Treatment of Gustilo grade III leg fractures by external fixation associated with limited internal fixation

ZHANG Chun-qi, ZHENG Hong-yu, WANG Bing, HUANG He, HE Fei* and ZHAO Xue-ling

Objective: To explore the clinical effects of external fixation associated with limited internal fixation on treatment of Gustilo grade III leg fractures.

Methods: From July 2006 to December 2008, 40 cases of Gustilo grade III leg fractures were emergently treated in our unit with external fixation frames. Soft tissue injuries were grouped according to the Gustilo classification as IIIA in 17 cases, IIIB in 13 cases, and IIIC in 10 cases. All the patients were debrided within 8 hours, and then fracture reposition was performed to reestablish the leg alignment. Limited internal fixation with plates and screws were performed on all the Gustilo IIIA cases and 10 Gustilo IIIB cases at the first operation. But all the Gustilo IIIC cases and 3 Gustilo IIIB cases who had severe soft tissue injuries and bone loss only received Vacuum-sealing drainage (VSD). Broad-spectrum antibiotics were regularly used and VSD must be especially maintained easy and smooth for one week or more after operation. Limited internal fixation and transplanted free skin flaps or adjacent musculocutaneous flaps were not used to close wounds until the conditions of the wounds had been improved.

Results: The first operations were completed within 90-210 minutes (170 minutes on average). The blood transfusions were from 400 ml to 1500 ml (those used for anti-shock preoperatively not included). All the 40 patients in this study were followed up for 6-28 months, 20.5 months on average. The lower limb function was evaluated according to the comprehensive evaluation standards of leg function one year after operation and the results of 28 cases were excellent, 9 were good and 3 were poor.

Conclusion: External fixation associated with limited internal fixation to treat Gustilo grade III leg fractures can get satisfactory early clinical therapeutic effects.

Key words: Leg; Fractures, open; External fixators; Internal fixators

High-energy leg injuries have been increasing year by year, of which open injuries account for 6%-8%. Open injuries commonly have the characteristics of large raw surface, serious contamination, poor blood supply and bad soft tissue condition, thus it is difficult to apply internal fixation and cover the wound surface. Previous reports found high infection rates. How to judge the degree of injury and take proper treatments timely and precisely, as well as how to decrease the infection rate and shorten the treatment course has always been the problems that clinicians have faced.

External fixation has been widely used in clinic currently, but it still needs further research on how to combine limited internal fixation to increase the stability of fractures, shorten the treatment course, and improve the therapeutic effects if the conditions of the wound surface permit. In this article, we retrospectively studied the data of 40 cases of Gustilo grade III leg fractures treated with external fixation associated with limited internal fixation in our department from July 2006 to December 2008.

METHODS

General data

The data of 40 patients, 26 males and 14 females, aged 18-45 years, 26.5 years on average, with Gustilo grade III leg fractures treated with external fixation...
associated with limited internal fixation from July 2006 to December 2008 were retrospectively studied in this article. Among them, 16 were injured by traffic accidents, 11 by crashes with heavy objects, 7 by crushes and 6 by falls from a certain height. According to the AO classification, fractures were classified as 41C in 7 cases, 42C in 14 cases, 43C in 11 cases, 42C+43B in 3 cases, 33B+41C in 3 case, and 43C on the left side+42B on the right side in 2 cases. Among them, 3 cases were combined with spine fractures and 2 with pelvic fractures. Operations were made 6-8 hours after injury with the mean time of 7.8 hours. Soft tissue injuries were grouped according to the Gustilo classification as IIIA (serious soft tissue damage without bone exposure, 17 cases), IIIB (serious soft tissue damage with bone exposure, 13 cases), and IIIC (serious soft tissue damage with bone exposure and important blood vessel injury, 10 cases). Among them, 6 cases were combined with leg skin avulsion with the avulsion area accounting for 8%-40% of the leg skin and 4 cases with partial tibia defect (Figure 1). Patients combined with head injuries, visceral injuries or patients with the mangled extremity severity score (MESS)>7 were excluded from this study.

Operative procedure

After a good control of shock and life-threatening complications, all the patients received operation within 8 hours after injury.

After general anesthesia, we initially irrigated the wound surface, judged the injury degree and injury range, and carried out the standard debridement. Contusive skin edges were cut for 1-2 mm, severe bruised and devitalized tissues, including subcutaneous fat, fascia, muscles, tendons, etc, were completely cleaned out. But important blood vessels and nerves ought to be left as far as possible after peeling the contaminated adventitia. Broken bones were retained as far as possible to prevent bone disunion unless they were too small. Avulsed skins were especially opened up and debrided. Crural fascial compartmental relief incision was made routinely.

