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Ilizarov bone transport after massive tibial trauma: Case report

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ABSTRACT

INTRODUCTION: This is a case report of extreme lengthening of the tibia of about 14.5 cm using bone transport technique following road traffic accident trauma to the lower limbs. The management of the subsequent massive skeletal defects was challenging to orthopedic surgeons. Based on reported cases, the highest tibial lengthening was 22 cm using bifocal transport, while the highest unifocal tibial lengthening reached 14.5 cm.

CASE PRESENTATION: A 20-year-old male driver was brought to the emergency department after a road traffic accident. The patient had a right Gustilo IIIA segmental open tibia fracture with bone loss and other severe injuries. The tibial defect was 14.5 cm and the patient was then admitted for Ilizarov application six months after the accident. Although this case was particularly complicated, full limb length was restored.

DISCUSSION: The management of this case was directed to correct the deformities and achieve equal length of both limbs to restore the normal function. Several new techniques have been developed recently to fill large bone defects. Limb lengthening using bone transport technique by application of Ilizarov ring fixator has been suggested as the leading option in filling massive bone gaps.

CONCLUSION: The use of bone transport technique using Ilizarov external rings has proved to be a minimally invasive and reliable method in managing massive bone defects. Accurate application of the Ilizarov frame and proper transport of the middle segment are important factors alleviating the risk for deviation of the transported segment. However, due to the need for regular follow-ups and monitoring, it demands high compliance from the patient to achieve optimal results.

1. Introduction

Lower limbs are highly vulnerable to trauma as well as to road traffic accidents (RTAs). RTAs are very common in Saudi Arabia as it occupies 20% of all its hospital beds [1–3]. The management of the subsequent massive skeletal defects is becoming a challenge to orthopedic surgeons. Multiple techniques have been considered for limb lengthening and reconstruction including autographs, free vascularized bone grafts, and bone transport with distraction osteogenesis [4–6]. Amputation is also a valid option if the previous techniques were not able to achieve the desired functional outcome [6].

Ilizarov technique uses the effect of gradual distraction to allow for new bone and soft tissue regeneration to fill the defect site [7,8]. It offers the advantage of lengthening a bone at one site (unifocal lengthening) for cases of minimum bone defects with good regeneration potential, or at two sites (bifocal lengthening) for cases of substantial bone defects [9]. Based on reported cases, the highest bifocal tibial lengthening was 22 cm whereas the highest unifocal tibial lengthening was 14.5 cm [5,10]. This case demonstrates the management of restoring the original length of the tibia after massive bone loss using bone transport technique.

2. Case presentation

A 20-year-old Saudi unrestrained male driver was brought to our emergency department after involvement in an RTA. He had a right Gustilo IIIA segmental open tibial fracture with bone loss (Fig. 1), bilateral knee dislocation with right patellar tendon rupture, left anterior cruciate ligament (ACL) and medial cruciate ligament (MCL) rupture, bilateral distal femoral condyle fracture, grade II liver injury and grade III splenic injury. The patient received fluid resuscitation with no improvement and was moved to the

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Fig. 1. Preoperative X-ray on the admission day demonstrating the bone defect.

Fig. 2. Corticotomy was performed and Ilizarov apparatus was applied.

Table 1
Chronological events of the case.

Day	Event
–	Irrigation and debridement followed by external fixation on right tibia.
0	Ilizarov application. The transported segment is the middle segment. The defect is about 14.5 cm.
15	Distraction started at rate 0.25 mm three times per day (proximal–unifocal).
27	Beginning of appearance of the regenerate.
189	Incision and drainage of pin site infection. Adjustment of the two proximal pins with traction of the healthy bone that was transported. Fixation of both using two wrenches.
216	Distraction stopped.
540	Ilizarov frame application for right planter flexion deformity (hindfoot).
631	Acute correction for severe right planter flexion deformity (midfoot).
764	Ilizarov removal, cast applied, x-ray showed good bone healing.
Follow-ups: Patient walks with crutches.	
903	Fracture due to fall. ORIF of right tibia and bone graft with MIPO. MIPO was fixed and bone graft was placed on the docking site infection.
946	Infection. Plate was removed and IV antibiotic started. Re-application of Ilizarov with two rings for the proximal segment only.
976	Patient discharged.
Follow-ups: Patient still walks with crutches mainly due to the effect of the other limb (drop foot, foot deformity and ACL).	

operating room for a diagnostic laparotomy. The soft tissue injury over the fractured tibia was minimum; it was removed completely with many resultant scars in front of the tibia. Irrigation and debridement were performed for the open wounds of the lower limbs, followed by internal fixation of the bilateral distal femoral condyle fractures, and external fixation of the right tibia and left knee. Both dorsalis pedis pulses were palpable and the limbs were well perfused. The patient was discharged 41 days later in stable condition and normal operative fields.

