Case Report

Distraction osteogenesis using combined locking plate and Ilizarov fixator in the treatment of bone defect
A report of 2 cases

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Abstract

Distraction osteogenesis and bone transport has been used to reconstruct bone loss defect by allowing new bone to form in the gap. Plate-guided bone transport has been successfully described in literature to treat bone loss defect in the femur, tibia, and mandible. This study reports two cases of fracture of femur with segmental bone loss treated with locking plate fixation and bone transport with Ilizarov ring fixator. At the time of docking, when the transport segment is compressed with bone fragment, the bone fragment is fixed with additional locking or nonlocking screws through the plate. The bone defect size was 7 cm in case 1 and 8 cm in case 2 and the external fixation indexes were 12.7 days/cm and 14 days/cm. No shortening was present in either of our cases. The average radiographic consolidation index was 37 days/cm. Both cases achieved infection-free bone segment regeneration and satisfactorily functional outcome. This technique reduces the duration of external fixation during the consolidation phase, allows correction of length and alignment and provides earlier rehabilitation.

Key words: Bone defect, bone transport, distraction osteogenesis, external fixator, locking plate
MeSH terms: Distraction osteogenesis, Ilizarov technique, bone plates osteogenesis

Introduction

Various techniques of management of large bone defect have been mentioned in literature ranging from bone grafting, using vascularized fibular bone transfer[1] or cancellous bone graft[2] to bone transport. Different methods of bone transport have been described by multiple authors using Ilizarov fixator, and monolateral external fixator such as transport over an intramedullary nail. Distraction osteogenesis by the Ilizarov method has been a widely used method in the last few decades,[3-7] but it has its own complications including prolonged use of external fixation and poor patient compliance.[8] Monolateral external fixator has also been used to minimize the drawbacks of Ilizarov circular device.[9] Bone transport using a monorail fixator over an intramedullary nail is used to control anatomic length and alignment during transport and early removal of the external fixation system.[10-14] However, prolonged external fixation and presence of pin-tract infection are contraindications for the use of intramedullary fixation. Plate-guided bone transport has been successfully described in the literature.[15-17] In addition to the reduction to the time needed for external fixation during consolidation phase and protection against refracture, the plate helps to neutralize the forces on the bone and maintain stable anatomic alignment of the proximal and distal segment. This study reports two cases of fracture of femur with segmental bone loss, treated with locking plate fixation and bone transport with Ilizarov ring fixator. At the time of docking, when the transport segment is compressed with bone fragment, the bone fragment is fixed with additional locking or nonlocking screws through the plate.

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Materials and Methods

This study reports 2 cases of a large bone segment defect in the femur that were treated by locked plate and bone transport with Ilizarov ring fixation frame.

Case 1

A 25-year-old male sustained a Gustilo and Anderson Type 3b open fracture of the distal 1/3rd femur. The radiographs revealed a comminuted fracture of the distal 1/3rd shaft of the femur extending to the intercondylar area with Hoffa's fracture. The patient was initially treated elsewhere and fracture was stabilized with 2 K-wires [Figure 1a and b] with primary closure of the wound. The patient presented to us with foul smelling wound with copious amount of discharge coming out of it [Figure 1c]. The patient was then treated with implant removal, and extensive debridement of dead tissues, muscle, and bone was done, resulting in 7 cm segmental bone defect of distal femur [Figure 2]. After repeated serial debridements; on 12th day, the articular fracture was reconstructed and fixation was done with locking compression plate and interfragmentary screw for Hoffa's fracture. Antibiotic cement beads were placed in the defect. Routine wound inspection was done to look out for any signs of infection. The patient required a few more debridements until it become evident that no sign of infection was present. Split skin grafting was done over the clean wound bed to cover overlying skin defect. After 14 weeks, Ilizarov ring fixator was applied and midfemoral corticotomy was done [Figure 3]. Bone transport began 7 days postcorticotomy at a rate of 1 mm/day in four 0.25 mm increments. Active knee motion was encouraged and gradual partial weight bearing was advised. Gradual bone transport was carried out till the bone docked distally after 78 days [Figure 4].

