



International Journal of Current Research and Academic Review

ISSN: 2347-3215 Volume 1 Number 1 (2013) pp. 98-105

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Outcome of the docking site augmentation followed by Ilizarov's distraction osteogenesis technique for the treatment of skeletal defect created after debridement and resection of the necrotic bone

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KEYWORDS

Open Fracture tibia;
Dead Bone;
Bone Defect;
Bone graft;
Ilizarov's Technique.

A B S T R A C T

Open fractures of the tibia/fibula are common in RTA patients and may be fraught with complications as malunion, delayed union, nonunion, infection, deformity, bone loss and dead and necrotic bones. The Ilizarov method, as originally described for lengthening, treatment of non-union and bone transport, does not involve the use of bone-grafting at the docking site to aid rapid healing. The most common complication is nonunion of the docking site. In this report, we present a case of 18-year-old man with open fracture tibia/fibula treated initially with unilateral external fixation and followed by Ilizarov's distraction osteogenesis technique for skeletal defect created after adequate debridement and resection of the necrotic bone as a result of open fracture. We aimed to demonstrate the success of docking site augmentation of iliac crest cancellus bone graft has been shown to rapid consolidation, decrease the rate of non union and decrease the time of prolonged fixator use with respect to patient compliance managing complex frame adjustments.

Introduction

Road traffic accidents are daily occurrences on our roads that often produce crushed limbs with open fractures of the tibia / fibula and may be fraught with complications. Malunion, delayed union, nonunion, infection, dead or necrotic bone, with or without bone defect and deformity are all seen regularly after open tibia fractures (Chapman and Olson, 1996). Dead and necrotic bone is one of these

complications and it forms great clinical problems that make conventional management methods ineffective and requires several operations and long term treatment. The Ilizarov technique Ilizarov remain an important treatment method for surgeons performing post-traumatic reconstructive surgery, particularly in situations with no good alternatives, such as bone defect, nonunion, infection, dead or

necrotic bone as a result of open fracture (Paley *et al.*, 1989). The Ilizarov technique entails a segmental bone transport in which corticotomy is performed in the metaphysis and the bone is gradually distracted and the defect calling docking site gradually closed. The Ilizarov method, as originally described for lengthening, treatment of non-union and bone transport, does not involve the use of bone-grafting at the docking site. The most common complication is nonunion of the docking site. Many investigators had found that it was supposed that union at the docking site was achieved by the process of transformation osteogenesis but this technique might take longer time, the difficulties of prolonged fixator use and the potential of major and minor complications than with use of augmentation of bone graft. The leading edge of the transported segment is relatively avascular. This can delay union, unless the sclerotic end is trimmed and 50% of patients reportedly undergo debridement of the leading edge of the transported segment (Paley *et al.*, 1989; Paley and Maar, 2000). Numerous authors have demonstrated many successful secondary procedures to manage docking site failure. In this report, we present a case of 18-year-old man with open fracture tibia fibula treated initially with debridement, unilateral external fixation and followed by Ilizarov's distraction osteogenesis technique for skeletal defect created after debridement with supplementation of cancellus bone graft at docking site to allow rapid consolidation and decrease the overall the rate of non union and decrease the time of prolonged fixator use with respect to patient compliance managing complex frame adjustments (Paley and Maar, 2000; Watson *et al.*, 1995; Bobroff *et al.*, 2003; Green *et al.*, 1992; Chao *et al.*, 1989; Goulet *et al.*, 1997; Cattaneo *et al.*, 1992).

Materials and Methods

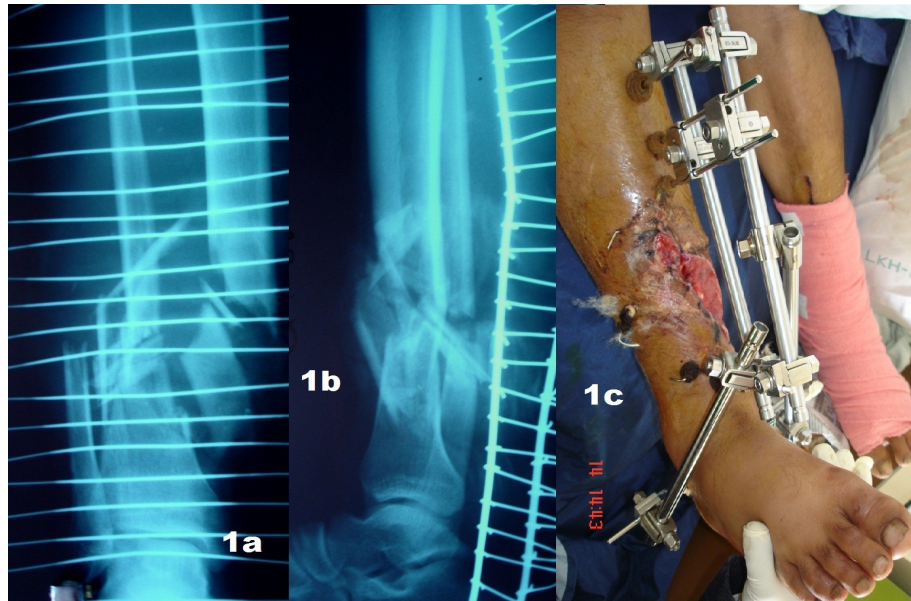
The patient is 18 years old man who was struck by a bus while riding a motorcycle. He was hospitalized in the emergency of Dhulikhel Hospital two hours after the injury. At the time of presentation there was open wound size 5x8 cm anteromedial aspect of middle third of right leg with exposed bone that had been stripped of its periosteum. Neuro-vascular status distal to the fracture was intact. After radiographs, fracture was diagnosed by Gustillo and Anderson classification as Grade IIIB open comminuted fractures middle third shaft tibia/fibula of right leg with associated lacerated injury heel of left foot.