Six months later, the patient was admitted for Ilizarov application after a thorough discussion that involved his family. The measured tibial defect was 14.5 cm using X-rays and the distal neurovascular function was intact on the right side. Corticotomy was performed to the distal segment to transport it proximally (Fig. 2). The patient was recommended to have an extension of the tibial external fixator to support the ankle joint to prevent joint contractures and further deformity. However, the patient preferred not to go through it. Table 1 demonstrates chronological events in the case.

Physiotherapy and partial weight-bearing were initiated one week after the procedure. The bone was gradually distracted at a rate of 0.25 mm three times a day. The appearance of the regen-

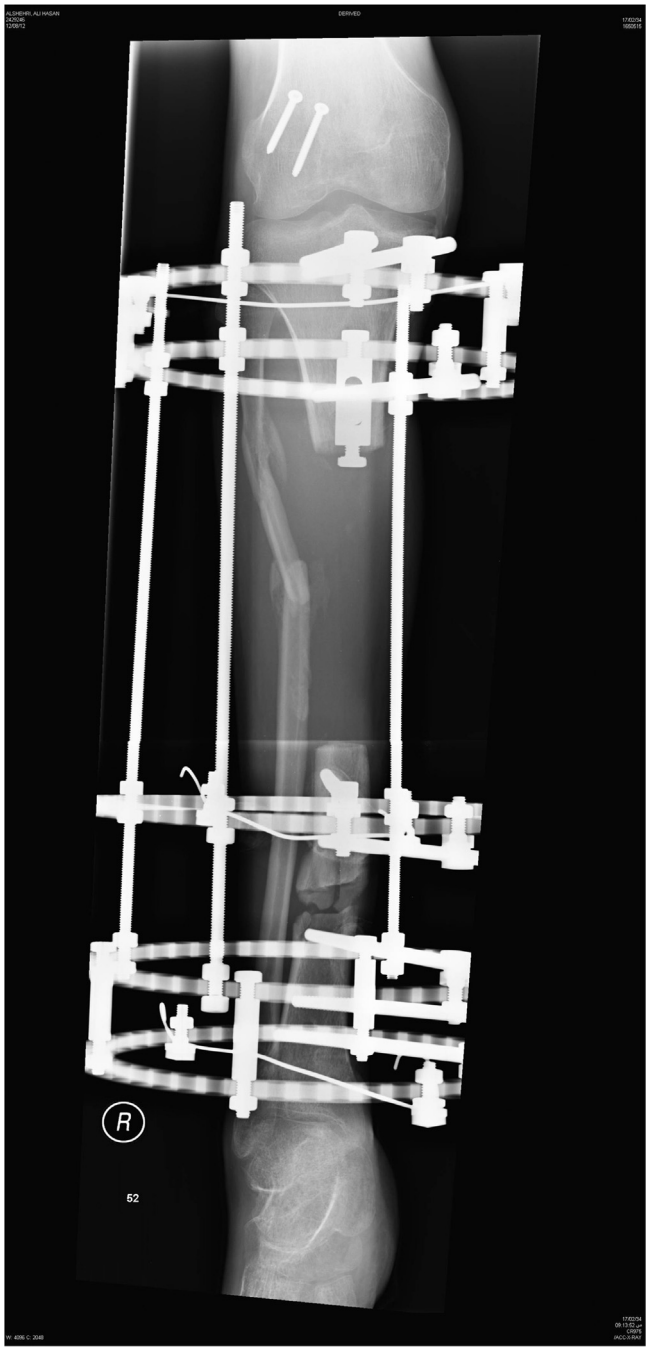

Fig. 3. Fine lines of regenerate formation.

erate on X-ray began 20 days after starting the distraction (Fig. 3). The patient was discharged in stable condition to continue his daily lengthening at home with a prescription of low molecular weight heparin and acetaminophen. The distraction was continuous and lasted for seven months until the tibia restored its original length (Fig. 4). The patient was following in the outpatient clinic weekly.