Figure 1: Case 1: A 25 year old male presented with open fracture lower 3rd right femur. X-ray anteroposterior (a) and lateral (b) views showing fracture distal 1/3rd of femur fixed with 2-K-wires (c) Clinical photograph showing wound condition at the time of presentation

Figure 2: Case 1: (a and b) Peroperative photographs showings implant removal and extensive debridement of dead tissues, muscle, and bone, resulting in 7 cm segmental bone defect of distal femur. After repeated serial debridement, on 12th day, the articular fracture was reconstructed and fixation of fracture distal 1/3rd of shaft of femur with locking compression plate (c) X-ray anteroposterior and lateral views showing antibiotic cement beads

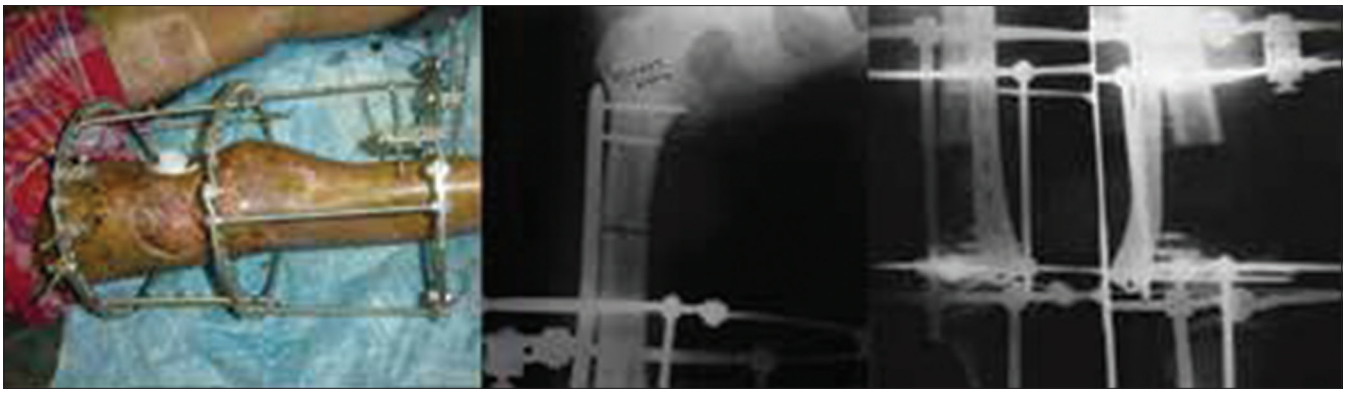

Figure 3: Case 1: Clinical photograph and x-rays of thigh showing Ilizarov fixator (applied at 14 weeks) and mid-femoral corticotomy (After one week of bone transport started)

Figure 4: Case 1: X-ray of thigh with knee joint anteroposterior and lateral views showing removal of ring fixator, and fixation of previous metaphyseal plate with locking screw

The transport segment was docked and fixed to the plate with 2 percutaneous screws and the Ilizarov ring fixator was removed [Figure 4]. Autologous iliac bone graft was grafted at the docking site. Total time in external fixation was 89 days. The patient was followed up for 3 years. The patient achieved good radiological bony union at both docking and distraction site and there was no recurrence of infection. There was no shortening present. The knee motion was 0–100° and the patient remains satisfied with his outcome [Figure 5].

Figure 5: Case 1: (a) X-ray of thigh with knee joint anteroposterior and lateral views showing complete osseous union and (b,c and d) clinical photographs showing good range of motion at 3 years followup

Case 2

A 22-year-old male sustained Gustilo and Anderson Type 3b open fracture of the shaft of femur from road traffic accident. The radiographs revealed a comminuted fracture of the distal 1/3rd of the shaft of femur extending to the intercondylar area with approximately 8 cm segmental bone loss. The patient was initially treated elsewhere with K-wires and cancellous screw for femoral condyle and spanning external fixator with primary closure of the wound over the anterolateral aspect of the right knee [Figure 6]. The patient was then treated with implant removal, extensive wound debridement was done, and the fracture was stabilized with condylar locking compression plate with interfragmentary screw in anteroposterior direction. Antibiotic cement beads were placed in the defect. Eight weeks after the initial stabilization with plate, reconstruction of the defect by bone transport began with application of the Ilizarov ring fixator and mid femoral corticotomy was done [Figure 7].

Figure 6: Case 2: Clinical photograph and x-rays of thigh with knee joint showing that the patient presented with open fracture lower 3rd femur with bone loss. Spanning external fixator was applied earlier elsewhere along with k wire fixation for femoral condyle