The patient was brought to the operating room within 6 hours from the time of injury. Irrigation of the wound area was performed followed by debridement as removal of the devitalized bone fragments and soft tissue. After wound irrigation and debridement, stabilization of open tibia fracture was performed by placing the unilateral external fixation. (Figures 1a,b,c).

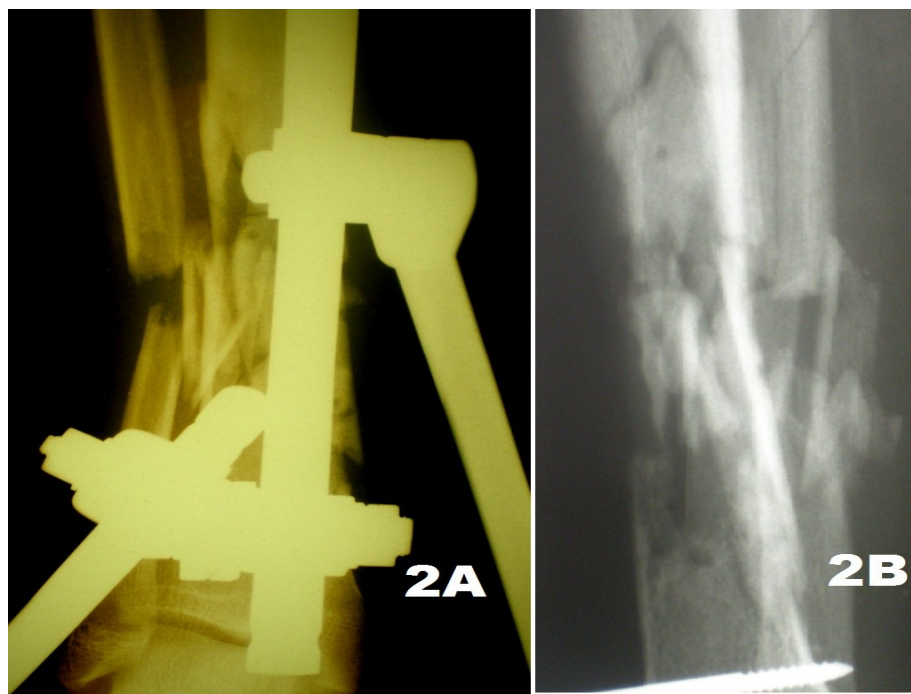
Post surgery x-ray shows fracture site was alignment. The patient continuously received IV antibiotics as cefazolin for two weeks, gentamycin and metronidazole for 7 days to prevent infection. After daily twice dressing and good granulation formation, open wound site was grafted with split skin taken from right thigh.

At follow up after three months of post op, patient was clinically evaluated there was wound healed, no discharge, external fixator was stable, radiographs of fracture site evaluated and founded dead and necrotic bone at the fracture site of right tibia (Figures 2a,b).

Figures.1a,b,c AP /Lateral radiograph and post op Unilateral Ex Fix showing initial status of a 18-year-old man who sustained open comminuted fractures of middle third tibia/fibula (Grade IIIB)



Figures.2a,b One month follow up Anteroposterior and Lateral radiograph showing dead and necrotic bone at the fracture site of right tibia



Different treatment options were considered to achieve bony union and a novel approach was selected as debridement by resection of the necrotic focus of fracture site and bone transport by Ilizarov is distraction osteogenesis technique to fill skeletal defect created after debridement. After counseling and educating to the patient regarding the importance of distraction process at a proper rate and care of the Ilizarov's frame and pin site, the patient was brought to the operating room. Under spinal anaesthesia, at first removed unilateral external fixator and the fracture site was exposed via antero-lateral approach of the right leg. Dead and necrotic bones was covered with fibrous tissues were seen during operation. Resection and removal of all non viable bone pieces as well as fibrous tissues were performed. After freshening proximal and distal bone edges of tibia and fibula with Gigli saw created bone defect as 9cm of tibia and 10cm of fibula to facilitate the process of compression of tibia during distraction osteogenesis process.

