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Successful Limb Salvage Using Bone Transport for Complete Loss of Distal Tibia and Talus: A Case Report

Sang Woo Kim, MD, PhD[1], Dong-Kyo Seo, MD[2], Chae-chil Lee, MD[1], Hanwook Kim, MD[3], Il-Yeong Hwang, MD[4]

[1] Associate Professor, Department of Orthopedic Surgery, Ulsan University Hospital, University of Ulsan College of Medicine, Ulsan, Republic of Korea
[2] Assistant Professor, Department of Orthopedic Surgery, GangNeung Asan Hospital, University of Ulsan College of Medicine, Gangwon, Rebulic of Korea
[3] Senior Resident, Department of Orthopedic Surgery, Ulsan University Hospital, University of Ulsan College of Medicine, Ulsan, Republic of Korea
[4] Assistant Professor, Department of Orthopedic Surgery, Ulsan University Hospital, University of Ulsan College of Medicine, Ulsan, Republic of Korea

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ABSTRACT

Complex comminuted fractures involving the distal tibia, ankle joint, and talus are often accompanied by bone loss and are highly prone to complications such as soft tissue infection, fixation failure, and posttraumatic arthrosis, with joint reconstruction being difficult in cases with severe joint destruction or bone loss. In this case, bone transport and fusion procedures were performed to treat a patient with an open fracture involving total talar dislocation, talar bone loss, and distal tibial bone loss. Just as in this case, where the surrounding soft tissues remain healthy, limb salvage via segmental bone transport may be a reasonable option in fractures with massive bone loss that include joints.

Complex comminuted fractures involving the distal tibia, ankle joint, and talus are often accompanied by bone loss and are highly prone to complications such as soft tissue infection, fixation failure, and posttraumatic arthrosis, with joint reconstruction being difficult in cases with severe joint destruction or bone loss. Total talar dislocation owing to injury is mainly caused by the high energy acting on the plantar flexed and inverted foot The treatment methods of such talar dislocation that were commonly used in the past included fusion with bone graft after talectomy or regraft after debridement (1). Recently, cases involving the use of talar implants or reconstruction using total ankle replacement arthroplasty have been reported; however, these methods can be used only in cases where the distal tibia is present (2).

In this case, bone transport and fusion procedures were performed to treat a patient with an open fracture involving total talar dislocation, talar bone loss, and distal tibial bone loss (12.5 cm total). Moreover, this case was unique, with total talar dislocation and one fourth of distal tibial bone loss but with virtually no damage to the fibula. Accordingly, an understanding of the injury mechanism and treatment for the extensive bone loss near the ankle joint are reported here.

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Address correspondence to: Il-Yeong Hwang, MD, Department of Orthopedic Surgery, Ulsan University Hospital, University of Ulsan College of Medicine, 877 Bangeojinsunhwando-ro, Dong-gu, Ulsan 44055, Republic of Korea
E-mail address: yebben10@naver.com (I.-Y. Hwang).

Case Report

In April 2011, a 39-year-old female sustained injuries from a traffic accident while sitting in the back seat of a passenger car. The patient was admitted to the emergency department at our hospital for severe trauma to both sides of feet and ankle areas.

On the initial examination, the patient had a 15-cm open wound on the lateral aspect of the left ankle joint. Through the open wound, there were open total talar dislocation, open fracture dislocation of the distal tibia (95 mm), and open fracture of the fibular tip (Fig. 1). The right side (the contralateral side) also showed fracture/dislocation of the ankle joint and multiple metatarsal fractures. The lost talus, tibia, and fibula bones were retrieved from the accident site after 1 hour, but the bones could not be used for reconstruction because they had been severely damaged and contaminated.

Based on the patient's condition of having an open wound on the left ankle, along with talar dislocation and distal tibial bone loss, the mechanism of injury to the left leg was believed to involve strong compression and varus forces at the time of impact, causing an avulsion fracture of the lateral malleolar tip as a supination-adduction-type ankle injury. A sustained varus force caused talar dislocation and tibiofibular ligament rupture, with the axial compression force exposing the tibia and fibula outside the wound, with only the tibia sustaining a distal tibial fracture and bone fragment loss. The patient did not want to lose her left leg, and as such we decided to perform reconstructive surgery.