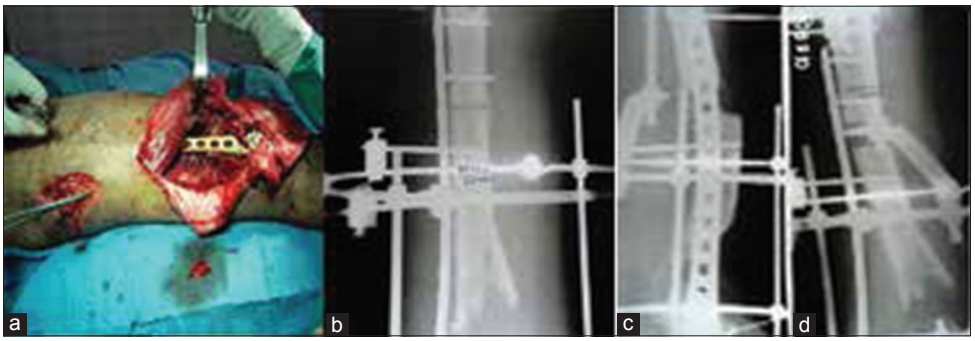

Figure 7: Case 2: Peroperative photograph and x-rays of thigh showing (a) removal of tubular external fixation and lateral two K-wires, wound debridement (b) fixation with distal femoral metaphyseal plate (c) stabilization with Ilizarov ring fixator and corticotomy upper femur (after 8 weeks of distal femoral metaphyseal plate) (d) bone transport started after 10 days of corticotomy

Bone transport began 10 days post corticotomy at a rate of 1 mm/day in four 0.25 mm increments. During the bone transport, the patient was allowed to walk full weight bearing and examined every 3 weeks for local signs of infection. Approximately, 3 weeks after beginning transport, pin exchange and pin-tract debridement was done due to pin-tract infection. However, there is complete resolution at pin site infection. The transport segment was docked and fixed to the plate with 2 screws and the Ilizarov ring fixator was removed. The autologous iliac bone graft was harvested at the docking site [Figure 8]. The duration of transport period was 96 days. The total time in external fixator was 112 days. There was no shortening present. The patient was followed up for 34 months. The radiograph showed bony union at both docking and distraction site. The knee motion was 0–70° [Figure 9].

Discussion

Distraction osteogenesis is a surgical treatment designed to regenerate bone that may have been "abnormally short as a result of injury, disease, or malformation." Distraction osteogenesis generates new tissue through the application of tensile forces to develop a callus via a controlled osteotomy. Distraction osteogenesis is characterized by three separate phases involving the latency phase immediately following the osteotomy, the active or distraction phase involving active separation of the bony segments, and the consolidation phase where active distraction has ended and healing of the callus begins. In general, the consolidation phase is twice the distraction phase.

Distraction osteogenesis by the Ilizarov method is a traditionally used technique for reconstructing bone loss defect.[3-7] However, the difficulties that occurred using Ilizarov are pin track infection, axial deviation, and decreased range of motion in the surrounding joints. Prolonged use and poor patient compliance are the other important limitation factors for the Ilizarov.[8] Bone transport using the combination of an intramedullary nail and a monolateral external fixator for transport maintains length and alignment during transport, allows earlier removal

Figure 8: Case 2: X-ray anteroposterior and lateral views of thigh with hip joint (a) and thigh with knee joint (b) showing docking, removal of Ilizarov fixator and bone grafting at docking site

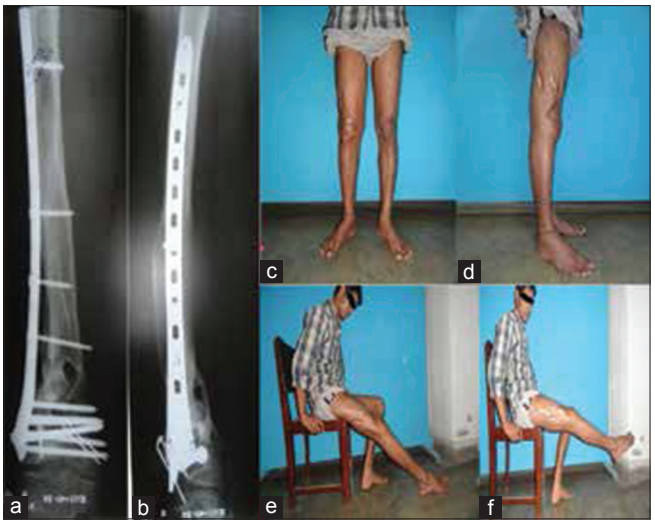

Figure 9: Case 2: (a and b) X-ray of thigh with knee joint anteroposterior and lateral views showing osseous union at docking at distraction site (c,d,e and f) clinical photographs showing good range of motion at 34 months followup

of the external fixator system.[10-14] However, it has its own minor and major complications including pin-tract infection and increased infection rate after prolonged use of external fixation system. The risk of creating a deep intramedullary infection with nailing transport is of greater concern. Infection rates as high as 22% have been reported in literature, leading to discontinuation of this technique by many surgeons. Simpson *et al*.[18] reported deep infection rate of 15% in their series, where two of the three infections occurred after previous open femoral fractures. Kristiansen and Steen[19] reported in 3 out of 9 patients that fatigue fractures of the intramedullary nail or interlocking screws occurred that needed revision and bone grafting. In one patient, a deep intramedullary infection occurred.