A 4 ring Ilizarov's apparatus were used: one ring with pairs of 1.8mm tension wires were placed in the proximal tibia with adequate tensioning, a second ring was placed below the level of proximal corticotomy site with a pair of tensioned wires, a pair of wires connected to an intermediate ring was placed to the distal third of the tibia. One of half 4th ring was applied to the calcaneus and 2nd half ring placed on foot dorsally by passing tension wire through metatarsals and connected to the distal tibial ring to maintain ankle in physiological position.

After application of Ilizarov's ring, percutaneous corticotomy to the proximal metaphysis of tibia was performed by Gigli saw preserving periosteum and medullary

canal to create a middle segment of bone which was gradually transported within the surrounding soft tissue envelope to the other side of the bone defect called docking site. The approximation between the segments and checking the alignment of the bone were verified under image intensifier. On 5th day of post corticotomy, gradual compression and distraction osteogenesis process were started at a rate of 1mm/day dividing 0.25mm four times a day. After 3 weeks of distraction osteogenesis process, Ultrasonography was performed to confirm regeneration process at the site of corticotomy (Figures 3a-d).

At 17 weeks of distraction osteogenesis process, discontinue bone transport and distraction osteogenesis process and grafted iliac crest cancellus bone at docking site and continue lengthening process only up to 5 weeks more to maintain limb length.

At 49 weeks (12 months) of distraction osteogenesis process, the Ilizarov ring fixator was removed after complete consolidation of the regeneration at coticotomy site and union at docking site (Figures 4a,b). After removal ring advised to patient for continue physiotherapy and non weight bearing with axillary's crutch.

The time taken to accomplish radiographic and clinical union was recorded and all complications as pin track infections, ankle stiffness were noted. Patient was followed up to every 2 weeks until full weight bearing allowed.

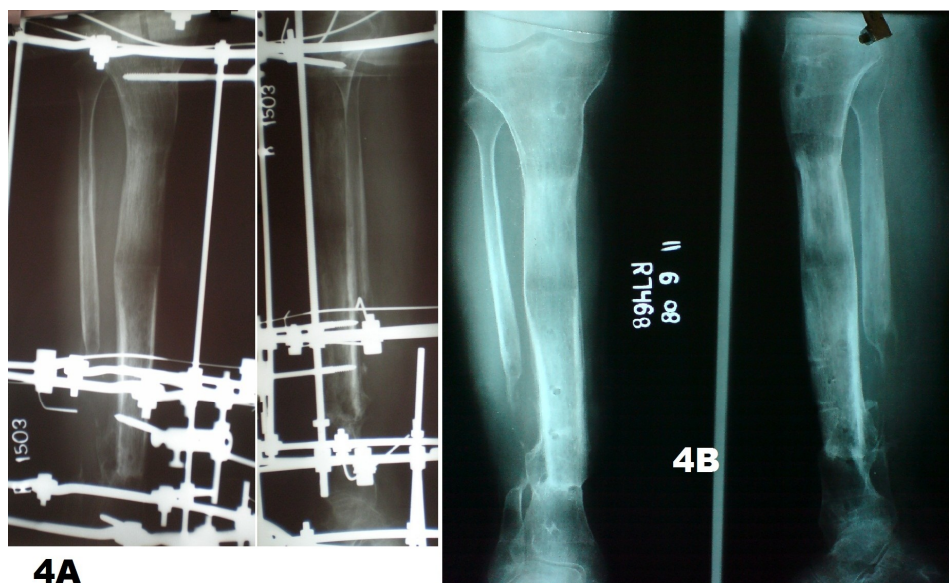
Result and Discussion

Bone healing and functional results were evaluated according to a modified Association for the Study and Application of the Method of Ilizarov (ASAMI) classification. For bone healing 4 criteria

Figure.3a AP/Lat radiograph showing post op percutaneous corticotomy to the proximal metaphysis of Rt tibia; **3b**: At 3 weeks of Ilizarov's distraction osteogenesis process AP and Lateral radiograph showing visible regeneration formation at the distraction site; **3c**: USG of distraction site at 3 weeks follow up (white arrow showing regeneration formation at the distraction site); **3d**: Pt on Ilizarov's fixator



Figures.4a,b At 12 months of the distraction osteogenesis process AP and Lateral radiograph shows good consolidation of the regeneration at distraction site and union at the docking site and removal of Ilizarov ring



Figures.5a-d Photographs showing a good clinical appearance and functional outcome of the patient after 20 months of treatment.