Prosthesis began once debridement had been completed. First of all, the lower limb alignment was reestablished by traction and the parallel between the knee and the ankle was especially paid attention to. We got the stability and balance mostly by an external fixator (Stryker, Hoffmann external fixation, USA). Screws were not placed in open fractured sites or soft tissues in bad conditions. Three-dimensional frames were implanted for the convenience of dressing change and postural drainage. As for the 43C type fractures, external fixators can constitute a triangle structure across the ankle joint, maintaining the stability of the ankle joint after reduction. If soft tissue conditions permit, bridge plates were used to connect the upper and lower sides of fractures. As for those soft tissues in bad conditions, lag screws were applied to fixate bone mass and strengthen the stability. Patients with serious contamination of soft tissues or difficulty to cover wound surface, vacuum-sealing drainage technique (VSD) was applied to close the wounds. Negative pressure aspiration was continued until infection was under control and granulation tissues grew well, and then secondary skin graft or skin flap transposition was applied to cover the wounds. As for the patients with skin avulsion, dissected skins were poked a hole so as to close the wounds with mesh grafts (Figure 2).

Postoperative treatment

Patients were regularly given antibiotics for 5-7 days after operation. It was important to prevent infection to maintain VSD easy and smooth for a week or more. Heat energy lamps were switched on above the wounds to keep the leg warm. Drugs that could induce thrombosis were not used. Limb blood circulations were observed carefully, pinpoints of the external frame were cared, and X-ray was performed to observe the reduction of fractures. External frame were adjusted to improve the leg alignment if necessary, and functional exercises of unfixed joints were encouraged as early as possible after operation. Patients were followed up till fibrous bones had been observed to grow on X-ray films. When local press pain and percussion pain in the axial direction diminished, external fixators could be dismantled and the internal fixators were remained till bone union.

RESULTS

All operations were completed within 90-210 minutes (170 minutes on average). Blood transfusions were 400-1 500 ml (not including those for antishock preoperatively). All the 40 patients in this study were followed up for 6-28 months, 20.5 months on average. Lower limb functions were evaluated according to the
Figure 1. Preoperative X-ray of the Gustilo IIIIC and 43C fractures.

Figure 2. External fixation combined with limited internal fixation by a bridge plate striding across the ankle.

Figure 3. Degloved skin healed after in situ hole poking and skin grafting.

DISCUSSION

Debridement of Gustilo III leg fractures
The majority of leg Gustilo grade III fractures are caused by high-energy injury frequently with crushed pieces, large wound surface, serious contamination, severe soft tissue injury or even combined injuries of nerves, blood vessels or other organs. Anatomically, there are few soft tissues and skins close to the neighbor bones of the leg, so it is difficult to cover the wound surface. Thus, treatment of this kind of fracture requires careful preoperative preparation, injury evaluation, debridement, and excision of the severely injured and necrotic tissues judged according to their viability, color, contractibility and bleeding. Severely injured and devitalized muscles, tendons should be excised thoroughly but the basic integrality of the tissues should be kept as far as possible. The external membranes of undisrupted but contaminated nerves and blood vessels should be peeled carefully to clear the pollutants. For the raw surface difficult to cover at the first stage, deeply contaminated or easily infected, VSD was performed to drain the effusion thoroughly, decreasing tissue filling, vessel afterload and inter-tissue pressure, improving capillary circulation and blood flow, elevating oxygen supply of local tissues, and lightening tissue edema. Besides, it is good for narrowing the raw surface and shortening the waiting time before flap transplantation. It can also form a shield circumstance isolated from the outer world to prevent invasion of outer bacteria, thus lowering the mixed infection rate.

Methods for fracture fixation
We used interlocking bone nails to realize axis fixation, which has small stress shrink and little influence on periphery tissues, making it mechanically advantageous in the treatment of long bone fractures. It is the main method to treat diaphysis fractures, but the placement of nails has a risk of causing infection to spread over the internal bone marrow for severe open fractures. Therefore, it should be very cautious to use bone nails on patients with open fractures.