The maximum length of time in an external fixator before conversion to intramedullary nailing remains controversial. In a recent meta analysis, based on the available evidence, the authors concluded that patients who had external fixation in place for >28 days had significantly increased rate of infection.[20] In cases where there is angular deformity, an excessively sclerotic or narrow medullary canal, it is difficult to perform intramedullary nailing. Both the cases in our study presented with intraarticular involvement of fracture of distal femur with Hoffa's fracture in case 1, where nailing might not be a good option to perform.

Distraction osteogenesis used in combination with plate-guided bone transport has been described several times in the literature. Windhager *et al*.[21] described the technique of distraction osteogenesis in the femur of six male sheep using a custom-made osteosynthesis plate which was fixed on the lateral side of the femur, and two transporting plates driven by the transcutaneously inserted screw driver moved two bone cylinders simultaneously over the bone defect. The result shows that distraction osteogenesis can be achieved with an internal device, and recorticalization and restoration of a medullary canal occurs despite rigid internal stabilization by the plates.

Apivatthakakul and Arpornchayanon[15] reported two cases of open fracture of the femur with segmental bone loss that were treated successfully by minimally invasive plate osteosynthesis combined with distraction osteogenesis. Both went on to bony union with good alignment. Girard *et al*.[16] described successfully bony union in two cases of large tibial bone defects using locked bridge plating and bone transfer with a monolateral external fixation frame. Oh *et al*.[17] reported total of ten patients who underwent distraction osteogenesis with a locking plate to treat previously infected posttraumatic segmental tibial defects. In all the cases, primary union of the docking site and distraction callus was achieved, with an excellent bony result.

Variation of this technique has also been described to successfully treat mandibular segmental defects in humans after resection of malignancies.[22] Similar methods described in the literature for different indications. In 2007, Iobst and Dahl[23] described a novel technique of limb lengthening combining an Ilizarov-style circular fixator frame with percutaneously inserted locking plate.

This advantage of technique of bone transport using plate with Ilizarov ring fixation includes correction of length and deformity, maintains stable anatomic alignment of the proximal and distal segments, and has the ability to treat massive bone defects. It also offers the opportunity to additionally compress and stabilize the transported segment at the time of docking using

additional nonlocking or locking screw through the plate and facilitates earlier frame removal. This technique reduced the mean duration of external fixation in our cases by almost 50% [Table 1]. This technique of plate-guided bone transport also proved to be especially useful over nail transport in our cases where long standing external fixation pins had been in place, making the use of an intramedullary nail more problematic. The spatial configuration of the Ilizarov wires is done in such a way that it does not have any contact with the locking plate or screw. External fixation pin insertion is also simplified in the absence of an intramedullary implant. Plate-guided bone segment transport has been successfully described in literature to treat open or infected large segmental bone defect without occurrence of infection.[15-17]

In case 1 of this study, the total time for external fixation was 89 days for a 7 cm defect, and in case 2, the total time was 112 days for a 8 cm defect. To reduce the external fixation time in the consolidation phase, the transport segment is fixed to the plate by a percutaneous screw and the external fixator is removed. With this technique, the external fixation time is only in the distraction phase. In general the consolidation phase is twice the distraction phase. In both the cases, bone grafting at the docking site was done. The lengthening/external fixation index for case 1 was 12.7 days/cm and for case 2, it was 14 days/cm which is less compared to other means of bone transport. No shortening was present in either of our cases. The average radiographic consolidation index was 37 days/cm.

The limitations of this technique of distraction osteogenesis using combined use of plating and Ilizarov include the risk of plate failure, infection, and these methods are technically more demanding. A common problem is pin-tract infection during lengthening. In one of our cases, pin exchange and pin-tract debridement was done due to pin-tract infection.

Table 1: Comparison of different methods of bone transport

Author	Bone	Method of lengthening	Average length achieved (cm)	External fixation time (days/cm)
Paley *et al.*[8] (1990)	Femur	Ilizarov	5.6	51
Paley *et al.*[14] (1997)	Femur	Intramedullary nail	5.8	20
Simpson *et al.*[18] (1999)	Femur and tibia	Intramedullary Nail	4.7	20
Oh *et al.*[13] (2008)	Tibia	Intramedullary Nail	5.9	26
Apivatthakakal *et al.*[15] (2002)	Femur	Plate	7.5	12
Oh *et al.*[17] (2013)	Tibia	Plate	5.9	13
Girad *et al.*[16] (2013)	Tibia	Plate	11	17
Present report	Femur	Plate + Ilizarov	7.5	13

Conclusion

This technique of combined plating and Ilizarov is an alternative method for bone transport in the cases of large segmental bone loss. This technique has the advantage of reducing the duration of external fixation, allows correction of length and alignment, prevents refracture, and provides earlier rehabilitation.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Conflicts of interest

There are no conflicts of interest.

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