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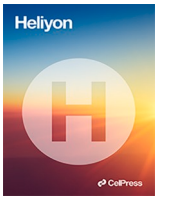

Case report

An unusual case of traumatic injury to the first metatarsal a case report

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ABSTRACT

A 44-year-old male sustained trauma to his foot leading to a 5-cm defect of the first metatarsal bone and infection of the bone by *Staphylococcus aureus*. Osteotomy is the most suitable method for treating large metatarsal defects complicated with osteomyelitis, however few reports have been published on this challenging approach. In this case, osteotomy and external fixation for distraction were performed. Finally, the osteomyelitis of the patient was well controlled, the bone length was restored, and the patient could carry weight completely, and the treatment effect was satisfactory.

1. Introduction

Thorough debridement is the premise of bone infection treatment and the key to reduce recurrence. The infection should be treated as a low-grade malignant tumor, and the hard-to-control bone infection should be transformed into a repairable bone defect [1].

The Ilizarov bone transport method following osteotomy of a damaged bone fragment has been used by orthopedic surgeons worldwide [2–4]. It has been employed for limb lengthening, deformity correction, and bone defect and nonunion treatment. It is based on the theory that under tension-stress stimulation, tissue formation, cell proliferation, and biosynthesis are more vigorous. Furthermore, osteogenesis is stimulated by axial compression and elastic fretting between fracture gap.

Osteotomy is the most suitable method for the treatment of large metatarsal defects with osteomyelitis, however few reports have been published. Metatarsals are relatively short, and the operation is difficult, especially for large traumatic metatarsal defects.

We reported a 44-year-old male sustained trauma to his foot leading to a 5-cm defect of the first metatarsal bone and infection of the bone by *Staphylococcus aureus*. We use the technique of osteotomy, a relatively challenging approach, to treat the patient and achieved remarkable results.

2. Case report

A 44 years old male presented with a chief complaint of left foot pain and blooding by motor. The patient is a car mechanic, who is

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170 cm tall and 80 kg weight, with a BMI of 27.7. He hadn't had any surgery before. His trauma was caused by his foot hitting a high-speed whirling wheel. Physical examination and ultrasound examination confirmed that the patient had no vascular or nerve damage. Antibiotic prophylaxis begins 2 h after injury with cefuroxime.

Physical examination and radiographic imaging revealed a large defect to the skin and soft tissue in the medial portion of the left forefoot (Fig. 1a). Preoperative radiographic measurements indicated that the length of the bone defect was approximately 5 cm, stretching from the proximal third of the first metatarsal bone to the first half of the proximal phalanx (Fig. 1b and c).

After emergency admission, the patient received the following debridement treatment: After irrigating the wound with a large amount of salt water, debridement is carried out from shallow to deep. Necrotic skin soft tissue and tendon tissue without blood transport were first removed, and then the free and heavily polluted fracture fragments without blood transport were removed. Finally, the wound was washed again with normal saline and hydrogen peroxide in large quantities, and then soaked with iodine. After completion, the fracture end was fixed with Kirschner wire and the wound was covered with VSD. Infection prevention (cefuroxime 1.5g, Q12 until 48 hours after the operation) and regular replacement of the VSD were given to the patient. When the wound bed was stable with growth of granulation, autologous skin grafting was performed. Two months after the injury, a small amount of exudate was observed occasionally in the exposed part of the transverse Kirschner needle, but there was no obvious associated swelling (Fig. 2a–c). The level of white blood cells (WBC) and C-reactive protein (CRP) were normal, and erythrocyte sedimentation rate (ESR) was 20 mm/h. Liquid culture from a single point of transverse Kirschner needle was performed twice and were both positive for *Staphylococcus aureus*.

This case included the following problems: a large short bone defect about 5 cm long, and *Staphylococcus aureus* infection indicating osteomyelitis. Our treatment options included the following: free fibula transplantation, intramembranous osteogenesis (Masquelet technology), or distraction osteogenesis. We selected the osteotomy technique as the most suitable method for treating large metatarsal defects with osteomyelitis. However, the metatarsal is relatively small, leading to a challenging surgery.

External fixation was installed using C-arm positioning during the operation (Fig. 3b and c). A 0.8 cm straight incision was made to dissect out the extensor tendon. Osteotomy was performed with minimal damage to the periosteum using percutaneous drilling. Excision of lesioned tissue during the operation for pathological examination revealed fibrous and angioproliferation, local lymphocyte, plasma cell, and neutrophil infiltration, bone necrosis, and pathological changes in line with chronic osteomyelitis (Fig. 3a).