Plate-screw technique mainly includes the techniques of neutrality plates, bridge plates and compression plates. The traditional compression plate is thick and needs many screws. When it is used in open leg fractures, the lack of soft tissues to cover it could increase the incidence of infection, skin necrosis, delayed bone union, bone nonunion and exposure of internal fixations. In recent years, the concept of biological osteosynthesis has been widespread in fracture treatment with plates and screws. Its core content is to protect the biological circumstances of bone healing.
especially the blood supply of the fractured extremities, to apply the concept of “endoprosthesis” into fracture fixations using commonly or specially designed plates to bridge fixations, and to utilize the reduction of tendons and indirect reduction technique to realize the reposition of fractures.

In 1997, Krettek et al proposed the concept of minimally invasive plate osteosynthesis (MIPO), in which bridge plate technique is the comparative classic theory. In this technique, plates with only two ends of the plates are fixed stride over the comminuted fractured areas, which can support and maintain the fracture contraposition. There is no direct stress transduction between the main fractured blocks of the two sides. The plate takes all the functional loadings at the early stage, which belongs to elastic fixation in biomechanics. The secondary healing of fractures is achieved through callus formation. The advantages of bridge plates include: (1) There is no need to peel and expose the fractured blocks, which can protect the blood circulation around the fractured parts and tissues and is in accordance with the biological fixation principle; (2) It can provide stable and reliable elastic fixation; (3) Stability does not depend on the friction between the compression plates and the bone, which avoids local osteonecrosis caused by firm fixation; And (4) it can also lower the risk of delayed union and nonunion of fractured bones.

Bridge plates showed apparent superiority in clinical application. Joseph considered that an effective operation consists of indirect reduction, decreased exposure and minimal invasive implant of plates. Krettek et al applied this technique to the treatment of middle and lower tibia fractures and achieved a positive effect, which also confirmed that it can reduce the risk of leg blood vessel injury. Farouk et al and Baumgaetel et al separately made comparative experiments between compression plates and bridge plates on flesh human corpses and sheep femurs. Results of their experiments proved that indirect reduction has minor blood flow destroy and can achieve a quicker fracture healing.

External fixation with frames, which can be combined freely and and construct stable, easily-adjustable rigid connectors quickly, is another important technique to treat open fractures. This technique is minimal invasive, safe and simple. The implant sites are far from the fractured extremities, which brings little interference on the fractured area, makes no new local injuries, and makes it easy to remain limb length and alignment. It is also good for protecting local blood circulation and reducing infectious risks. Appropriate use of external frames can reduce the surgery times and shorten the course of disease.

**Advantages of external frames combined with limited internal fixation**

With the development of the theories and techniques of fixations of orthopedic biology, a minimal invasive technique that combines the biomechanical advantages of different fixations is gradually employed in clinic. Furthermore, it shows important function in treatment of severe fractures.

Gustilo grade III leg fractures belong to comminuted fractures with poor conditions of the whole body, severe injuries and raw surface difficult to cover. Application of external frames can stabilize the fracture in a short time, keep comparatively good contraposition and alignment, and also provide favorable conditions for dressing change, skin treatment and early functional exercises. But for severe comminuted fractures, in order to achieve relatively stable fixation and strive for anatomic reduction, just an external frame often cannot provide enough stability. Therefore, to obtain comparably ideal fixation, fracture reduction and functional recovery, combined bridge plates are considerable, which can strengthen fracture fixation and also provide favorable conditions for early functional exercises after the removal of external fixation, avoiding late complications like ankylosis, functional impairment caused by internal joint fixation. However, the technique of bridge plates is bases on the principle of indirect and flexible biological fixation. Therefore, it is difficult to obtain comparable effects of fixation and anatomic reduction as compression plates. Even worse, if the bases of ideal contraposition and alignment were lacked, malunion, delayed union of fractures and influenced function recovery were probable. Thus, combined external frames can make up the weakness of insufficient stability; meanwhile, combined lag screws, VSD, skin grafting for second intention, etc, can further benefit the coverage of this kind of fracture.

The treatment of Gustilo grade III leg fractures by external frames associated with limited internal fixation (bridge plates and lag screws) aims to combine
the respective advantages of the two indirect fixation methods (internal and external) to achieve more rigid fracture stability, thus to benefit fracture reduction, save operation time, shorten treatment cycle, and carry out functional excises earlier. Application of bridge plates can avoid the aggravation of blood circulation impairment around the broken ends and strengthen the fracture stability to avoid postoperative infection and promote fracture healing.

We conclude that external fixation combined with limited internal fixation is stable and reliable and has various advantages of minimal operative trauma, simple and quick procedures, postoperative adjusment, and so on.

REFERENCES