients treated by various modalities e.g. 5 patients by an ipsilateral fibular transport utilizing an Ilizarov, external fixator and 4 patients by tibialization of the fibula and 3 patients by vascularized free fibula graft. The outcome of this case study indicates that each method has its own pros and cons and each method must be individualized on the basis of clinical circumstances like presence of infection, availability of contralateral fibula, nerve injury, requirement of soft tissue coverage, vascularity of the limb, condition of the ipsilateral fibula etc.

INTRODUCTION

Different techniques have been used to treat large segmental tibial defects such as autogenous cortical bone grafts, tibiofibular synostosis, ipsilateral fibular graft, allograft reconstruction, vascularized free fibula transfer, and bone transport. Ipsilateral fibular transport is a novel option in limb salvage surgery for patients with long tibial defects. With vascularized grafts, specialized microvascular techniques are used to re-establish the blood supply. Free vascularized fibular grafting is a complex procedure that requires the expertise of a microvascular surgeon. Complications of thrombosis, non-union, and deformity have been reported. In addition, complications related to the fibula harvest include hematoma, nerve injury, infection, and valgus deformity of the ankle. The Ilizarov method has been used to successfully transport bone and soft tissues longitudinally to treat tibial bone loss and at times to close an accompanying soft tissue defect. A less common application of the Ilizarov technique is transverse bone transport. The frame allows for gradual transport of the fibula into the adjacent tibial defect site, precise proximal and distal alignment of the fibula, and compression at tibial contact sites. This is a minimally invasive technique which requires little surgical dissection.

MATERIALS AND METHODS

CASE 1

A 40-year-old male patient involved in a motorcycle accident presented with a high energy right open tibia fracture with massive bone and soft tissue loss. He was initially treated with provisional external fixation and serial irrigation and debridement. The initial defect was approximately 12 cm in length. A split thickness skin graft was performed early to obtain soft tissue coverage and avoid infection. After six months of his accident, he underwent an application of an Ilizarov along with a single level fibular osteotomy for bone transport. A six-ring frame connected struts was applied to the leg. This spanned the bone defect and stabilized the proximal and distal bone segments in line with each other. This allowed control of the proximal and distal segments on either side of the defect. An Ilizarov plate was then connected to the frame anteromedially in preparation for the fibular transport. A single level osteotomy of the fibula was planned at the level of the tibial defect. Two pulling olive wires were placed through the fibula aiming from the anterolateral to the posteromedial (Fig. 2b). The tails of the olive wires were cut at the level of the bead and the olives were positioned against the fibula.

These wires were set up as pulling wires and were attached to the anteromedial plate via three short slotted rods that had the capacity to pull both of these olive wires. The position of these wires was such that it would pull the fibula from the anterolateral position in a posteromedial direction into the tibial defect. Next, a 1-in. skin incision was made at the proximal margin of the fibula, where the proximal osteotomy was planned. Dissection was carried down between the lateral and posterior compartments, and using a microsagittal saw, osteotomy of the fibula was made. Similarly, at the distal end of the defect, exposed end of fractured and dead fibula end excised upto the normal bone level and adjusted to the level of distal tibial defect. The fibula transport was started intraoperatively and immediate postoperatively utilizing the principles of distraction osteogenesis. Distal tibial metaphyseal corticotomy performed and after a week bone segment transport started. After two weeks of the application of the frame and the fibular transport and transport of distal bone segment of tibia, the frame was modified to optimize contact between the tibia and the transported fibula (Fig. 3a.) The position of the fibular graft remained satisfactory. The alignment was assessed in coronal and sagittal planes using fluoroscopy. Two weeks later, the overall anteroposterior and Lateral alignment was normal. There was a limb length discrepancy of 3 cm (Fig. 4). Three month following frame modification, a follow-up office visit revealed the graft to be in a satisfactory position. Most importantly, he was allowed weight bearing immediately after fair alignment of the fibula was achieved in two weeks of frame application.

CASE 2

A 30 year old male h/o RTA operated with external fixator and plastic coverage for soft tissue injury. After 5 months, external fixator was removed and at that time there was 4 cms shortening of the right lower limb and of the tibia. Then Patient was sent to our institute for further management. After 1 yr and 4 months, he was operated for the segmental bone defect of tibia by free vascularized fibula graft from contra lateral side. The flap was based on the peroneal artery, which arose soon after the bifurcation from the posterior tibial artery. The limb vascularity was to be assessed if the peroneal artery was taken with the flap. The graft was fixed to the recipient bone at both ends by one proximal and two distal cortical screws. Once the graft survived with respect to vascularity and there was no further danger to blood supply of vascularised fibular graft, the external fixator was removed

and the above-knee plaster of Paris slab was put for a period of eight-to-twelve weeks, during which time the patient was non-weight-bearing and crutch walking. When the graft was seen to be uniting with the host bone after approximately seven months, a gradual increase in protected weight bearing, with the aid of a Patellar Tendon Bearing cast or brace was started. Total duration of the surgery was about 7 hours and needed an expert microvascular and plastic surgeon for harvesting the graft.