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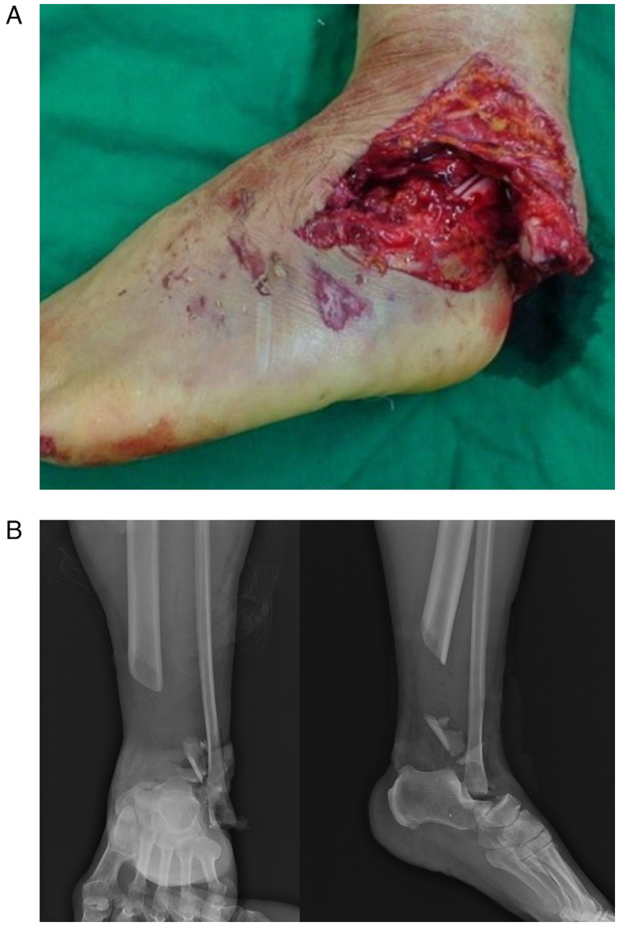

Fig. 1. (*A*) Initial open wound on the anterolateral aspect of the left ankle was observed. (*B*) Initial radiograph of the left ankle joint revealed total open dislocation of the talus, open fracture dislocation of the lower tibia, and open fracture of the lateral malleolus.

Surgical Technique

Emergency surgery was performed on the day of admission. First, open wounds in both ankles were washed several times and subsequently debrided. For the left ankle, a polymethyl methacrylate (PMMA) cement spacer mixed with the vancomycin was inserted through the open wound into the talus and lower tibia that had been lost to prevent infection by any residual bacteria. Additionally, a temporary monofixator was applied to retain the length and shape of the leg (Fig. 2).

The wound was disinfected and treated with antibiotics for 15 days after the injury. The second surgery was performed after the results of bacterial culture tests performed during the first surgery were confirmed to be negative, indicating no infection. On the left side, a new 10-cm longitudinal incision was made on the anterior portion of the ankle area to remove the cement, and the inside was confirmed to be clean with no signs of infection. On x-ray examination, comparison with the right leg revealed that the bone loss in the left leg was 95 mm from the distal tibia and 30 mm from the talus, for a total of 12.5 cm. While maintaining the distance between the fracture margin of the remaining tibia and upper calcaneus at 12.5 cm and confirming that the position of the calcaneus aligned with the mechanical axis, an Ilizarov external fixator (U&I, Seoul, Republic of Korea) was applied with Ilizarov rods parallel to the remaining tibial shaft. Two olive pins that would pull the bone distally were placed obliquely at the medial and lateral aspect of the cortical bone on the tibia fracture margin. Next, the pins were pulled through the space inside the leg where the missing bone had been, then passed through the medial and lateral aspects of the calcaneus under the skin and exited through the skin on the plantar medial and plantar lateral aspect of the foot.

A corticotomy was performed on the area about 10 cm distal to the tibia fracture margin. An incision was made about 4 cm anterior to the area, and a periosteal elevation was performed, with care taken to avoid injuring the periosteum. After using a 2.7-mm drill for multiple drilling on the planned area, an osteotome was used to perform corticotomy. Next, cut periosteum was sutured. Bone transport was initiated after a postoperative latency period of 10 days, with the rate of distraction being 1 mm/day and the rhythm of distraction being 4 times/day (Fig. 3).

An open reduction and internal fixation were performed on the right leg. There was no period of interruption during bone extension. At 18 weeks, after confirming that the planned bone transport of 12 cm had been achieved and that the bone had reached its docking position on the upper calcaneus, 2 pins were screwed on the moving bone segment and externally fixed to the ring already set in place, after which the olive pins and the plantar ring were removed. From this point on, partial weightbearing was allowed, and greater weightbearing, as much as tolerable, was allowed over time.

