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Case Report

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The Management of Problems in Lower Extremity Salvage Using Shortening-Lengthening Technique and Free Flaps: A Case Report

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Abstract

High-energy trauma leads to the increasing number of patients with severe leg injuries, often resulting in severe comminuted bone fractures with large area of soft tissue defects and vascular, nerve and muscle injuries. In the 1950s, Ilizarov technique was applied to the treatment of large tibial defect with bone transplantation and bone lengthening techniques. In recent years, shortening-lengthening technique was also used in the second stage. One case of complex lower extremity injury was also treated by shortening-lengthening technique combined with free flap transplantation. The problems in the process were managed properly. The clinical effect was good and the patients were satisfied. The report is as follows.

Introduction

With the modernization of society, the number of patients with severe trauma caused by high-energy injury is increasing, which often results in severe comminuted bone fracture with large area of soft tissue defects and vascular, nerve and muscle injuries. Such injuries often result in deformities and functional limitations, which seriously affect the quality of life of patients. According to Gustilo classification [1], this kind of injury belongs to Gustilo III. In the early stage, the injured tissue should be thoroughly debrided and the fracture should be temporarily fixed. After the soft tissue defect is repaired and the infection is controlled, the second stage bone defect should be treated according to the situation. Small tibial defect can be treated by autogenous bone transplantation or allogenic bone transplantation. The disposal of large tibial defect is difficult because of the limited amount of bone in donor site [2]. With the guidance of Ilizarov's Law of Tension-Stress (LTS) biological principle theory in the 1950s, the application of ring external fixator in bone transplantation and bone lengthening technology has brought new ideas for the treatment of large tibial bone defect [3]. Iizarov technique is widely used in the treatment of large tibial defect [4]. It is reported that shortening-lengthening technique can shorten the healing time of bone defect and has a good clinical effect [5]. In this paper, shortening-lengthening technique combined with free flap transplantation has been used to treat complex leg trauma, and satisfactory clinical results have been achieved. The problems in the process were managed properly. The treatment process and experience are described as follows.

Case Report

The patient, a 22-years-old man, was admitted to the emergency department of our hospital on Dec. 2, 2011. He suffered from swelling, pain, deformity and bleeding in many parts of the body caused by the traffic accident for 2 hours. Physical examination: swelling and deformity in the right lower limb and ankle, about 30 cm*15 cm tissue defect wound with serious skin contamination, dislocation of ankle joint, exposure of bone, tendon, muscle, nerve and blood vessel ruption defect (Figures 1a,1b).

