Two-stage procedure protocol for minimally invasive plate osteosynthesis technique in the treatment of the complex pilon fracture

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Abstract

Purpose Here we introduce a two-stage procedure protocol for minimally invasive plate osteosynthesis (MIPO) to treat complex pilon fractures and evaluate surgical wound healing and infection rates after this method was applied in clinical practice.

Method This is a retrospective study design. The protocol consisted of immediate (within eight to 24 hours) open reduction and internal fixation of the fibula, using a fibular plate or one third tubular plate and application of an external fixator spanning the ankle joint. Patients were discharged after initial stabilisation and reevaluated approximately ten to 14 days after discharge. Formal open reconstruction of the articular surface using MIPO depended on whether soft tissue swelling had lessened. Artificial bone was then injected into the defect rather than open surgery. Objective evaluation criteria were wound infection rates. Objective criteria (amount of post-traumatic arthritis, range of ankle movement, number of arthrodeses) and subjective criteria (pain, swelling, restriction of work or leisure activities) were identified via chart and radiograph reviews, patient interviews and physical examination.

Results Twenty-nine patients, each with one pilon fracture were included. First-stage operations were performed from eight hours to seven days after injury, depending on whether the fracture was open or not. Average time from external fixation to open reduction and revision was one month (range 24–38 days); average time for the second-stage operation was 58 (range 45–110) minutes; average amount of haemorrhage was 400 (range 150–560) ml; average time of

follow-up was 24 months and average time of healing was 6.7 (range five to 11.5) months after the second stage. There was no superficial or deep infection or wound-healing problem. All patients had normal functioning ankle joints.

Conclusion Application of the two-stage procedure protocol with MIPO seems to play a key role in reducing infection rates associated with open reduction and internal fixation of pilon fractures. Its effectiveness in closed and open fractures will be further tested by a late randomised controlled study.

Introduction

Type C tibial pilon fractures [Arbeitsgemeinschaft für Osteosynthesefragen (AO) classification] are the most severe injuries to the ankle joint. The weight-bearing surface of the tibia is comminuted in type C fractures and is usually impacted upwards into the cancellous bone of the tibial metaphysis. Optimum repair of the articular damage demands precise anatomical reduction accompanied by early motion. Achieving this ideal, however, is often hindered by factors such as loss of bone mass, infection and partial-thickness skin or wound necrosis, which makes surgical treatment difficult or results in failure [2, 5] and can contribute to a less than optimal reconstruction that may predispose the ankle joint to the development of post-traumatic arthrosis, nonunion, malunion or pseudarthrosis. Although, historically, various types of treatment have been developed for type C pilon fractures [6, 9, 11], there is no consensus regarding operative or nonoperative treatment because results have been less than optimal. For example, the issue of localised devitalisation of bone and further damage to surrounding soft tissue may occur after internal fixation. In addition, external fixation was introduced to treat type C pilon fractures as an alternative because it could reduce most

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of the above-mentioned complications at a certain level. However, pin-tract sepsis was not always avoidable. Other complications such as longer healing time and higher incidence of malunion and nonunion also affected the results of this treatment.

The two-staged procedure protocol—use of the external fixator in the first stage and the internal fixator in the second stage—has been applied in the treatment of pilon fractures for many years in different countries [1, 4] and has been widely accepted by many orthopaedic surgeons. However, no study to date shows that a two-stage procedure protocol using a minimally invasive plate osteosynthesis (MIPO) technique has been tried for treating type C pilon fractures [7, 8].

The purpose of this study was to introduce the two-stage MIPO technique for treating complex pilon fractures and evaluate surgical-wound healing and determine infection rates after application of this method for treating complex pilon fractures.

Patients and methods

Between January 2002 and January 2006, 29 patients with one pilon fracture each (43C1, 43C2 and 43C3 fractures based on the AO comprehensive classification system) were treated at the trauma centre of Changhai Hospital (Fig. 1). The two-stage procedure protocol using the MIPO technique was followed closely by all attending staff. Average patient age was 48.3 (range 26–77) years, with 13 women and 16 men. The mechanisms of injury included motor-vehicle accidents and falls from a height and were all

high-energy axial-loading injuries. Nearly all cases had severe damage of the soft tissue. Eleven patients had open fractures; five of those 11 were classified as grade C and the remainder as grade B based on the Gustilo method. Soft tissue conditions in closed fractures were graded by the Tscherne system. The 18 patients with closed fractures had a score of 2.3. In addition, two of the 29 patients had distal radius fractures, four had closed head injuries and three had spinal fractures. All the fractures were fresh and the procedure was performed following a period of temporary fracture stabilisation with plaster.

