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Pathogenesis and Treatment Strategies for Pilon Fractures With Ankle Dislocation

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A R T I C L E I N F O

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A B S T R A C T

The present study investigated the pathogenesis and treatment strategies for pilon fractures with ankle dislocation. A total of 58 patients (47 males and 11 females) who had sustained pilon fractures with ankle dislocation were treated. The mean patient age was 48.1 years. Using the AO classification, 8 cases were type B2, 17 were type B3, and 33 were type C3. The dislocation was medial in 13 cases, lateral in 9, anterior in 11, posterior in 14, and longitudinal in 9. Radiologic examinations were conducted to evaluate the postoperative reduction, dislocation correction, fracture healing, and internal fixation. Ankle function was evaluated according to the Kofoed and Danborg scoring system. The patients were followed up for 4 to 27 months. Anatomic reduction was achieved in 39 cases (67.24%), good reduction in 13 (22.41%), and poor reduction in 6 (10.34%). No internal implant failure occurred, and the fractures had healed after 2 to 4.3 (mean 2.8) months. The rate of good or excellent ankle recovery was 84.00% for those with type B fractures, 75.76% for those with type C, 76.92% for those with medial dislocation, 77.78% for lateral dislocation, 81.82% for anterior dislocation, 78.57% for posterior dislocation, and 81.82% for longitudinal dislocation. Pilon fractures often occur with ankle dislocation in different directions. In such cases, the original anatomy should be restored and the longitudinal alignment recovered to minimize complications as much as possible.

Pilon fractures are serious intra-articular fractures of the weightbearing articular surfaces of the distal tibia and account for 3% to 10% of tibial fractures and <1% of lower limb fractures (1). Pilon fractures are often concomitant with fibula fractures (2). Fractures are high-energy injuries caused by high falls or traffic crashes, among others, and often involve compression, tilt, and force line migration in the different directions of an articular surface. The epiphysis of the distal tibia and articular surface will break when pilon fractures occur. The weightbearing center of the talus can cause an offset when combined with medial and lateral malleolus and fibular fractures, resulting in inferior tibiofibular and anterior talofibular ligament injuries. We believe that talus offset is not only the cause, but also the result of this structural destruction. However, data on these pathologic changes have rarely been discussed. Therefore, we propose a new concept for pilon fractures with ankle dislocation according to our review of anteroposterior radiographs of the distal tibia and ankle as follows: the center of the talar body offsets the load line of the distal tibia or the center of the articular surface. We hypothesized that if the dislocation were not corrected, it would lead to failure of fracture reduction, an abnormal force line, ankle instability, ankle deformity, other serious complications, and serious impairment of ankle function. Thus, we designed a rational treatment plan according to the form of the pilon fracture and the status of ankle dislocation. From June 2006 to October 2011, 58 patients who had sustained pilon fractures with ankle dislocation were treated in our department. We report the treatment results for these patients.

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Patients and Methods

We treated 58 patients (47 males and 11 females) with a mean age of 48.1 (range 17 to 76) years. Of the 58 injuries, 27 were of the right ankle and 31 of the left ankle. The cause of the injury was a high fall in 26, traffic accident in 21, heavy pound injury in 3, and downstairs fall in 8 patients. Using the AO classification (3), 8 cases were type B2 (13.79%), 17 were type B3 (29.31%), and 33 were type C3 (56.90%). The dislocation was medial in 13 cases (22.41%), lateral in 9 (15.52%), anterior in 11 (18.97%), posterior in 14 (24.14%), and longitudinal in 11 (18.97%). According to the Gustilo classification (4), 11 were open fractures, including 8 type I and 3 type II. The mean period from injury to surgery was 8.7 (range 5 to 14) days. All the 11 patients with open fractures underwent debridement and suturing in the first stage and internal fixation surgery 5 to 14 days postoperatively (5). The present study was conducted in accordance with the Declaration of Helsinki, and the ethics committee of Xi'an Red-Cross Hospital approved the present study. All participants provided written informed consent.