There were other injuries playing a role in the patient's well-being throughout the course of the bone transport. The patient had subsequent left foot drop and sensation loss over its dorsal and lateral aspects due to the left knee dislocation with ACL and MCL rupture. The foot drop was corrected by ankle arthroscopy arthrodesis. He also had a three centimeters ulcer over the dorsum of the left foot, which was consistent with chronic osteomyelitis.

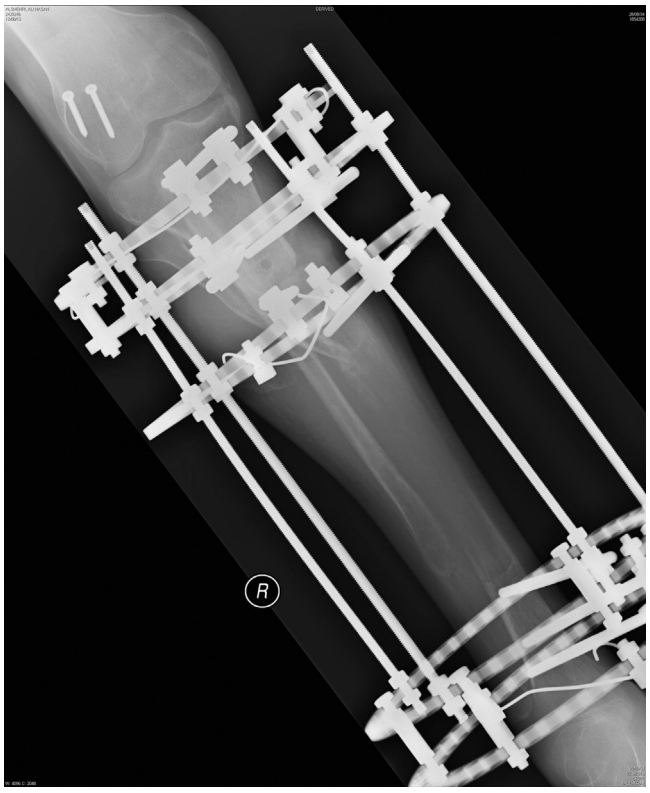

Fig. 4. X-ray demonstrating the regeneration after completing the distraction period.

The patient was admitted to the department six months post Ilizarov application with the main complaint of pain and discharge from the pin site. The culture revealed *Staphylococcus Aureus*. Accordingly, irrigation and debridement were carried on, and treatment with intravenous (IV) antibiotics was started with an oral course of Cefazolin and Rifampicin.

The patient developed fixed severe plantar flexion deformity of the right foot, probably due to muscle imbalance after the trauma and not having the ankle stabilized with an additional frame. The correction of this deformity was performed at two levels; the midfoot deformity was corrected acutely and achieved 90% optimal correction whereas the hindfoot deformity was corrected using Ilizarov frame and achieved a good result.

Two years later, the Ilizarov frame was removed after confirming good bone healing with X-ray (Fig. 5). Consolidation index was 52.7 days/cm. The patient was on a permanent non-weight-bearing cast, owing to the recent midfoot surgery, and was discharged in stable condition.

The patient had an unfortunate incident of falling down six months after the frame removal. He sustained fractures in the mid-distance of the new consolidated bone and in the docking site. Open reduction internal fixation (ORIF) of mid-tibia and bone graft for the docking site was performed using Minimal Invasive Percutaneous Osteosynthesis (MIPO) (Fig. 6). Six weeks after the repair, the bone graft became infected and the patient presented with an exposed plate in the anterior proximal tibia. Deep tissue culture showed *Enterobacter Cloacae.* The infection was managed by consecutive irrigation and debridement sessions, removal of the plate and bone graft, IV antibiotics, and three months course of oral antibiotics upon Infectious Disease team consultation. Ilizarov frame was re-applied to the proximal segment with two rings to compress the malunion of docking site (Fig 7).

The patient is still following up with the outpatient clinic. Regular follow-ups and close x-ray monitoring guided the success of

restoring the total length of the tibia. However, as the patient suffered from an interaction of multiple complex injuries that are not limited to the tibia, the functional outcomes of the final repair were difficult to assess (Fig. 8). He walks now with crutches, mainly due to the effect of the other limb injuries.

3. Discussion

The management of this case was directed to correct the deformities and achieve equal length of both limbs to restore the normal function. Several new techniques have been developed recently to fill large bone defects, some have shown limited success, others do well but with a high rate of complications [4].