Subsequently, after 6 months of consolidation, the talonavicular, calcaneofibular, and distal tibiofibular fusions were performed. From 1 month after the fusion procedure, partial weightbearing was allowed again, and starting from the second month on, full weightbearing was allowed. In the third month, the Ilizarov ring fixator was removed, and full weightbearing under patellar tendon brace assistance was started.

Results

The patient has been under follow-up supervision for 5 years since the final surgery. Bone fusion and consolidation have progressed well, and no specific complications have been observed, except for a paresthesia and neurologic pain on the dorsal aspect of the foot owing to the injury to the left superficial peroneal nerve that was sustained at the time of the accident (Fig. 4).

Comparison of leg lengths using a lower extremity scanogram showed that the left leg was 8 mm shorter than the right leg. The mechanical axis was within the normal range, with 1° varus on the nonaffected side and 3° valgus on the affected side, whereas the posterior tibial slope was 7° on the nonaffected side and 3° on the affected side, but with no recurvatum (Fig. 5).

The American Orthopaedic Foot and Ankle Society score was measured to be 76 points because of the reduced range of motion of the ankle joint as a result of arthrodesis. The patient is very satisfied with the outcome and is able to walk without any restrictions in daily activities but does have some limitations on running and exercising.

Discussion

Distal tibia fracture and talar dislocation are caused by high-energy trauma, and they can be accompanied by soft tissue injury and comminution. When high-energy injuries are treated surgically, complications, including soft tissue complications, infection, rupture or breakage of internal fixator, and osteomyelitis, are highly prevalent. In cases with severe soft tissue or bone loss, reconstruction may be impossible (3). Viberg et al (4) conducted a multicenter retrospective study on 71 patients with distal tibia fracture who were treated with internal fixation using a locking plate and reported that complications occurred in 69% (n = 49) of patients. In particular, serious complications, such as deep infection, large soft tissue defect, nonunion, malunion, and rupture or breakage of internal fixator, occurred in 21% (n = 15) of patients (4). In a retrospective cohort study by Van den Berg et al (5), 75% of 118 patients with distal tibia fracture reported loss of ankle fusion, whereas 2 of 3 patients complained of pain during daily activities. Complications such as dehiscence, necrosis, infection, and nonunion were reported in

Fig. 2. Immediate postoperative radiographs after emergency operation. Bone loss area was filled with antibiotic cement and fixed with a monofixator to maintain the length and shape of the leg.

23.7% of patients. Fractures that were more complex resulted in poorer outcomes, and the quality of soft tissue was a key factor that had an impact both before and after the surgery. In a retrospective study by Joveniaux et al (6), of the 101 cases of distal tibia fracture, complications were reported to occur at a rate of approximately 30%. In particular, high complication rates and poor function outcomes were seen in patients who used an external fixator.

Various methods have been reported for treating segmental bone defects. For defects <5 cm, autogenous bone graft and acute shortening are useful treatment methods. For relatively large defects >5 cm, induced membrane technique, distraction osteogenesis, and vascularized fibular graft transfer are recommended. Moreover, primary amputation may be considered for complete disruption of the posterior tibial nerve or crush injury with a warm ischemic time of ≥6 hours.

The induced membrane technique involves first performing radical debridement on the bone defect, followed by insertion of a PMMA cement spacer (7). If soft tissue healing is achieved after 6 to 8 weeks, the cement is removed, and bone grafting is performed. Here, the ratio of autobone to bone substitute should not exceed 1:3.

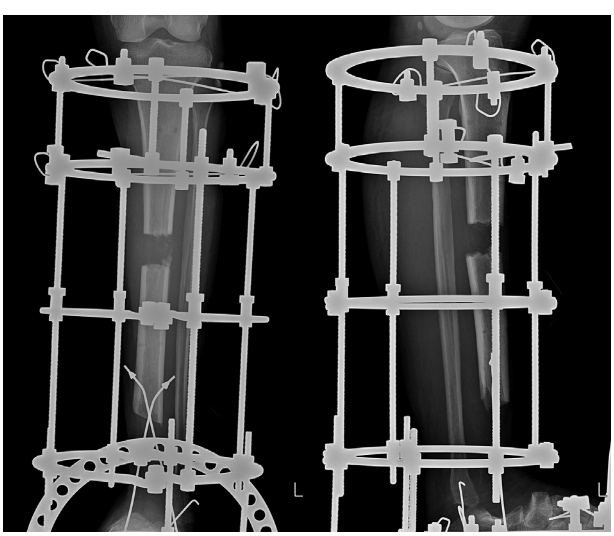

Fig. 3. Left tibia at 1 month after the bone transport procedure.