Preoperative Preparation

We performed staged treatment in the 11 patients with open fractures (6). The first stage of debridement and suture was performed immediately, and the ankle dislocation was corrected. The 11 cases were managed with a single-arm external fixator (7) to provisionally fix the distal tibial fractures. Of the 11 patients, 9 had fibular fractures that were immediately treated with open reduction and internal fixation. Postoperative infection was prevented with antibiotics and wound dressing changes in these patients. In addition, we used decongestant medications to eliminate the limb swelling until the conditions of the local soft tissues had improved. Next, the patients underwent second-stage fixation surgery. After hospital admission, we used manual reduction as much as possible to achieve temporary reduction in the closed fractures in the 47 patients. Next, we used a brace or plaster for temporary fixation. For some cases, calcaneal skeletal traction to maintain the reduction of the pilon fractures and ankle dislocation and temporary immobilization to prevent additional damage to the local soft tissues were performed. Icing and decongestant medications were administered to improve the condition of the local soft tissues. Patients with tension blisters were treated with syringe-suction effusion and alcohol gauze wet compresses. Once the conditions of the local soft tissues had improved and the swelling had subsided, we proceeded with second-stage fixed surgical treatment. Attention was given to the blood flow in the limb to prevent bone fascia compartment syndrome and other complications. The patients underwent anteroposterior and lateral radiographs of the ankle joint after admission. Ankle computed tomography and reconstruction were conducted for temporary fixation to further clarify the fracture type and ankle dislocation. Particular attention was given to the articular surface of the distal tibia.

Surgical Methods

Subarachnoid block anesthesia and epidural or general anesthesia were used for the surgery. The patients assumed a supine position, a pneumatic tourniquet was placed for $<$1 hour, and routine disinfection and draping were performed. The surgical approaches included a lateral and a medial approach. The lateral approach included a lateral leg incision along the fibula surface projection for the fibula fracture. Another longitudinal incision in the ankle joint plane was made at the leading edge of the fibula of the patients with talofibular joint dislocation. This incision extended to the bones of the outer side and opened the ankle. The distal incision revealed the anterior talofibular ligament and talofibular joint, and the visible proximal incision revealed the anterior tibiofibular ligament and its ending point on the fibula and tibia. The medial approach included a longitudinal skin incision in the fracture range made along the outside edge of the tibial crest, for a distance of approximately 1 cm, to cut open the skin, subcutaneous layer, and periosteum. A distal incision was made from the forward ankle to the prominence of the medial malleolus. The incision was continued until it exposed the deep fascia layer and the anterior and medial side of the tibia subperiosteally. Reconstruction of the lateral column was performed by way of simultaneous medial and lateral incisions, which facilitated the intraoperative assessment of the fracture and dislocation. We began restoration and reconstruction of the lateral column by subperiosteal dissection of the fibula fractures and correcting the fibular shortening, rotation, and angular deformity. One third of the tubular plate was fixed. Next, we corrected the dislocation of the ankle joint and maintained the neutral position of the ankle to restore the anatomic position of the ankle joint. Thus, we could use the point reduction clamp to reset the talofibular joint under direct vision. We fixed the talofibular joint provisionally with two 2.0-mm Kirschner wires to ensure the normal anatomic position of the talus. It was the basis for the fracture reduction. Therefore, the medial column and distal tibial articular surface was reset and fixed step-by-step using the talus as an anatomic template. To repair the medial column and distal tibial articular surface, we returned the ankle to the normal anatomic position by repairing and fixing the lateral column. First, we corrected the lower limb force line of the tibia, reset the medial tibial fracture and medial malleolus bone, reconstructed and fixed the medial column, and redeveloped the tibia force line. The use of the Kirschner wire was determined based on the dislocation situation of the medial malleolus and medial articular surface of the talus. The talar articular surface was used as the template to restore the distal tibial articular surface. Afterward, we opened the fragment of the anterior ankle, retained all the fracture fragments, and then temporarily reset and fixed the posterior malleolar fracture. The distal tibial articular surface was reset, and the joint surface with an osteotomy of $>$1 cm of the articular surface was heavily compressed. The articular surface was reset and reconstructed and then supported with the bone graft to ensure formation of the articular surface. Next, we certified the reduction of the dislocation and fracture with C-arm radiography, maintained the joint reset and force line, and fixed the locking plate system in the coronal or sagittal position. Next, two 2.5-mm Kirschner wires were used to fix the tibiotalar joint by the pelma to prevent dislocation recurrence when fractures around the ankle joint had been severely crushed. Finally, wound drainage tubes were placed, and the sutures of the tenaculum were extended. A deep fascia incision was made to extend the inside flap and then sutured and closed. If necessary, a plaster or brace was used to temporarily fix and maintain ankle stability.

