Case Report

Introducing Negative Pressure Wound Therapy for Lower Limb Defects: A Report of Three Cases of Open Fractures Fixed with Ilizarov External Fixator

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ABSTRACT

The Ilizarov external fixator fixes the ring frame to the bone using steel wires and pins, then connects the plurality with rods. It enables stronger fixation and adjustment in various angles and directions than that by other modular external fixators. It is often used for damage control and reduction fixation of open fractures, but there are difficulties in handling necrotic skin and soft tissue over time. In particular, when the bone is exposed, it is recommended to cover it with a flap or skin graft as soon as possible. However, in cases of a wound surrounded by an Ilizarov external fixator, flap plasty would be challenging due to the large number of steel wires and pins inserted. Therefore, the wound needs to be carefully managed until it is closed.

We report three cases of lower limb open fractures with tissue defect, in which negative pressure wound therapy was introduced simultaneously with fixation using the Ilizarov external fixator and proper wound management.

Key words: Ilizarov external fixator, negative pressure wound therapy (NPWT), wound management

Introduction

In case of an open fracture, debridement, reduction fixation, and wound closure should be performed as soon as possible¹,²; however, this may not be clinically feasible in some cases. Even in these cases, it is known that there is not so much increased risk of infection when proper management is performed³⁴⁶. If there are concerns about bleeding, infection, or flap blood flow not secured, temporary or long-term external fixation may be required. An Ilizarov external fixator is installed to surround the part to be fixed by connecting the ring-shaped frame with rods. It is suitable for long-term installation because it can be adjusted three-dimensionally, and the load can be applied to the affected limb⁵. Wound management with negative pressure wound therapy (NPWT) is useful for wounds that require drainage and where early shrinkage is desired⁶⁷⁸. In cases of a wound surrounded by an Ilizarov external fixator, the installed ring frame and a large number of inserted steel wires make it challenging to introduce NPWT. We report three cases in which NPWT and wound management were performed for a tissue defect in the lower limb with an open fracture, fixed with Ilizarov external fixator with some ingenuity.

Patients

The patients were trauma patients who were transported to our emergency department by ambulance, with ages ranging from 44 to 68 years old. All of them were involved in traffic accidents and sustained open fractures of the lower limbs (Table 1).

Method

All the patients were admitted to the operating room within 8 hours of the emergency call (Table 1). Debridement and vascular embolization were performed as needed. A modular external fixator (Hoffmann II external fixation system, Stryker) was used for the initial fixation. Once debridement was completed and the wound was stabilized, the modular external fixator was used for damage control and reduction.
fixator was later replaced with an Ilizarov external fixator (Ilizarov external fixator system, Smith & Nephew or Orthofix, Japan Medicalnext). Tissue defect wounds were managed by NPWT. We selected RENASYS®, (Smith and Nephew) as manufactured NPWT device. Adhesives and pastes were used in advance in areas where film peeling and pressure leakage were expected (Fig. 1). Negative pressure of 120 mmHg was applied. After obtaining a sufficient amount of granulation tissue in the wound, split-thickness skin grafting was performed.

Case 1

A 44-year-old woman driving a truck was injured in a rear-end collision with a passenger car, then was transported by ambulance. An open fracture of the left lower leg and a complete rupture of the tibialis anterior muscle were observed (Fig. 2). Since the wound was heavily contaminated and the blood flow in the wound that was exfoliated and became a flap was unstable, debridement and external fixation by a modular external fixator was performed on the day of the injury. Debridement was also performed on post-injury day (PID) 1 and 3 (Fig. 3A). When the necrotic area of the flap became clear (Fig. 3B), debridement was performed and the external fixator was replaced with an Ilizarov external fixator on PID6 (Fig. 3C). After confirming hemostasis, NPWT was introduced on PID7. The wound spanned two-thirds of the circumference of lower leg, and there were a large number of inserted steel wires and ring frames, so effective sealing could not be obtained. However, a certain degree of sealing was done by filling the entire circumference of the ring frame with the wound filler and covering the entire ring frame with a film (Fig. 3D). First, we attempted to use a manufactured NPWT device; but it did not work due to a lot of exudation that required frequent replacement of the canister. Moreover, leakage of pressure through the film occurred beyond the function of the manufactured device. Therefore, a normal suction unit installed in the patient’s room was used for the first six days. Although the negative pressure applied by the suction unit was not set accurately, we determined the negative pressure to be 120 mmHg while referring to the filler shrink temporarily connected to the manufactured NPWT device. After obtaining a complete seal, the manufactured NPWT device was used on PID13. Sufficient wound shrinkage and good granulation tissue