Operations were done in two stages with the patient in the supine position on a radiolucent table. A tourniquet was used to decrease bleeding. The procedures were as follows:

1. Debridement (if open fractures)
2. First-stage operation: (Figs. 2, 3)
  - Fibula fixation:

All cases were associated with fibula fracture. The fibula plate (Depuy, Johnson & Johnson Company, USA.) or the one third tubular plate was used to fix the fracture. The fibula lateral approach, at least 6 cm away from the fractured tibial segment, was chosen. In principle, no less than three screws should be placed on each side of the fracture; however, in some cases in which the distal segment was very small and comminuted, no more than two screws were used.
  - Placement of external fixator spanning the ankle joint, and reduction

Three 4.5-mm pins were usually applied on the anterior surface of the proximal tibia. For the distal

Fig. 1 One case of complex pilon fracture [type C; Arbeitsgemeinschaft für Osteosynthesefragen (AO) classification] before operation

Figs. 2 and 3 After the first stage of the operation

segment of the pilon fracture, the pin sites were chosen according to the condition of soft tissue and type of fracture. The external fixation pins should be placed well away from the subsequent surgical incision both proximally and distally. Two pins on both sides of the calcaneus, two on the medial side of the calcaneus and talus and three on both sides of the calcaneus and medial of the talus were used. It is not necessary to place the pins in sequence, but the distal calcaneal pins were always placed first for convenience. After reduction, the external fixator was assembled. The purpose of so doing is to maintain tibial length and make all planes stable, thus allowing soft tissue healing.

3. Timing of the second stage

- Patients with isolated injuries were discharged home and seen in the outpatient clinic ten to 14 days after discharge to determine whether or not soft tissue swelling had subsided. Patients with multiple injuries were seen daily in the hospital during rounds. Once oedema had resolved, surgery could be performed.

4. Second stage of the procedure (Figs. 4 and 5)

- Removal of the external fixation
- Debridement of the soft tissue pin tracks
- Application of the plate using the MIPO technique
 A small incision (2–3 cm) was made over the medial malleolus and the plate inserted subcutaneously and extraperiosteally. Its position and fracture reduction were monitored using fluoroscopy. Additional incisions (punctiform) were chosen to assist reduction and Kirschner pins were used for temporary fixation. In principle, these additional incisions must be away from the main incision. A plate of the same size and shape was chosen as a guideline to assist fixation of the inserted plate. Several tiny incisions were used to place the screws.
- Minimally invasive bone graft
 Bone graft with artificial bone (Wright Company, USA) was applied in all cases. Bone was injected into the defect rather than via incision. Of our 29 patients, only one—with a systemic infection and purulent drainage from pin sites—was treated by the

Figs. 4 and 5 After the second stage of the operation

two-step technique: the first step was removal of external fixation; the second step was application of internal fixator on a subsequent day.

5. Postoperative management

All patients were nonweight bearing for a minimum of six to eight weeks without plaster. Follow-ups took place at four weeks and at three, six, nine, 12 and 24 months after surgery with a clinical and radiological examination (lateral and posterior–anterior X-ray). Until the first follow-up visit at four weeks, patients were only allowed partial weight bearing with crutches (maximum ten to 15 kg). Total weight-bearing was allowed only when healing had occurred.

Results

The first-stage operations were all performed between eight hours and seven days after injury depending on whether or not the fracture was open. Revision timing was determined by the following:

1. soft tissue condition
2. nature of initial injury (open or closed)
3. possible need for further surgical debridement
4. associated open fasciotomy wounds
5. location of previously placed external fixator pins
6. condition of existing external fixator pins
7. mechanical stability of the external fixator configuration
8. bone and soft tissue loss
9. associated neurovascular injury
10. presence or absence of infection.

Generally, the average time was one month (range 24–38 days). The average duration of the second stage was 58 (range 45–110) min. Average amount of haemorrhage was 400 (range 150–560) ml. The average healing time was 6.7 (range 5–11.5) months after the second-stage procedure, based on our clinical and radiological definition of fracture healing. (Fig. 6)

There were no superficial or deep infections or wound-healing problems at an average follow-up of 24 months, and no instances of a broken plate. Skin irritation occurred in one patient in whom the internal fixator chosen was a Pilon LCP plate (Synthes, USA). Another patient had implant-related pain over the plate due to the high plate profile; eventually, local skin damage occurred, which healed following local flap grafting. All patients achieved a full range of motion by six to 12 months postoperatively. Based on subjective criteria, 23 (80%) reported good results, four (14%) fair results and two (6%) poor results. All patients attained normal function in the ankle joints.

Fig. 6 Good function after operation

Discussion

In 1969, Ruedi and Allgower were the first to report successful results with primary open reduction and internal fixation [3]. However, it was difficult to deal with soft tissue problems before and after operation. In 1988, some authors noted significant complications when open reduction and internal fixation was applied to complex pilon fractures; they reported infection rates ranging from 6% to 55%. Problems with internal fixation led many authors to use an external fixator as an alternative [10, 14]. Although they could eliminate wound necrosis and skin slough, other problems arose, such as high rates of pin-tract infection and malalignment with subsequent nonunion. Thus, skin conditions around the ankle were viewed as a bottle neck in the treatment of the complex pilon fractures [13]. The two-stage procedure has been widely accepted by many authors around the world, as it has two major advantages:

- soft tissue management is optimised. Studies showed that in complex pilon fractures, the highest rate of wound complications occurred when internal fixation surgery was performed less than 7 days after the injury.
- the two-staged approach offers the ability to attain anatomical realignment of the articular surface under direct visualisation.