Autologous bone graft requires multiple donor sites in cases of large bone defects, which is associated with considerable morbidity [4]. Although free vascularized fibula transfer from the contralateral limb is an appropriate option for large defects, it is best done when the contralateral limb is not on high functional demand as in our case. Allograft, on the other hand, requires challenging preparations and preservations [4,6]. Furthermore, the involvement of soft tissue and the extension of the defect limit the chance of using the previous methods unless the soft tissue is treated first, which is time-consuming. Amputation is also a valid option as it has good functional outcomes in a short treatment time. However, the permanent limb loss is not acceptable as a first line option for most patients.

More recent methods in the management of large segmental bone defects have been described. Distraction osteogenesis and induced membrane technique are both reliable options. Nevertheless, the need for adequate autologous bone grafts, in induced membrane technique, makes it less suitable for this case [6,11].

Limb lengthening using bone transport technique with Ilizarov apparatus has been suggested as the leading option in filling massive bone defects. It is mainly valuable when the defect extends to the soft tissue as it allows for new bone and soft tissue regeneration without the need for bone grafting or internal fixation [8]. It was chosen for this case after a thorough discussion with the patient as the most appropriate option that meets the primary treatment objective. The patient was young, cooperative, and has good family support. The patient's age is of an importance in the adjustment of the distraction rate to avoid complications such as premature consolidation or exceeding the capacity of ingrowth of the vascular supply [8,12]. Moreover, the patient was given comprehensive

Fig. 5. Ilizarov frame removal after proper consolidation with partial union at docking site.

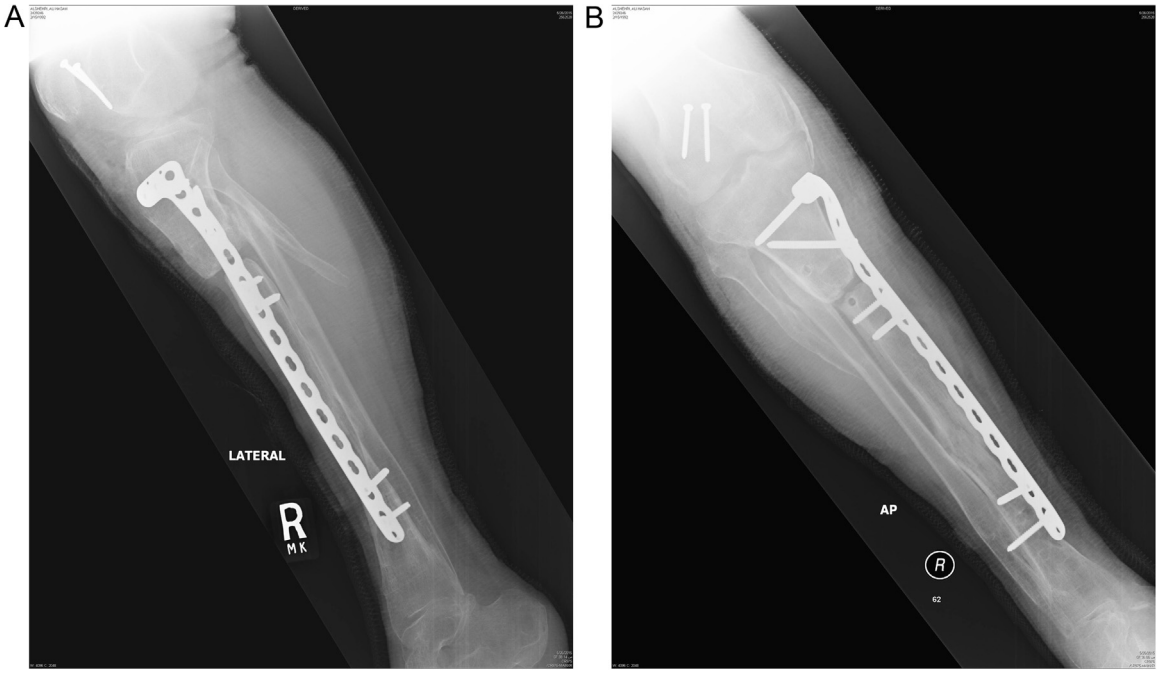

Fig. 6. X-ray demonstrates internal fixation and MIPO of docking site.

education, which is essential due to having the apparatus placed for prolonged periods of time and the need for regular follow-ups and monitoring.