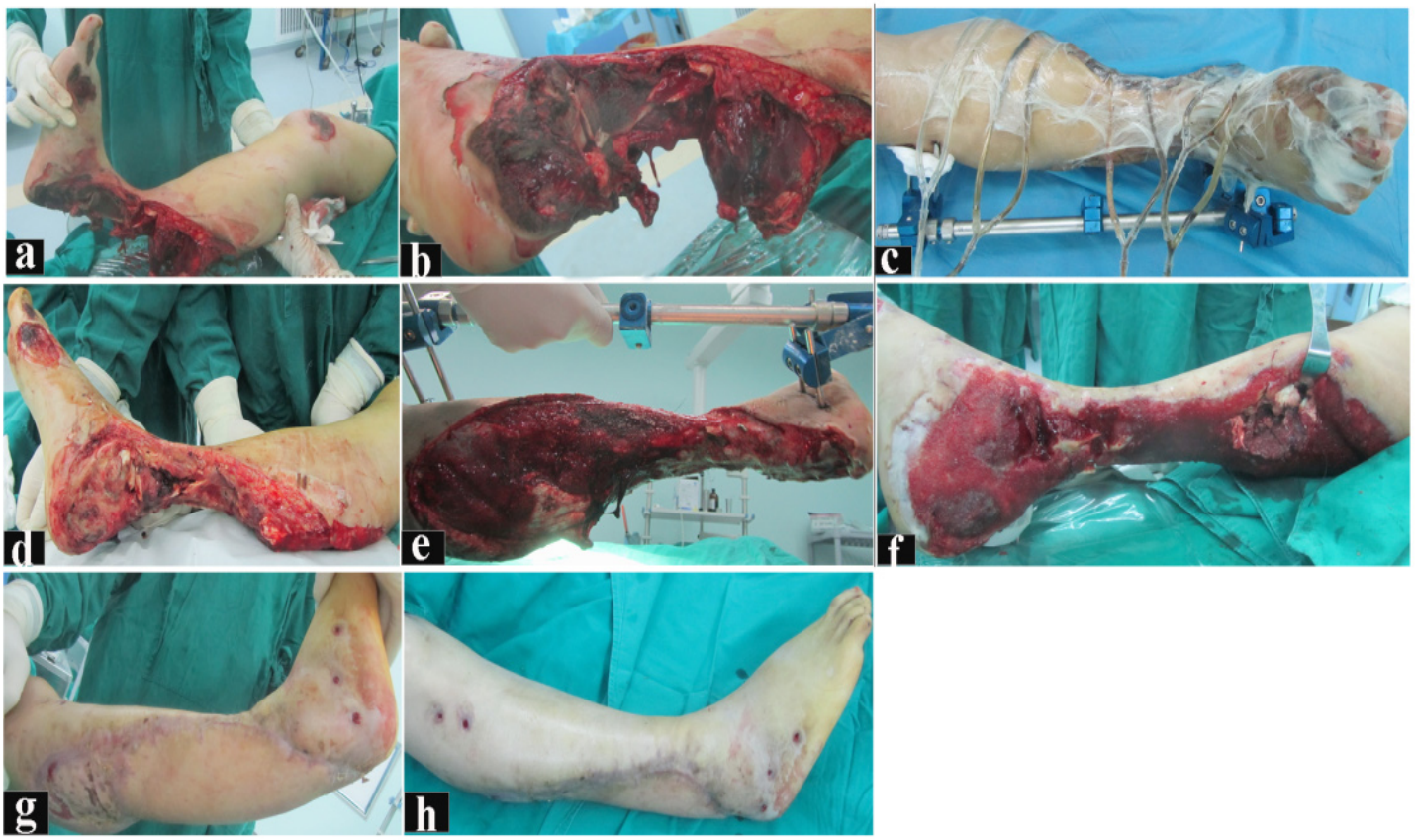

Figure 1: a,b: Appearance photos of the lower right extremity at admission (Dec. 2, 2011); **c:** Appearance photo after emergency operation (Dec. 2, 2011); **d:** Appearance photo when removing VSD (Dec. 9, 2011); **e:** Appearance photo when removing VSD (Dec. 16, 2011); **f:** Appearance photo when removing VSD (Jan. 1, 2012); **g,h:** Appearance photos when The original external fixator of the right tibia was removed and the bone transport was performed (March 7, 2012).

The right lower extremity was characterized by low skin temperature, pale color, no pulsation of dorsal pedal artery, poor sense of distal blood supply. Large tibial defect was seen on X-ray films (Figure 2a). The admission diagnosis was as follows: Absence of tissue in the right lower extremity and the posterior part of the ankle with distal blood supply disorder (most of the posterior muscles, tibial nerve and posterior tibial artery and vein were absent, open defective rupture of anterior tibial muscle, contusion of anterior tibial artery and vein, rupture of great saphenous vein), open comminuted defective fracture of the right tibia and fibula with subluxation of ankle joint, open defective calcaneus and talus Fracture, right femoral condyle fracture, craniocerebral injury, right second rib fracture and traumatic pneumothorax (compression 90%). Emergency operations were performed immediately: debridement and suture of wounds in the right lower extremity, exploration and anastomosis of tendons, nerves and vessels, reduction and fixation of fracture and dislocation, VSD drainage (Wuhan Weisidi Medical Technology Co., Ltd.) corvering the wound surface and a closed thoracic drainage. Intraoperative high ligation of tibial nerve and posterior tibial artery and vein was managed. The ruptured great saphenous vein was repaired by end-to-end anastomosis. The shortening of the lower extremity due to large defect of bone and soft tissue was handled with external fixation (Beijing Fule Technology Development Co., Ltd.). Two Kirschner wires were used to fix the right fibula. Postoperative photographs and X-ray films were respectively showed on Figures 1c,2b. According to the condition of the right lower extremity affected limb, he was performed the surgical treatment of VSD removal, wound debridement and suture and VSD drainage replacement in Dec. 9, 2011 (Figure 1d), Dec. 16, 2011 (Figure 1e) and Dec. 28, 2011, respectively.

