Clinical efficacy of extended modified posteromedial approach versus posterolateral approach for surgical treatment of posterior pilon fracture: a retrospective analysis

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Research article

Keywords: posterior pilon fracture, approach, fracture fixation, buttress plate

Posted Date: March 30th, 2020

DOI: https://doi.org/10.21203/rs.3.rs-19392/v1

Abstract

Background: Posterior pilon fracture is a type of ankle fracture associated with poorer treatment results compared to the conventional ankle fracture. This is partly related to the lack of consensus on the classification, approach selection, and internal fixation method for this type of fracture. This study aimed to investigate the clinical efficacy of posterolateral approach versus extended modified posteromedial approach for surgical treatment of posterior pilon fracture.

Methods: Data of 67 patients with posterior pilon fracture who received fixation with a buttress plate between January 2015 and December 2018 were retrospectively reviewed. Patients received steel plate fixation through either the posterolateral approach (n = 35, group A) or the extended modified posteromedial approach (n = 32, group B). Operation time, intraoperative blood loss, excellent and good rate of reduction, fracture healing time, American Orthopaedic Foot & Ankle Society (AOFAS) Ankle-Hindfoot Scale score, and Visual Analogue Scale score were compared between groups A and B.

Results: All patients were followed up for an average period of 15.4 months. No nonunion, failure of internal fixation, or anklebone stiffness occurred in either group during the follow-up period. However, the operation time was significantly shorter, intraoperative blood loss was significantly lower, AOFAS Ankle-Hindfoot Scale score was significantly higher, and Visual Analogue Scale score was significantly lower in group B than in group A ($P < 0.05$).

Conclusion: Compared to the posterolateral approach, the extended modified posteromedial approach can provide a better surgical field for the treatment of posterior pilon fracture, which allows reduction and fixation of this type of fractures under direct vision and evaluation of reduction effects, and reduces operation time and intraoperative blood loss. Combining this approach with supporting steel plate fixation enables early functional rehabilitation of the ankle with more satisfactory clinical results.

Background

The concept of posterior pilon fracture was first proposed by Hansen in 2000 [1]. Posterior pilon fracture is described as a posterior malleolar fracture extending into the posterior colliculus or even the anterior colliculus that is commonly complicated by posterior dislocation and cartilage injury of the ankle. Previous research showed that this type of fracture accounts for 6–20% of all ankle fractures [2, 3]. Moreover, its treatment results are poorer than those for the conventional ankle fracture [4]. The reason for the large statistical difference and poor therapeutic efficacy is the lack of understanding of the mechanisms of posterior pilon fracture, which is frequently misdiagnosed as a conventional trimalleolar fracture [5]. There is no current consensus on the classification, approach selection, and internal fixation method of the posterior pilon fracture due to short recognition time, low incidence, and small number of case reports [6].

Posterior pilon fracture is an intra-articular fracture. Its surgical treatment aims to achieve anatomical reduction of the articular surface and firm fixation of fractured fragments in order to reduce the incidence of traumatic ankle arthritis. This retrospective study investigated the clinical efficacy of reduction through the extended modified posteromedial approach versus posterolateral approach during the surgical treatment of posterior pilon fracture.

Methods

Study population

All cases of posterior pilon fracture treated by surgical reduction through the extended modified posteromedial approach or posterolateral approach in combination with fixation with a buttress plate at the Department of Orthopedic Trauma of Jining Medical College between January 2015 and December 2018 were reviewed. Patients aged ≥ 18 years, with good ankle movement prior to injury, and a new closed fracture corresponding to the imaging characteristics of posterior pilon fracture [7] (distal tibial fracture line extending along the coronal plane into the posterior colliculus or even the anterior colliculus, with or without the "double contour sign" of the proximal medial malleolus, the posterior malleolus displaced proximally, and the margin of the bone mass compressed and fragmented; Die-punch bone masses, with or without subluxation of the posterior talus, were also present) were included. Patients with pathological fractures, associated neurovascular injuries, a history of ankle disease or serious trauma prior to injury, and a follow-up < 12 months were excluded.

A total of 67 patients were included. Patients with dislocation were treated with plaster fixation and calcaneus traction. If blisters appeared, the fluid in the blisters was extracted and the epidermis was preserved and dried with infrared light. The affected limb was elevated, and detumescence and anticoagulant therapy were performed. Operations were carried out when the swelling subsided obviously, the skin folded, and blisters dried out [8].

This study was approved by the Ethics Committee of the Affiliated Hospital of Jining Medical University, China. The IRB approval number is 2015C001. All patients had signed informed consent prior to surgery.

Surgical treatment

Patients were divided in two groups (A and B), according to the used surgical approach. The operation was performed under epidural or general anesthesia in the prone position. A tourniquet was applied to the proximal thigh on the affected side and the leg was padded high to facilitate the lateral perspective.