Following a latency period of 7 days, distraction begun (Fig. 4a–c). A total of 5 weeks were lasted until the end of the therapy. As for antibiotic treatment, cefuroxime was given 1.5g Q12 for 2 weeks intravenously and then orally for 4 weeks after diagnosis of osteomyelitis.

Through six years of outpatient follow-up, we learned that the patient recovered well after surgery. Osteomyelitis is well controlled and bone length is restored (Supplementary Fig. 1 shows X-rays pictures of 7 months after surgery and 2 years after removal of the external fixator). No significant limitations were showed in patient's daily life except for stiffness at the bone union. The patient can walk normally and walk for long periods without discomfort. He is fully weight bearing and has returned to work.

3. Technique

The lengthening was performed using a unilateral external fixator (Xinzhong, China) with 3 mm wide self-drilling and self-tapping screws, and two proximal and two distal screws placed on the dorsal aspect. One half-pin was drilled though the proximal portion of the first metatarsal into the second metatarsal to avoid dislocation and excess mobility. A 0.8 cm straight incision was made to dissect

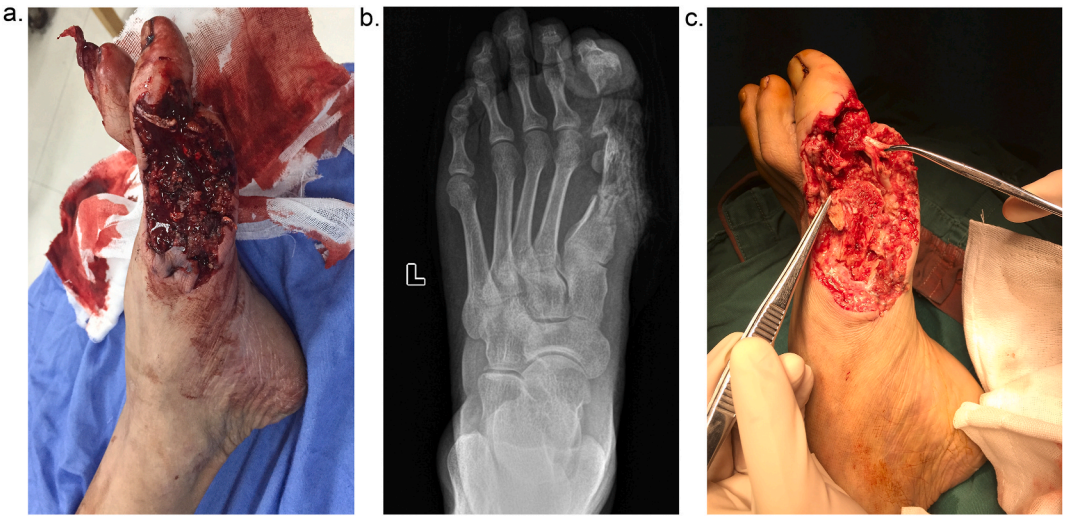

Fig. 1. A 44-year-old male with injured left foot. a. Photos of injuries. b. Preoperative X-ray. c. Intraoperative.

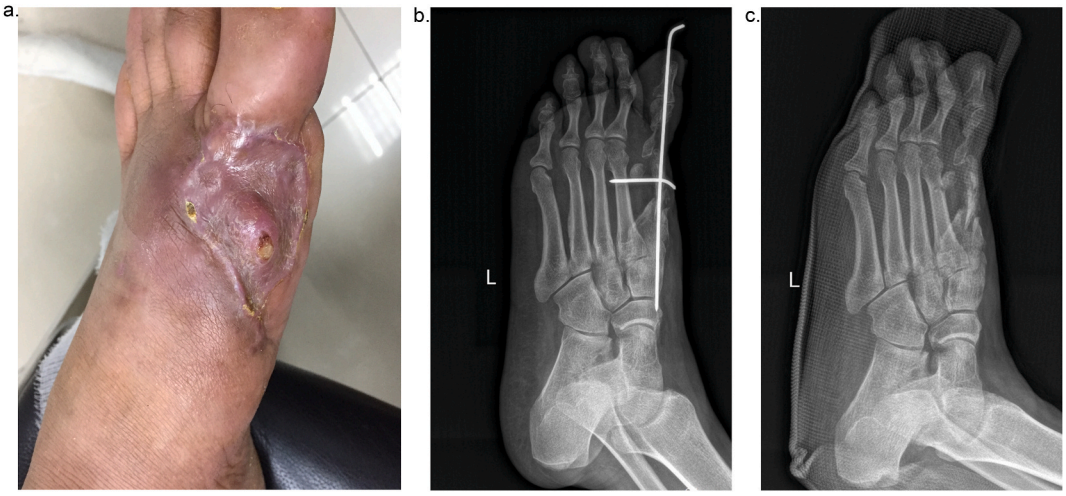

Fig. 2. After debridement and skin grafting. a. Gross appearance. b. Postoperative X-ray. c. X-ray after the removal of the Kirschner needle.