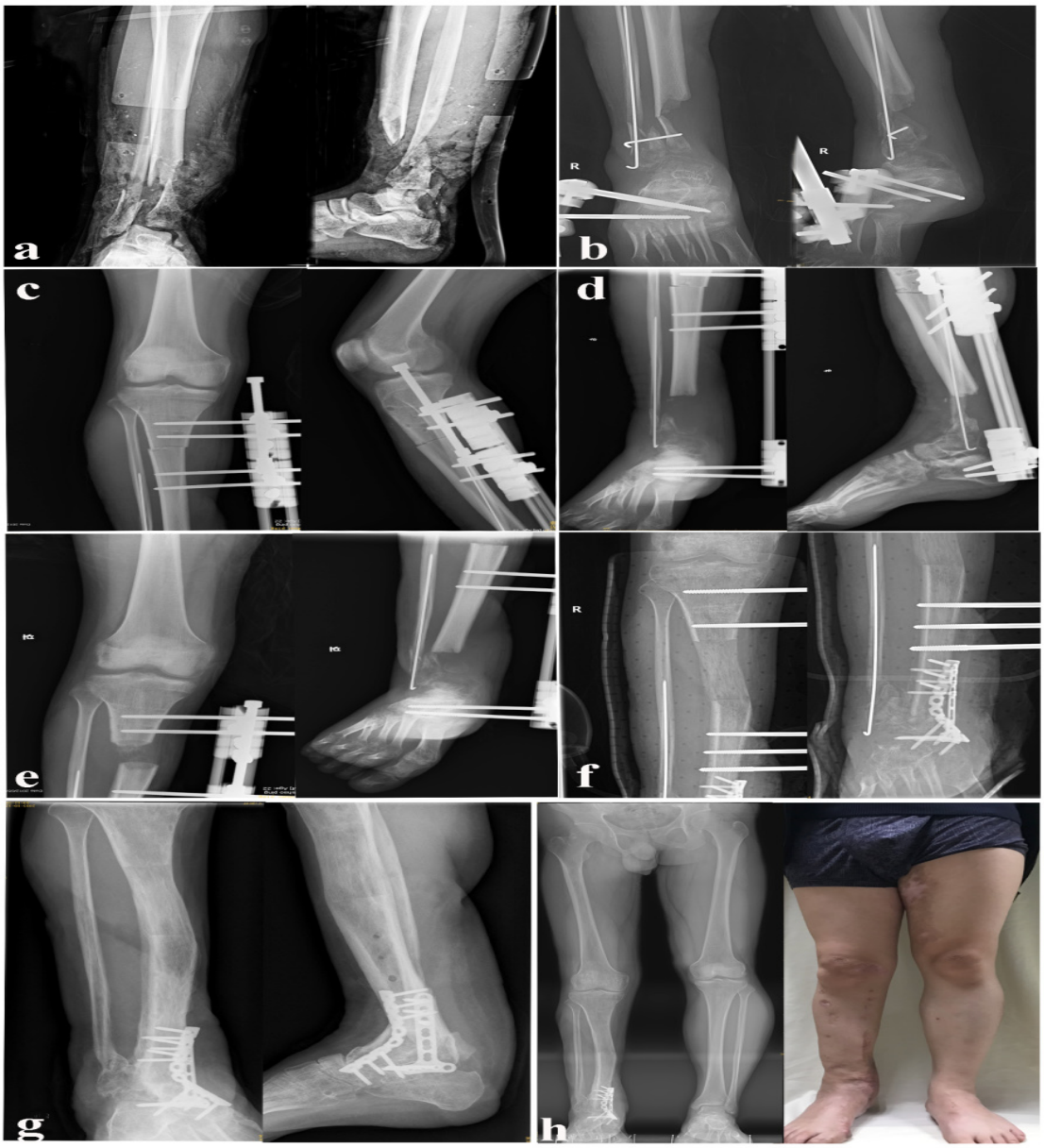

Figure 2: a: X-ray films of right lower extremity at admission (Dec. 2, 2011); **b:** X-ray films of right lower extremity after emergency operation (Dec. 2, 2011); **c,d:** X-ray films after bone transport operation (March 7, 2012); **e:** X-ray films 2 months after bone transport operation (May 7, 2012); **f:** X-ray films after the right ankle joint fusion at 6 months after bone transport operation (Sep. 28, 2012); **g:** X-ray films after removal of the fibula internal fixation (Oct. 11, 2013); **h:** The full-length weight-bearing film and appearance photo of both lower extremities (Dec. 1, 2018) .

The granulation of the wound surface was show on Figure 1f (Jan.6, 2012). The wound of the right lower extremity was debrided and was repaired with the free latissimus dorsi myocutaneous flap and abdominal skin. The latissimus dorsi myocutaneous flap with a size of 25 cm*13 cm was designed on the left scapula along the line between the left axillary posterior arm and the left posterior superior iliac spine. The thoracodorsal artery and vein were maintained in the center of the flap, and the donor area was completely dissected. Reduce and suture the area as far as possible, leaving about a 15 cm*7 cm of wound size. The skin and subcutaneous tissue of about 15 cm*8 cm were cut from the left abdomen. And the mid-thick skin was trimmed. The abdominal incision was sutured and bandaged directly. The free latissimus dorsi myocutaneous flap was transplanted to cover the wound of the right lower extremity. The artery of the flap was anastomosed with the residual end of the right posterior tibial artery, and the vein of the flap was anastomosed with the residual end of the right posterior tibial vein. On the second day post-operation, vascular crisis of the free skin flaps occurred. The right lower extremity skin flap was explored immediately at Jan. 7, 2012. It was found that the vein of the flap anastomosed with the right posterior tibial vein was highly swollen. The color of the vein was purple and the tension of the vein was high. The anastomotic site was