Posterolateral approach: a longitudinal incision was made on the surface of the fractured lateral malleolus or fibula. Attention was paid to protect the gastrocnemius nerve and saphenous vein. The incision passed through the long and short peroneal tendons and the flexor longus tendons. The flexor longus tendon was pulled medially to expose the fractured part of the posterior malleolus. The peroneal tendons were pulled laterally to expose the fractured lateral malleolus. If a complete fracture of the medial malleolus occurred together with posterior pilon fracture, an arc-shaped incision was made on the medial malleolus for reduction.

Extended modified posteromedial approach: A longitudinal incision was made along the posterior margin of the tibia and arced forward at the tip of the medial malleolus. The flexor retinaculum was incised. The incision passed through the flexor longus tendon and the posterior tibial vascular nerve bundles. The flexor longus muscle was pulled laterally and the posterolateral malleolus was exposed through the "lateral window." The posteromedial malleolus was exposed through the "medial window" created between the posterior tibial tendon and the flexor digitorum longus tendon.

In both surgical approaches, the fractures of the lateral malleolus or fibula were treated first. As for the common short oblique fractures of the lateral malleolus, tension screws were placed perpendicular to the fracture line and fixed with steel plates. Then, the posterior malleolus fracture was treated, avoiding any damage to the posterior tibiofibular ligament. The broken ends of the fracture were opened using the book opening-like technique along the fracture line between the fractured posteromedial and posterolateral parts to expose the articular surface. The collapsed bone masses were reduced. If the fractured mass was ≤ 2 mm in diameter and dissociated, it was removed to avoid the entry of the dissociated bone mass into the articular cavity. The fractured posterior malleolus bone mass was reduced. Taking the continuity recovery of the proximal cortex of the fractured part as an anatomical sign, fluoroscopy was performed to ensure good fracture reduction and flat articular plane. Then, buttress plates were implanted. The fractured medial malleolus was exposed through the anterior side of the posterior tibial tendon and fixed with hollow screws or Kirschner wires after reduction. Then, cotton tests were performed. Lower tibiofibular screws were used to fix the unstable lower tibiofibular joint. After confirming that the supporting steel plate did not influence the tendon sliding, the incision was sutured.

Postoperative management

Antibiotics were used 24 hours after operation to prevent infection. Routine detumescence, analgesia, and anticoagulation therapy were performed. On day 1 after surgery, patients were instructed to perform isometric contraction of the quadriceps femoris, and active and passive flexion and extension of the toes and ankles. On day 2 after surgery, an anteroposterior radiograph of the ankle joint was obtained. At 2 months after surgery, partial weight-bearing exercise of the affected limb was initiated. At 3 months after surgery, full weight-bearing exercise of the affected limb was started according to the results of imaging examination.

Efficacy evaluation and statistical analysis

The quality of fracture reduction, reduction loss, and fracture healing were evaluated according to Burwell-Charnley imaging criteria [9]. The Visual Analogue Scale (VAS) score (0–10) was used to evaluate the intensity of resting and movement-related pain during follow-up. At the last follow-up, patients were evaluated using the American Orthopaedic Foot & Ankle Society (AOFAS) Ankle-Hindfoot Scale score [10]. Operation time, intraoperative blood loss, fracture healing time, AOFAS Ankle-Hindfoot Scale score, and VAS score were compared between groups A and B. Statistical analysis was performed using SPSS 19.0 software (SPSS Inc., Chicago, IL, USA). All measured data were expressed as mean ± SD. Wilcoxon's rank-sum test was used to compare non-normally distributed data, t-test was used to analyze normally distributed data, and chi-squared test was used to compare categorical data between the two groups. P values < 0.05 were considered statistically significant.

Results

In the posterolateral approach group (group A, n = 35, 19 men), the posterior pilon fracture occurred on the left side in 16 patients and on the right side in 19 patients. The causes for the posterior pilon fracture included slip and fall (n = 11), traffic accidents (n = 12), and high fall (n = 12). According to the classification proposed by Professor Jianzheng Zhang, General Hospital of Northern Theater Comman in 2017 [11], type I posterior pilon fracture occurred in 5 patients, type IIa posterior pilon fracture in 6 patients, type IIb posterior pilon fracture in 9 patients, IIIa posterior pilon fracture in 8 patients, and IIIb posterior pilon fracture in 7 patients. The time to surgery ranged between 6 and 11 days. In the extended modified posteromedial approach group (group B, n = 32, 18 men), posterior pilon fracture occurred on the left side in 15 patients and on the right side in 17 patients. The causes for the posterior pilon fracture included slip and fall (n = 10), traffic accidents (n = 10), and high fall (n = 12). According to AGH classification, type I posterior pilon fracture occurred in 4 patients, type IIa posterior pilon fracture in 5 patients, type IIb posterior pilon fracture in 8 patients, IIIa posterior pilon fracture in 9 patients, and IIIb posterior pilon fracture in 6 patients. The time to surgery ranged between 6 and 13 days.