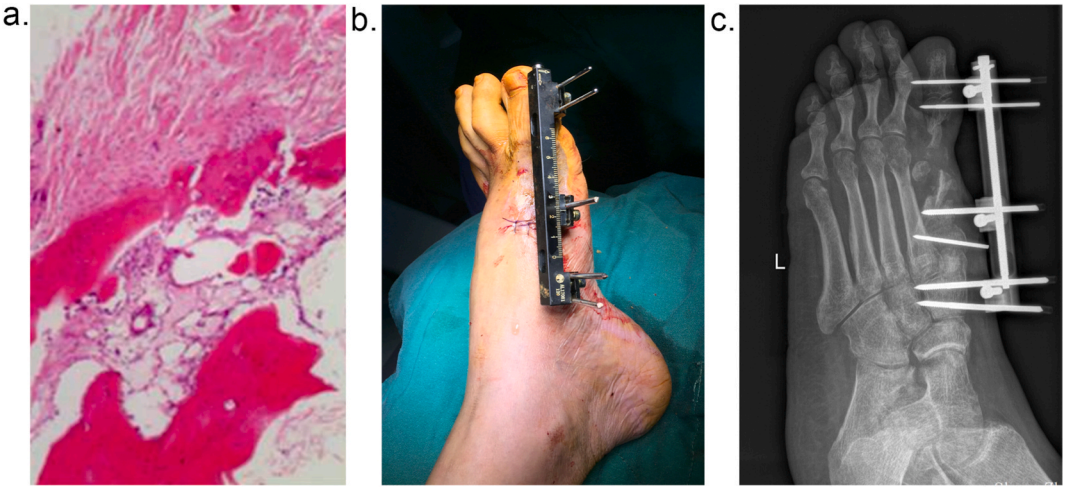

Fig. 3. Distraction osteogenesis using a unilateral fixator. a. Postoperative pathology. b. Gross appearance. c. Postoperative X-ray.

out the extensor tendon. Osteotomy was performed with minimal damage to the periosteum using a percutaneous drilling method [3]. Following a latency period of 7 days, distraction was started at a rate of 4 × 0.25 mm/day (Fig. 3b and c). The speed of distraction is adjusted by routine X-ray review every week. After four times of adjustments, the final speed was 1.75mm/d, and when three cortical bones appeared, the external fixator was removed.

4. Discussion

In 1950, Ilizarov reported his use of distraction osteogenesis according to the tension-stress rule of tissue regeneration [4]. It has been used for limb lengthening, deformity correction, and bone defect and nonunion treatment. It is based on the theory that under tension-stress stimulation, tissue formation, cell proliferation, and biosynthesis are more vigorous. Furthermore, osteogenesis is stimulated by axial compression and elastic fretting between fracture gap.

Distraction osteogenesis is a commonly used and powerful technique for correcting limb deformities, and there are several reports in the literature of its successful use to treat brachymetatarsia [5–7].

This method allows for the achievement of greater bone length while avoiding bone grafting and the associated complications. It is also suitable for multiple lengthening procedures, causes a shorter delay in weight-bearing use after metatarsal lengthening, and results in a lower incidence of neurovascular damage [8]. However, there are few reports on metatarsal bone transport. Metatarsal lengthening, similar to bone transport, is used to treat congenital metatarsal shortening [9,10].

Due to the 5cm long bone defect and *Staphylococcus aureus* infection, the treatment option were limited to free fibula transplantation, Masquelet technology and distraction osteogenesis [11]. For free fibula transplantation, donor site injury and