cut off. The vein was microscopically anastomosed again. The flap has good blood supply post-operation. Postoperative anti-spasm, anti-platelet coagulation, anti-infection, regular dressing change nursing were performed. The flap grew well at March 7, 2012. The original external fixator of the right tibia was removed, and the bone transport was performed Figures 1g,1h. Two external fixation screws were drilled into the proximal medial part of the right tibia and the medial part of the right calcaneus. Two screws were drilled into the middle part of the tibia as traction screw. The right tibial tubercle was osteotomized about 3 cm below the right tibial tubercle. X-ray films post-operation were showed on Figures 2C,2d. X-ray films 2 months' post-operation were showed on Figure 2e.

A screw was drilled into the medial part of the middle tibia to adjust the axis due to the deviation of the axis of the right tibia to the lateral side at May 7, 2012. The patient can have partial weight-bearing one week after the bone transport and complete weight-bearing one month later. At July 3, 2012, the patient was discharged from hospital for 214 days on account of the good condition of the flap and the stable external fixation. At Sep. 28, 2012, tibial transport was completed with a total traction of 7.5 cm. Because of the old fracture of the right ankle and dysfunction, the patient was admitted to our hospital for the right ankle fusion operation. Wedge-shaped osteotomy surface was designed and 90 degrees of the ankle joint was fixed with anterior and medial plate and screw. Autogenous iliac bone was grafted to the bone defect. The metatarsal aponeurotomy was performed and the X-ray films post-operation were showed on Figure 2f. At Oct. 11, 2013, the right fibula internal fixation was removed and X-ray films were examined Figure 2g. The right ankle plate and screws were removed at Oct. 12, 2013. The patients were followed up for 7 years up to Dec. 1, 2018. The patient has been back to work normally. The full-length weight-bearing films of lower limbs and the appearance photos were showed on Figure 2h.