A case in which tibiocalcaneonavicular arthrodesis was used with intramedullary nail and reamer-irrigator-aspirator to treat metaphyseal bone defect has been reported. When the reamer-irrigator-aspirator is used, an average of 40 (range 25 to 75) mL of bone from the femur can be grafted, which makes it useful in cases with relatively large defects; however, this device cannot be used in Korea because it has not yet been introduced (8).

Vascularized fibular graft transfer technique is used mostly for bone defects >10 cm. The advantage of this method is that the fixator can be removed more quickly than in external fixation, but it cannot be used in cases with severe infection or leg length discrepancy. Furthermore, because donor site morbidity and fibular hypertrophy take a long time, weightbearing may be limited, and a brace must be worn for a long time.

For an open fracture of the distal tibia, a case of reimplantation after washing of the extruded long bone segment has been reported. Farrelly et al (9) performed reimplantation with an external and internal fixator after washing a 15-cm osteoarticular segment of the distal tibia in a 14-year-old female who suffered the injury during a traffic accident. After the surgery, repeated debridement and skin grafts were performed, along with antibiotic treatment. Tibial bone union was achieved after 4 months, and the patient was able to walk after 9 months. Meininger et al (10) performed reimplantation and intramedullary nail fixation on an approximately 20-cm-long bone extrusion of the distal tibia in a 33-year-old male who sustained the injury during a traffic accident. The patient was able to walk without a brace at postoperative 6 months; however, because the long bone segment was completely crushed, as was the case in our patient, reimplantation was not an option.

As an alternate method, primary shortening with secondary limb lengthening, may be considered as well. This method allows simple wound closure and can be useful for life-threatening injuries; however, it is difficult to achieve satisfactory lengthening with this method when the shortening of the entire bone length is >25%. Moreover, there is a maximum limit of 15 cm; the procedure is difficult with longitudinal wounds, and there are reported cases of complications involving proximal tibiofibular dislocation or equinovarus deformity (11).

The treatment of traumatic large bone defects via osteodistraction after external fixation using the Ilizarov method is already well known. This method offers the advantages of having a low risk of

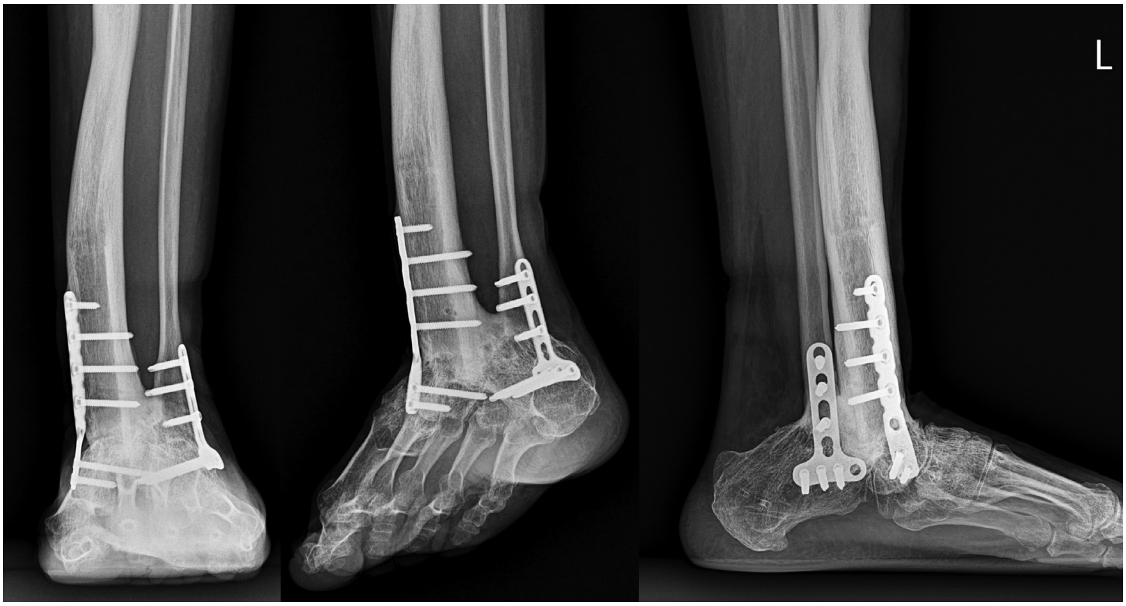

Fig. 4. Progression of bone fusion and consolidation at 5 years after surgery.