The purpose of the MIPO technique in the treatment of the complex pilon fractures is to reduce the infection rate and increase the capacity for bone healing. This technique gives priority to biology over mechanics. Using this technique, the fracture zone was not exposed and the periosteal blood supply to the fragments was not further damaged during surgery. Two types of plates are used in the MIPO technique: the LCP Pilon Plate (Synthes) and Pilon plate (Depuy, Johnson & Johnson). We chose the former for overweight patients or patients with a severely comminuted fracture; the latter was chosen for patients of normal body weight. They have been viewed as the good “biology” of the implants. In fact, the insertion of locking-head screws dispenses with the need for compression

between plate and bone, which means there is little or no impairment of the periosteal blood supply beneath the plate and, thus, bone necrosis that has been observed beneath conventional plates is prevented. Preserving the viability of bone fragments is the key to unimpaired fracture healing. Biological fracture management provides environmental conditions that allow the natural healing process to occur as quickly and as undisturbed as possible. The new biological plating technique imitates the concept of intramedullary fixation.

Many styles of bone graft require adequate exposure of the graft site, which is impossible in patients with complex pilon fractures; however, artificial bone (Wright Company, USA) can be injected into the defect rather than via incision. In some previous studies, patients were permitted to fully weight bear based on clear radiological evidence of callus formation and clinical evaluation. However, given the complexity and severity of intra-articular fractures in some patients in our study, they were not permitted to fully weight bear for a minimum of six to eight weeks postoperatively (second-stage operation). The evidence gained from this study confirmed the value of the two-stage procedure protocol with MIPO application for treating complex pilon fractures and provides a basis for functional after treatment and rapid bony consolidation with a low infection rate [12].

Conclusion

Application of the two-stage procedure protocol with MIPO seems to play a key role in reducing infection rates associated with open reduction and internal fixation of pilon fractures. Its effectiveness and efficiency in treating closed and open pilon fractures will be further tested by a late randomised controlled study.

References

1. Barbieri R, Schenk R, Koval K, Aurori B, Aurori K (1996) Hybrid external fixation in the treatment of tibial plafond fractures. *Clin Orthop* 332:16–22
2. Barei DP, Nork SE, Mills WJ, Henley MB, Benirschke SK (2004) Complications associated with internal fixation of high-energy bicondylar tibial plateau fractures utilizing a two-incision technique. *J Orthop Trauma* 18:649–657
3. Bhandari M ZM, Tornetta P III, Schmidt A TDC (2005) Intramedullary nailing following external fixation in femoral and tibial shaft fractures. *J Orthop Trauma* 19:140–144
4. Bonar SK, Marsh JL (1993) Unilateral external fixation for severe pilon fractures. *Foot Ankle* 14:57–64
5. Bone LB, Stegemann P, McNamara K, Seibel R (1993) External fixation of severely comminuted and open tibia pilon fractures. *Clin Orthop* 292:101–107
6. Carmack DB, Kaylor KL, Yaszemski MJ (2001) Structural stiffness and reducibility of external fixators placed in malalignment and malrotation. *J Orthop Trauma* 15:247–253
7. Clasper JC, Phillips SL (2005) Early failure of external fixation in the management of war injuries. *J R Army Med Corps* 151:81–86
8. Dickson KF, Montgomery S, Field J (2001) High energy plafond fractures treated by a spanning external fixator initially and followed by a second stage open reduction internal fixation of the articular surface: Preliminary report. *Injury* 32(suppl 4):SD92–SD98
9. Dougherty PJ, Vickaryous B, Conley E, Hickerson K (2003) A comparison of two military temporary femoral external fixators. *Clin Orthop Relat Res* 412:176–183
10. Egol KA, Tejwani NC, Capla EL, Wolinsky PL, Koval KJ (2005) Staged management of high-energy proximal tibia fractures (OTA types 41): The results of a prospective, standardized protocol. *J Orthop Trauma* 19:448–455
11. Nowotarski PJ, Turen CH, Brumback RJ, Scarboro JM (2000) Conversion of external fixation to intramedullary nailing for fractures of the shaft of the femur in multiply injured patients. *J Bone Joint Surg Am* 82:781–788
12. Holmes SM, Bombardieri D, Baumgaertner MR. *J Orthop Trauma* (2004) May-Jun;18(5):316–9
13. Sirkin M, Sanders R, DiPasquale T, Herscovici D Jr (2004) A staged protocol for soft tissue management in the treatment of complex pilon fractures. *J Orthop Trauma* 18(8 suppl):S32–S38
14. Tejwani NC, Achan P (2004) Staged management of high-energy proximal tibia fractures. *Bull Hosp Jt Dis* 62:62–66