Postoperative Treatment and Evaluation Standard

The postoperative soft tissue blood supply was carefully monitored. All the patients were instructed to elevate their limbs. A dehydrating agent was applied to minimize obvious swelling, and antibiotics were used for 3 to 5 days. The wound drainage tube was removed 24 to 72 hours postoperatively. The passive activity of the digits at 24 hours postoperatively and the active activity of the digits and ankle at 48 hours postoperatively were examined. The radiographic images were reviewed 4, 8, 12, and 16 weeks postoperatively, and the results were combined with the fracture healing status to determine the walk and weightbearing times. The temporarily fixed needle in the ankle was removed at 4 to 6 postoperative weeks, and passive and active exercises of the ankle were begun. The limbs were not allowed to bear any weight for 6 to 8 postoperative weeks. The radiologic images confirmed fracture healing at 12 to 16 postoperative weeks, and the patients were encouraged to walk with partial weightbearing.

Burwell and Charnley (8) proposed the following reset standards for pilon fracture imaging: anatomic, good, and poor. The postoperative radiographic images of the patients were measured and analyzed seriatim, and the reset effect was evaluated. The Kofoed and Danborg ankle function score standard (9) was also used to assess ankle function: pain, 50 points; function, 30 points; and activity, 20 points. Scores $>$85 are defined as excellent, 75 to 84 as good, 70 to 74 as passable, and $<$70 as poor.

Results

General Data

All the patients underwent postoperative follow-up examinations for 4 to 27 (mean 12.6) months. Of the 58 patients, 39 (67.24%) had an anatomic reset, 13 (22.41%) a good reset, and 6 (10.34%) a poor reset (Figs. 1 and 2). Of the 58 patients, 13 (22.41%) had had a medial dislocation; 9 (15.52%) a lateral dislocation, 11 (18.97%) an anterior dislocation, 14 (24.14%) a posterior dislocation, and 11 (18.97%) a longitudinal dislocation. No fracture complications such as loose and broken internal fixation were observed in the later stage. All the fractures healed. The healing time was 2 to 4.3 (mean 2.8) months. Three patients with local skin necrosis required a local rotary flap to close the wound. Fracture malunion occurred in 2 patients, ankle joint stiffness in 4 patients, traumatic arthritis in 3 patients; none of the 58 patients experienced limb discrepancy, collapse of the articular surface in the second phase, ankle instability, or dislocation. All the patients had begun partial weightbearing ambulation at 12 to 16 (mean 14) weeks postoperatively. The ankle range of motion was 8° to 18° (mean 12°) dorsiflexion and 26° to 40° (mean 32°) plantarflexion.

Evaluation

Evaluations of ankle function using the Kofoed and Danborg ankle function score standard (9) revealed excellent, good, passable, and poor results in 17, 4, 2, and 2 in type B fractures, respectively, with a good and excellent rate of 84.00%. For type C fractures, 18 were considered excellent, 7 good, 4 passable, and 4 poor, with a good and excellent rate of 75.76%. Of the medial dislocation cases, 8 were considered excellent and 2 good, with a good and excellent rate of 76.92%. Of the lateral dislocation cases, 5 were considered excellent and 2 good, with a good and excellent rate of 77.78%. Of the anterior dislocation cases, 7 were considered excellent and 2 good, with a good