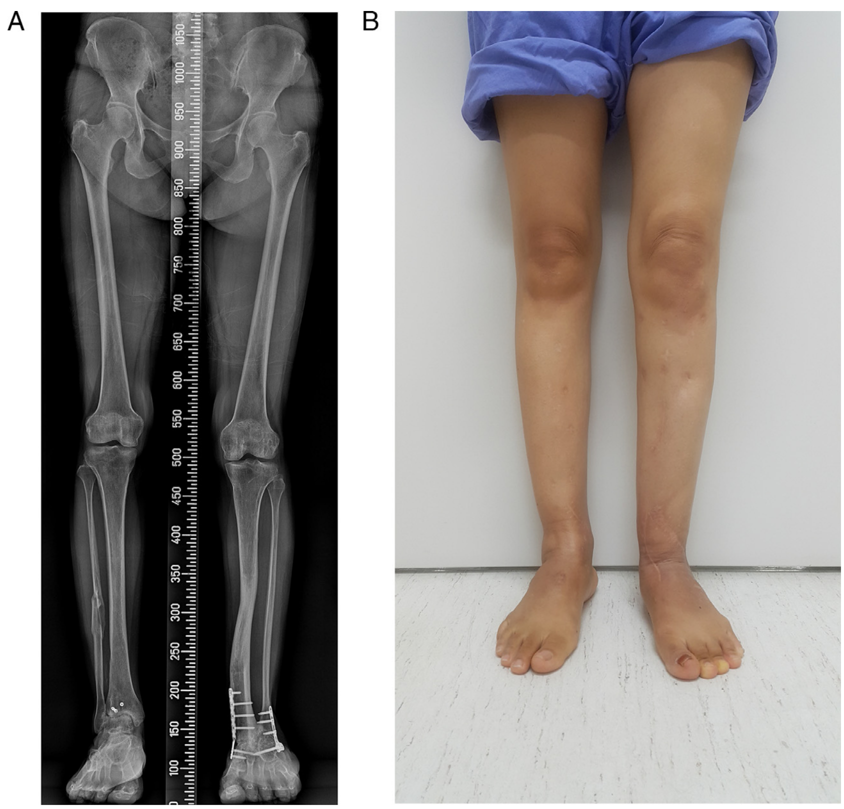

Fig. 5. (*A*) At the 5-year follow-up, the left leg was found to be shorter than the right leg by 8 mm, and the mechanical axis of the left leg was well maintained at close to 0°. (*B*) Scar formation of the skin and deformity of the ankle did not appear to be severe.

soft tissue damage, allowing weightbearing during the procedure, even for large defects; however, the method also has the disadvantages of possible joint contracture, deviation of transported segment, pin tract infection, and fracture of regenerated bone, along with requiring a long period of time (12). Thakeb et al (13) achieved satisfactory results using the Ilizarov and bone transport method on 16 patients with contained bone defects (mean gap 50.3 mm). Mekhail et al (14) showed satisfactory results in their retrospective study on 19 patients (2 excellent, 11 good, 4 fair, 2 poor) and reported complications involving amputation or refracture of docking site. Alkenani et al (15) reported a case in which lengthening of 14.5 cm was achieved using the Ilizarov and osteodistraction on a Gustilo IIIA segmental open tibia fracture of the diaphysis and emphasized ankle frame application.

Koettstorfer et al (16) reported a case in which a patient with massive segmental bone loss was treated with a 2-stage technique using a bone transport method. Twelve patients had massive bone loss, with an average bone loss length of 12.5 (range 8–26) cm. The Ilizarov was used for the initial fixation, and further stabilization using internal fixation (plate or intramedullary nailing) after distraction reduced the incidence of axial deviation and refracture. Internal fixation did not increase the incidence of infection.

In this case, primary fixation was performed using an external fixator and PMMA cement spacer while maintaining the leg length without any primary shortening after debridement. After confirming that there was no infection, segmental bone transport was used to grow the bone as long as the tibial bone loss section and the talus, and internal fixation was performed on the docking site using plates and screws to achieve favorable outcomes after tibiocalcaneal arthrodesis. There have been many reported cases of open tibia fractures accompanied by long-segment bone defects >10 cm, but there has been no report on any case with total bone loss of 12.5 cm involving all parts of the distal tibia (9.5 cm) and total talus loss.

In conclusion, in cases of severe bone loss that involve joints other than the metaphysis, amputation may be considered as the first option; however, in cases where the surrounding soft tissues remain healthy, limb salvage via segmental bone transport may be a reasonable option in fractures with massive bone loss that include joints, just as in this case.

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