| Patient number | Sex | Age | Site          | Gustilo classification | Time from emergency call to admission to operating room | Days after injury to introduce Ilizarov external fixator/NPWT | Days after injury to skin grafting |
|---------------|-----|-----|---------------|------------------------|--------------------------------------------------------|---------------------------------------------------------------|----------------------------------|
| 1             | F   | 44  | Left lower leg| Grade IIIb             | 7 h. 11 min.                                           | 6/7 days                                                      | 34 days                          |
| 2             | M   | 56  | Right thigh   | Grade IIIC             | 4 h. 10 min.                                           | 25/28 days                                                   | 59 days                          |
| 3             | M   | 68  | Left ankle    | Grade IIIb             | 3 h. 33 min.                                           | 10/10 days                                                   | 50 days                          |

NPWT: negative pressure wound therapy.
growth were observed (Fig. 3E); thus, split-thickness skin grafting from the thigh was performed on PID34. After skin grafting, no skin defects were observed 119 days after the injury (Fig. 3F).

Case 2

A 56-year-old man driving a motorcycle collided with a truck, fell, and was injured, then transported by ambulance. An open fracture of the left femoral trunk and deep femoral artery injury were observed (Fig. 4A). On the day of the injury, coil embolization of the deep femoral artery was performed. The thigh was degloved, while the flap blood flow was unstable; therefore, external fixation was performed with a modular external fixator. The flap became congested and necrotic over time (Fig. 4B); then debridement was performed on PID13. The loss of soft tissue in the skin resulted in necrosis of the exposed femur (Fig. 4C). On PID25, debridement was performed, the necrotic femur was resected, and an Ilizarov external fixator was introduced (Fig. 5A and B). NPWT was introduced on PID28, while steel wires that fix the ring frame were also inserted at the center of the wound. Afterward, the wound filler was placed on the craniocaudal side, the film was attached, and then a paste material (Adapt skin protection seal, Hollister) was wrapped around the steel wires to obtain a seal (Fig. 5D). There was a gap of approximately 15 mm in the

Fig. 2. A 44-year-old woman sustained an open fracture of the lower leg. Immediately after transportation; Frontal view (A), side–posterior view (B).

Fig. 3. After initial reposition, skin flap became congestive 3 days after the injury (A), 5 days after the injury (B). An Ilizarov external fixator was introduced 6 days after the injury (C). NPWT was introduced 7 days after the injury (D). The wound was covered with sufficient granulation tissue at 34 days after the injury (E). After skin grafting, no further skin defect was observed 119 days after the injury (F).
bone trunk at the time of debridement, which was continuously shortened and joined on PID31 (Fig. 5C). Sufficient wound shrinkage and good granulation tissue growth were observed, so split-thickness skin grafting from the thigh was performed on PID59 (Fig. 5E). After skin grafting, no skin defects were observed 86 days after injury (Fig. 5F).

**Case 3**

A 68-year-old man driving a moped was injured in a collision with a passenger car, then transported by ambulance. Open fracture of the left ankle, scaphoid fracture, and rupture of the flexor digitorum longus tendon were observed (Fig. 6A and B). Debridement was performed on the day of injury. The flap...
on the heel was intricately damaged, while the fractures were fixed using a modular external fixator (Fig. 6C). On PID10, debridement was performed and an Ilizarov external fixator was introduced (Fig. 6D) simultaneously with NPWT. Skin necrosis of the heel progressed, interrupting NPWT on PID15. Debridement was then performed on PID23 and PID29, while NPWT was resumed on PID29 (Fig. 7A and B). Sufficient wound shrinkage and good granulation tissue growth were observed, so split-thickness skin grafting from the thigh was performed on PID50 (Fig. 7C).