Discussion

In the 1950s, Ilizarov put forward Distraction Osteogenesis (DO) technology based on LTS through a lot of clinical practice and basic research. The stimulating effect of stretching stress on tissue growth and regeneration can induce proliferative compensatory adaptation of skin, fascia, muscle, nerve and blood vessel. The new bone tissue formed after stretching is mineralized by intramembranous ossification. The normal bone tissue is formed under stress stimulation. Bone transport, also known as bone shortening and lengthening, is a method to treat bone defects caused by bone tumors, osteomyelitis and trauma based on the theory of distraction osteogenesis. The proximal and distal parts of the bone defect were fixed with 2-3 external fixator pins. Then, according to the location of the bone defect, the upper or lower parts of the defect were osteotomized. The cut bone segments were fixed with movable pins to the proximal or distal parts. The bone segments were moved 4-5 times a day at a speed of 1 mm/d. The bone segments were newly formed by distraction stress on the osteotomy surface. When the bone ends meet, they healed under normal physiological stress to repair large bone defects [3,6].

At present, traumatic bone defects of extremities caused by high energy injury are increasing. Large tibial bone defect is often combined with large area soft tissue defect. According to the principle of trauma treatment, debridement should be completed as soon as possible. And the free flap should be used to cover the wound. Anastomose blood vessels and fix the fracture end. The second stage of bone defect repair was allowed in case of the better condition of soft tissue [7]. For bone defect less than 3 cm, autogenous or allogenic bone transplantation can be used. For bone defect larger than 3 cm, bone transport or bone shortening and lengthening technique can be applied to reconstruct the defect. According to Gustilo classification, the patient was classified as Gustilo III IC type. The bone, tendon, muscle, nerve and blood vessel were exposed Figures 1a,1b. The lower right extremity was characterized by low skin temperature, pale color, no pulsation of dorsal pedal artery and poor sense of distal blood circulation. Large tibial defect was showed on X-ray films. The right lower extremity wound was debrided and sutured in 4 hours. Exploratory anastomosis, reduction and fixation of fracture and dislocation, and VSD drainage of wound provided an opportunity for the second stage treatment of large bone defect. The patient suffered from severe tissue injury and contamination when admitted to hospital.

After emergency operation, debridement and VSD drainage were performed for many times until the granulation tissue grew well. The latissimus dorsi myocutaneous flap and abdominal skin were used to transplant the soft tissue defect according to the tissue defect size about 25 cm*13 cm. Postoperative care should be taken whether there is a venous or arterial crisis of the flap. Once it exists, the blood vessels should be explored immediately. In this case, the tibial defect was about 7.5 cm. The large tibial defect was treated by bone shortening and lengthening technique. The patient can be back to work normally and the clinical effect was satisfactory.

However, many deficiencies in the process of bone shortening and lengthening may occur such as long treatment cycle, poor patient compliance, needle infection, poor callus growth, delayed union or non-union of the bone end, axial displacement of the segmental bone, stiffness of adjacent joints, skin and soft tissue invagination, chronic pain, etc. [8]. The treatment and rehabilitation time of our case was more than one year. Axial displacement of bone segment occurred in 2 months after bone transport. The screw was added to the bone segment to correct the distraction alignment. Six months later, the patient developed dysfunction of the right ankle joint. He was re-admitted to the hospital for right ankle joint fusion. Wedge osteotomy was designed with 90 degrees of the ankle joint. Anterior and medial plates and screws were used to fix the ankle joint. Autogenous iliac bone graft was applied to the bone defect and metatarsal aponeurotomy was performed.

Conclusion

At present, shortening-lengthening technique is mainly applied to the treatment of lower extremity salvage. In addition, it may be combined with intramedullary fixation, intramembranous induction, free fibular transplantation, tissue engineering and other technologies. In the article, one case of complex lower extremity injury was treated by shortening-lengthening technique combined with free flap transplantation. The problems in the process were managed properly. However, the treatment of large bone defect is still a clinical problem. There are still thorny problems to be solved in the reconstruction of limb function. This paper is also a retrospective case study, which needs to be confirmed by a large number of case studies.

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No conflict of interest exits in the submission of this manuscript, and manuscript is approved by all authors for publication. I would like to declare on behalf of my co-authors that the work described was original research that has not been published previously, and not under consideration for publication elsewhere, in whole or in part.

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