(union, infection, deformity and leg length discrepancy) were evaluated. An excellent result was defined of this case as bony union at docking site and consolidation at corticotomy site. Functional results were evaluated as significant limp on right side due to 2cm shortening occurred as a result of the debridement and resection of necrotic bone fragments and compression at docking site which was corrected by using 2 cm heel lift shoe to account for his leg length discrepancy. Equinus rigidity of the ankle joint, which was treated with manipulation under general anaesthesia and achilles tendon tenotomy at 16 months post distraction osteogenesis process and advise to the patient for full weight bearing. One of the pin track infection and cellulites of

dorsal aspect of right foot were treated with antibiotics.

At 19 months follow-up post injury the patient had right knee range of motion of 0 to 135°. He had 10° of dorsiflexion and 30° of plantarflexion of his right ankle. His right ankle dorsiflexion strength was four out of five and plantar flexion strength was five out of five. At 20 months post injury follow-up with full weight bearing without pain, full mobility of his knee and ankle (Figures 5a-d). Regardless of the outcome, the patient expressed pleasure at having retained his leg. He has returned to work after 20 months of injury.

Open fractures of the tibia/fibula are common in RTA patients and may be fraught with complications as malunion, delayed union, nonunion, infection, deformity, with or without bone loss and dead and necrotic bones. It is due to severe destruction of soft tissue, periosteal layer, endosteal vasculature, comminution of underlying bone, elimination of local and cellular defense mechanisms.

Dead and necrotic bones are one of complications that make conventional management methods ineffective and require several operations and long term treatment. Debridement, sequestrectomy and removal of dead and necrotic bones results in large gaps which are difficult to treat with conventional methods as internal fixation with dynamic compression plate (DCP) or interlocking nail.

In these conditions, a biological methods of treatment are preferred like segmental bone transport by Ilizarov's distraction osteogenesis techniques that increases the injured site circulation and fill the secondary skeletal defects due to debridement of dead and necrotic bones. The Ilizarov method, as originally described for lengthening, treatment of non-union, and bone transport, does not involve the use of bone-grafting. Most studies of bone transport for large bone defects of the tibia have demonstrated a high complication rate, because of a delay in contact and compression and the gradual closure of the defect. Soft tissue interposition also prevents compression and new bone formation at the docking site. This can delay union, unless the sclerotic end is trimmed and 50% of patients reportedly undergo debridement of the leading edge of the transported segment. The most common complication is nonunion of the docking site because the

leading edge of the transported segment is relatively avascular. Many investigators had found that Ilizarov method was supposed that union at the docking site was achieved by the process of transformation osteogenesis but this technique might take longer time, the difficulties of prolonged fixator use and the potential of major and minor complications than with use of augmentation of bone graft (Paley *et al.*, 1989; Bobroff *et al.*, 2003; Green *et al.*, 1992; Chao *et al.*, 1989). Numerous authors have demonstrated many successful secondary procedures to manage docking site failure. More recent experience has demonstrated that 30 to 50% of cases have required autogenous bone grafting at the docking site has been shown to decrease the overall rate of non-union and decrease the time of prolonged fixator use with respect to patient compliance managing complex frame adjustments. Delay in the formation of the regenerate at the distracted gap may prolong the duration of the fixator application. Healing at the target site does not begin until intercalary fragment lengthening is finished. Treatment becomes unnecessarily prolonged if the regenerate bone forms slowly. Pin-tract infection increases the risk of wire loosening, due to the weight borne by the external fixator, causing frame instability (Paley *et al.*, 1989; Watson *et al.*, 1995; Goulet *et al.*, 1997; Cattaneo *et al.*, 1992).

Ilizarov's distraction osteogenesis techniques produces earlier shared stability between the bone ends and the fixator, which offloads the fixator and reduces the likelihood of fixation failure. We recorded a low rate of severe pin tract infection and there was no wire loosening. No re-fracture was encountered at the docking site.

Our experiences with docking site augmentation of iliac crest cancellous bone

graft followed by Ilizarov's distraction osteogenesis methods for skeletal defect created after debridement and resection of the necrotic bone of the tibia as a result of open fracture showed to allow rapid consolidation at docking site without any leg length discrepancy and stiffness.

This study sought to highlight the complications of open tibia/fibula fracture and suggest ways of improving result of treatment with docking site augmentation of bone graft followed by Ilizarov's distraction osteogenesis technique for skeletal defect created after debridement and resection of the necrotic bone.

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