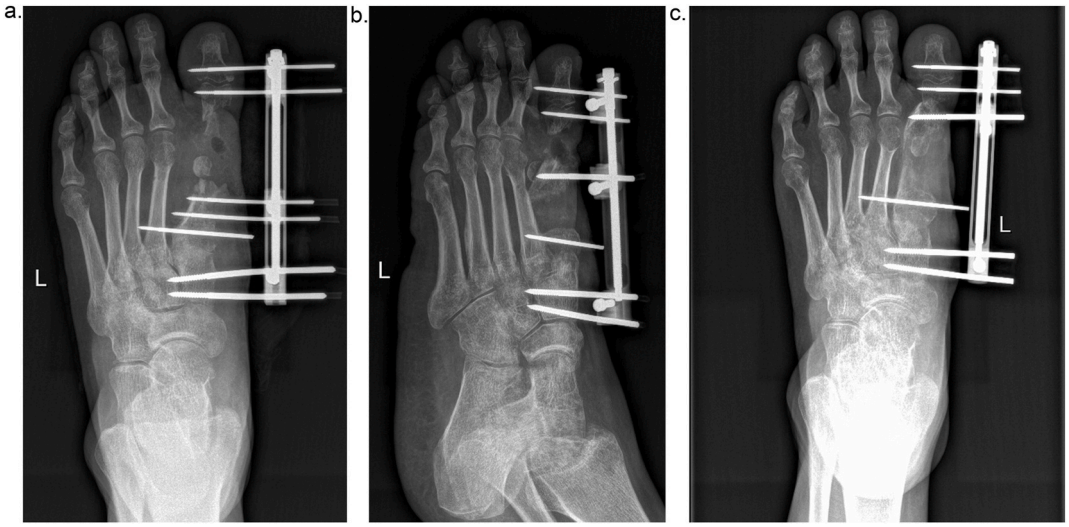

Fig. 4. X-ray taken during distraction osteogenesis using a unilateral fixator. a. 1 week post operation. b. 3 weeks post operation. c. 2 months post operation.

microsurgical techniques need to be considered. For intramembranous osteogenesis, good soft tissue coverage is required [12]. In this case, free skin grafting is used to cover the wound surface, which is not always reliable. Furthermore, for membrane formation, autogenous bone is also needed. Because of these requirements, we concluded that osteotomy is the most suitable method for the treatment of large metatarsal defects with osteomyelitis.

To determine the amount of metacarpal lengthening required, Aydinlioglu et al. [13] presented a formula specifying the mathematical relations between the following metacarpal bone lengths: first metacarpal length = 0.67 × second metacarpal length.

Metatarso-phalangial (MTP) or MCP joint angulation, stiffness, subluxation or dislocation, arthritis, and delayed union or non-union are the most common complications when lengthening the metatarsals for the lesser toe [14]. These outcomes have been observed in instances in which the mean lengthening percentages were more than 40 %, and the lengthening specifications were greater than 0.5 mm/day [15–17].

However, metatarsal bone transport is different from bone lengthening, as it does not take into account the influence on blood vessels and nerves. Vascular and nerve health influence distraction osteogenesis in a number of ways including the stability of fixation, energy of osteotomy, and traction speed and rhythm [18,19]. Rapid traction stretching extended periods of time in daily traction blocks the mineralization of new callus and lead to disordered bone formation [18,20].

In addition, we have paid special attention to the following issues: At the time of injury, the first distal metatarsal bone to the first proximal phalangeal bone, including 3/4 of the first metatarsophalangeal joint, had been damaged, and only one bone fragment remained. Therefore, the first metatarsophalangeal joint cannot be preserved after debridement of bone infection. After osteotomy, the proximal end of the metatarsal bone meets the proximal end of the first phalangeal bone to form a joint fusion. The metatarsophalangeal joint can be preserved if the first metatarsophalangeal joint is intact after injury [21,22], but this patient could not. If symptoms develop later, first metatarsophalangeal joint replacement may be considered. In metatarsal reconstruction, it should be noted that the first metatarsal head cannot be depressed after reconstruction, and appropriate shortening can be carried out, otherwise the patient will have pain in the first metatarsal head after bearing weight [22,23].

In conclusion, distraction osteogenesis is successful and reliable for the treatment of large metatarsal defects with osteomyelitis. The benefits of this method include no need for bone grafting, easier tendon stretching, fewer neurovascular complications, early weight bearing, and more length gain. Although the patient in this case achieved a good therapeutic effect, we believe that the subsequent use of this therapy still needs to pay close attention to complications such as pin tract infection, stiffness, angulation, subluxation of the MCP or MTP joints, and delayed union or non-union to obtain the best curative effect [24]. However, our study has some limitations, such as only one case, short follow-up time, and further observation to determine the long-term efficacy. But overall, we offer here a potential treatment for large metatarsal defects with osteomyelitis.

Ethics statement

Informed consent was obtained from the patient for the publication of all images, clinical data and other data included in the main manuscript.

Data availability statement

Data associated with this study has not been deposited into a publicly available repository and will be made available on proper

request.

CRediT authorship contribution statement

Tinghui Xiao: Writing – original draft, Resources. **Hanjun Qin:** Writing – review & editing, Data curation. **Peizhi Deng:** Project administration. **Jiandong Lin:** Project administration. **Siying He:** Writing – review & editing. **Xiaoming Zhang:** Project administration. **Xinjia Hu:** Supervision, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.heliyon.2024.e30040.

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