**Discussion**

The Ilizarov external fixator is an external fixator developed by Ilizarov GA\textsuperscript{[10, 11].} The ring-shaped frame is fixed to the bone trunk with steel wires and pins, and the target bone is fixed in the reduction position by connecting multiple rings with rods. Since the surface to be reduced is securely fixed by the ring frame, it is possible to adjust all vectors by changing the length, position, rotation, and distance of the rod. Due to the distributed weight by the ring frame, this can be loaded and is suitable for long-term indwelling\textsuperscript{[7].} There are many cases of open fractures where one-stage surgery does not result in final reduction fixation and wound closure. For example, there are cases if the wound is highly contaminated and the risk of infection is considered high even with debridement, or if bleeding cannot be controlled and reliable hemostasis cannot be guaranteed. There are possible cases where there is vascular damage and necrosis of bones, muscles, soft tissues, skin, etc.; hence, the Ilizarov external fixator is a good indication when wound closure is not expected soon, and when fixed adjustments will be required frequently. During long-term external fixation of open fractures, soft tissue defects in the skin are at risk of exposing the fracture. Thus, these must be covered and treated with caution. NPWT is known to be highly effective for wound management of tissue defects. It is a method that can accelerate wound contraction by draining the exudate from the wound with negative pressure. The NPWT system seals the wound through a film on the normal skin and creates negative pressure in the wound by applying suction pressure\textsuperscript{[9].} To obtain a sealed environment, it is important to firmly adhere the film to the entire skin. We always interpose the adhesive material between the film and the skin of the part that is easy to peel. The film is vulnerable to sharp objects and is easily torn; thus, it is good to blunt it by applying paste materials to the tip of the object in advance. Even if there are objects that would penetrate the film, paste materials are effective in preventing leaks. When introducing NPWT into a tissue defect wound in an open fracture fixed with an Ilizarov external fixator, the presence of a large number of inserted steel wires and ring frames placed

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**Fig. 6.** A 68-year-old man sustained open fractures of the left ankle and scaphoid; on the date of injury, medial view (A), posterior view (B). Initial reposition was performed using a modular external fixator (C). An Ilizarov external fixator was introduced 10 days after the injury (D).
around the bone make it difficult for film application. In addition, when the wound is large, there are cases where there is not enough normal skin to which the film can be applied; or when there is a lot of exudate, existing products cannot handle it. In the first case, since the wound covered 2/3 laps of the lower leg, the skin area for fixing the film material was insufficient when the wound filler was filled; moreover, the clearance with the rod could not be secured, so the film could not be inserted. Therefore, it was decided to fill the inside of the external fixator with wound filler and suction the whole. There were many leaks because the film was attached all around. The adhesive part between the skin and the film was sealed with a gel patch (RENASYS® adhesive gel patch, Smith & Nephew), while the part where the metal protruded from the ring frame was sealed using a paste material (Fig. 1A). If there is a large amount of exudation, the canister may be replaced frequently, so a reservoir may be interposed; however, the leak at the same time prompts the use of a normal suction unit that is installed in the patient’s room12). When multiple steel wires come out directly from inside of the wound, leaks are likely to occur due to the steel wires penetrating the film; hence, a seal is obtained by wrapping paste material around the roots of all the steel wires (Fig. 1B, C). Some reports suggest that the risk of infection may increase if NPWT is introduced over seven days after injury in cases of open tibial fractures13,14) In the first case, NPWT was introduced after resection of the necrotic bone, so no bony infection occurred until skin grafting. Of course, wound closure is expected as soon as possible, but if not possible, NPWT management reduces the complexity of the soft tissue procedure required to achieve wound closure15).

Conclusions

The introduction of an Ilizarov external fixator is useful in cases of open lower extremity fractures that require temporary or relatively long-term external fixation. If there is a tissue defect, we recommend the simultaneous application of NPWT for wound management.

Acknowledgments

None.

Conflicts of interest

None.

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