While Ilizarov technique is considered as a minimally invasive procedure [4], its association with complications is relatively common. The risk of developing pin tract infection is high, nearly 80%, [6] the pins then have to be replaced with proper debridement of the necrotic tissue. A major setback in the Ilizarov technique is nonunion of the docking site, which can be managed with bone grafting, acute shortening, or compression and healing by fracture callus [7]. However, the most common complications in tibial lengthening are joint contracture, secondary deformities and deviation of the transported segment [8]. Equinovarus contracture of the foot can be prevented by extending the frame to include the ankle. Paley et al. [14] recommends the prophylactic use of ankle frame in distal-to-proximal transport in defects larger than four centimeters. Axial deviation is the result of an imbalance in the tension generated over the soft-tissue around the bone [8]. Accurate application of the Ilizarov frame and transporting the middle segment were important factors alleviating this risk. Although the disability time is long, Green et al. found no difference in required fixation time between using bone transport and Papineau bone graft [10]. In Cierny and Zorn et al. [13] comparative study, the Ilizarov technique was in fact faster and less expensive than the cancellous bone graft group.

Multilevel bone transport is a good option for cases of substantial bone defects as it reduces the lengthening time. Lerner et al. used a bifocal lengthening for a massive tibial gap of 22 cm [5]. However, it requires a complex frame and might associate with slow maturation of the regenerate [6]. Therefore, unifocal lengthening was applied in this case although the bone gap was large. There was no need for intramedullary nail guide, and full restoration of 14.5 cm of the tibial length was achieved.

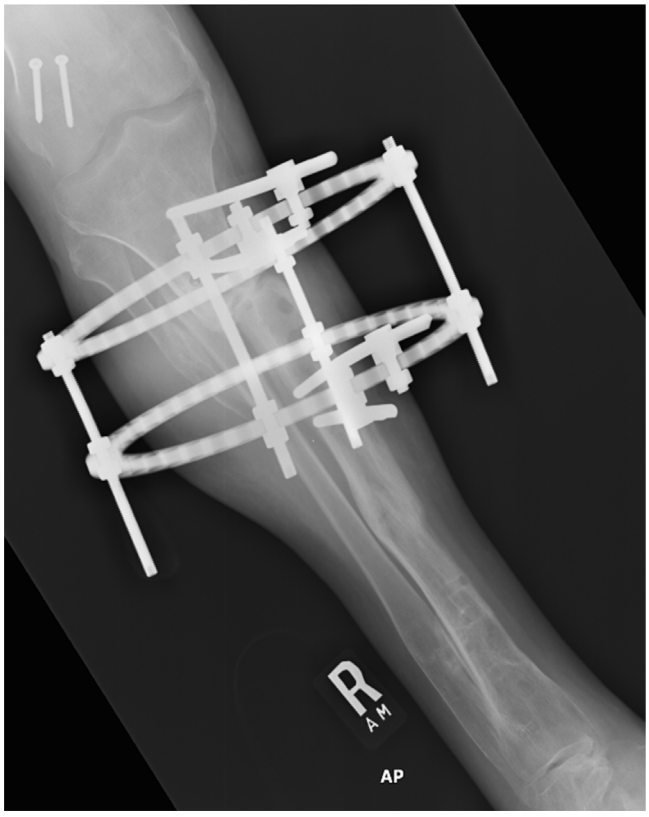

Fig. 7. Docking site compression with two rings to manage the nonunion.

4. Conclusion

The use of distraction osteogenesis proves to be an excellent option in managing and restoring massive limb bone loss without the need for guides or bone grafts. The full restoration of 14.5 cm of the tibial length was achieved, which to our knowledge is an extraordinary achievement to unifocal lengthening. However, as this was not an isolated case, the functional outcomes were difficult to assess. This case also demonstrates the importance of ankle frame application with large tibial defects.

Fig. 8. The final x-ray with full weight-bearing.

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There is no study sponsor.

Competing interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

Consent

The patient's permission for publication was taken by signing a Health Insurance Portability and Accountability Act (HIPAA) consent form.

Ethical approval

King Abdullah International Medical Research Center (KAIMRC) requires no institutional review board (IRB) approval for case reports other than signed patient consent form.

Author contribution

All authors contributed to the article. Study design has been suggested by Alkenani. Data were collected and analysed by Alosfoor, Al-Araifi, and Alnuaim. Alosfoor and Al-Araifi wrote the manuscript under supervision of Alkenani. Alosfoor drafted and critically revised the article.

Guarantor

Mariam A. Alosfoor under the supervision of Dr. Nader Alkenani.

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