CASE 3

A 45 year old male h/o RTA operated with external fixator and plastic coverage for soft tissue injury. After 2 months, external fixator was removed and at that time there was 5 cms shortening of the right lower limb and of the tibia. Then Patient was sent to our institute for further management. He was then operated by tibio fibular synostosis by using three screws to tibialize the fibula. Then he was closely followed in regular office visits every month for 6 month then every 2 month for a year. After approximately 18 months, once there was solid union sign of healing at both the ends, he was allowed to start protective partial weight bearing with a below knee brace and with a walker support.(Fig 6)

RESULTS AND DISCUSSION

A large segmental defect of the tibia is a difficult problem to treat. These patients will often present with other traumatic injuries, and treatment options become limited if soft tissue defects are combined with segmental bone loss. Various methods to fill segmental bone defects such as microsurgical transport of vascularized bone, e.g., rib, iliac crest, fibula, and allograft reconstruction, have also been employed. A below knee amputation is a reasonable alternative solution. However, it is not preferable, particularly in patients who have a normal foot and ankle and do not require vascular repair. Each of these methods is effective depending on the circumstances. They have drawbacks including the possibility of donor site morbidity, deep infection, peroneal nerve injury, and ankle instability on the contra lateral previously unaffected limb. They may be at a high risk of failure as infection, rejection, fracture, and nonunion all have been described with these techniques. A limb salvage reconstruction was chosen with understanding that an amputation could be performed if this failed.

In 1877, Albert first proposed the use of the fibula as a substitute for the tibia. He obtained fusion between the fibula and the femur in a patient with congenital absence of the proximal tibia. Since then, the fibula has been used as a substitute for a missing segment of tibia or to reinforce a weakened section. The major advantage of a perfused transplant is to retain the biological potential of living bone. This gives a shorter time for consolidation, increases potential for remodeling, confers greater resistance to infection, and has better long-term mechanical properties. Furthermore, in contrast to an allograft, it has no immunogenicity. The fibula is a straight cortical bone and is long enough to bridge most defects. While it normally carries only one sixth of the static loading of the leg, the fibula will undergo hypertrophy when it is subjected to greater loading stresses. This was our rationale for maintaining the patient in a dynamized frame for an extended period of time. This allowed remodeling of the tibia-fibula docking sites and fibula hypertrophy while protecting the fibula from fracture.

In the tibialization of the fibula method, though it was a simple method to perform, it took a very long time to allow the patient to bear the weight. Another drawback this method was the alignment of fibula was not in the line of the tibial axis as was in other two methods.

Illizarov described two methods for treating large defects with his fine wire fixator. In the first method, the fibular segment is translated medially, creating a proximal and distal, side-to-side tibiofibular synostosis. This is the method that we

used. In the second method, the fibula is split longitudinally and transverse distraction osteogenesis is performed. This technique is complex and no mention is made of the clinical results. Ipsilateral fibular bone transport using an Ilizarov is a successful approach to safely and effectively fill a tibial defect. It has the advantage of a vascularized fibular graft but does not require large dissection; there is no need for microvascular surgery, and there is no donor site morbidity. A tibia-fibula synostosis and bony healing is achieved at both ends of the defect.

CONCLUSION

The Ilizarov allows for stability and longitudinal compression without internal fixation. Furthermore, operative dissection of the fibula is minimal, and the bone remains well vascularized as both sources of blood supply are neither defined nor dissected. Muscle attachments are maintained without dissection and the overlying free flap remains undisturbed. The fibular segment is central and is held by the tibial remnants in a mechanically advantageous position in the line of the axis of the tibia. Weight bearing can begin almost immediately after surgery, and the proximal and distal joints are mobilized satisfactorily. Further, limb lengthening may be carried out through a separate corticotomy of either the proximal or distal tibial remnant. However, this procedure has its limitations. It requires a suitable length of uninjured fibula to be available in the same leg.

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FIGURES

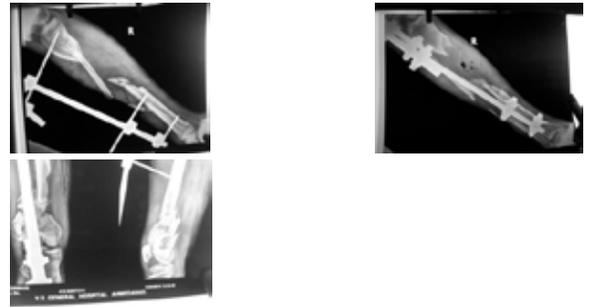


Fig. 1. This preop picture of the patient shows the leg in external fixator...

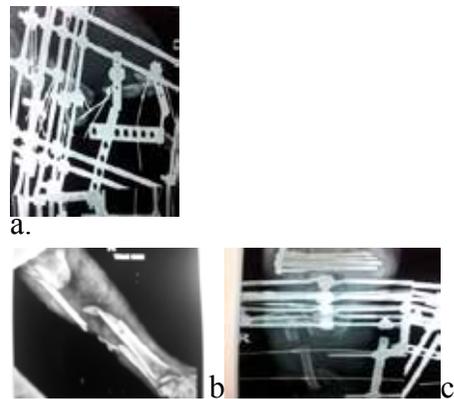


Fig. 2
a This is an illustration of the 12-cm tibial defect. **b** fibular transport shows the level of the fibular osteotomy and the direction of the fibular transport using three olive fibular pulling wires. **b, c** The AP/lateral ...

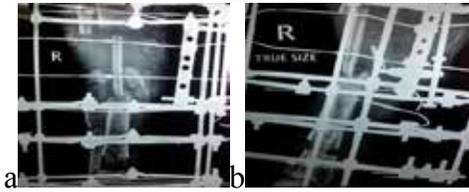


Fig. 3
a The AP view of the patient's leg shows the Illizarov after a modification. b This is a lateral view of the patient's leg after frame modification



Fig. 4
Three month follow up visit- alignment was acceptable.



Fig.5 X-ray anteroposterior and lateral view (a)(b) pre operative CT angiography plate and xray showing normal vascularity and approximately 11 cm bone defect of tibia. (c) Immediate postoperative X-ray (d) 3 months later (e) (f) clinical pictures of limb



Fig 6)
Tibialization of fibula.

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