No significant differences in sex (P = 0.753), age (t = 0.423, P = 0.280), injury side (P = 0.855), causes for injury (P = 0.741), fracture classification (P = 0.854), and time to surgery (t = 0.254, P = 0.801) were found between groups A and B.

All incisions in both groups healed by first intention. The excellent and good rates of reduction in the two groups according to Burwell-Charnley imaging evaluation criteria are shown in Table 1. All patients were followed up for an average time period of 15.4 (range, 12–23) months. No nonunion, failure of internal fixation, and anklebone stiffness occurred during the follow-up. Mild contracture of the flexor tendon occurred in 10 patients (6 from group A and 4 from group B). Four patients in group A had symptoms of gastrocnemius muscle nerve injury and three patients in group B had symptoms of tibial nerve injury. At 1 month after surgery, outpatient reexamination confirmed disappearance of these symptoms. Operation time, intraoperative blood loss, fracture healing time, AOFAS Ankle-Hindfoot Scale score, VAS score of the two groups are shown in Table 2. Images of a typical posterior pilon fracture case are shown in Fig. 1.

Table 1
Comparison of excellent and good rates of reduction between groups A and B

Group	n	Excellent (n)	Good (n)	Excellent and good rate
A	35	19	13	91.4%
B	32	27	4	96.9%
$x^2 = 7.036$, P = 0.030				

Table 2
Comparisons of investigated indexes between groups A and B

Group	Time to wait for surgery (days)	Operation time (min)	Intraoperative blood loss (mL)	Fracture healing time (weeks)	AOFAS Ankle-Hindfoot Scale score	VAS score
A (n = 35)	7.229 ± 1.286	109.686 ± 15.800	114.143 ± 58.341	12.743 ± 1.358	86.771 ± 3.565	0.886 ± 0.718
B (n = 32)	7.156 ± 1.020	95.719 ± 24.272	88.781 ± 28.281	12.813 ± 1.401	92.281 ± 3.929	0.781 ± 0.659
t	0.254	2.815	2.23	−0.207	−6.019	0.618
P	0.801	0.006	0.029	0.837	< 0.001	0.539
AOFAS: American Orthopaedic Foot & Ankle Society; VAS: Visual Analogue Scale						

Discussion

The results of this study showed that for surgical treatment of posterior pilon fracture, the extended modified posteromedial approach outperforms posterolateral approach in terms of operation time, intraoperative blood loss, fracture healing time, AOFAS Ankle-Hindfoot Scale score, and VAS score. This suggests that this approach may be more appropriate for routine surgical treatment of this type of fractures.

Klammer et al. [12] considered that the majority of posterior pilon fractures can be reduced by surgery through the simple posterolateral approach. The advantage of this approach is that fractures of the fibula and the posterior malleolus can be treated through the same incision, and the exposure is relatively simple. When a posterior medial bone mass exists together with medial bone compressing the articular surface, the reduction can be achieved through the book opening-like technique. However, if it is difficult to reduce the posterior medial bone block, a posterior medial incision should be also used. Moreover, the posterolateral approach has several shortcomings in the early treatment of posterior pilon fracture. First, in the treatment of a posterior pilon fracture with lateral malleolus fracture and comminuted posterior medial fracture, the medial edge of the posterior medial bone mass cannot be exposed through the posterolateral approach. Second, it is impossible to directly evaluate whether the posterior medial bone mass rotates, separates, and displaces. Third, when lateral malleolus fracture is fixed, the displaced posterior malleolus may be baffled by the lateral malleolus plate, and therefore, corresponding treatments may be omitted. Finally, although the posteromedial bone mass can be exposed through the book opening-like technique when a Die-punch bone mass is present in the posteromedial malleolus, in the clinical practice, the space for bone mass turning is limited and the visual field is narrow, and therefore the posteromedial incision must be used for direct evaluation of fracture reduction.

The posterior medial bone mass of the distal tibia can prevent the posterior dislocation of the talus. When posterior pilon fracture occurs, the posterior medial bone mass is connected to the posterior colliculus of the medial malleolus. Since the posterior colliculus of the medial malleolus is the deep attachment of the deltoid ligament, its fracture also aggravates the instability of the talus and ankle mortise.

Failure to effectively expose and reduce the posterior medial bone mass often results in poor posterior medial fracture reduction or malunion, leading to tibiofibular joint mismatch or posterior medial instability and aggravating degeneration after ankle trauma [2]. Blom et al. performed a 2-year follow-up study on patients surgically treated for ankle fracture combined with posterior malleolus fracture [3]. They found that the curative effect in patients with Haraguchi type II posterior malleolus fracture (with posterior malleolus fracture line extending to the medial part and an additional posterior medial fracture mass) is the poorest. This is attributable to the lack of good reduction and strong fixation because of insufficient understanding of the importance of the posteromedial fracture mass presence. An in-depth study on posterior malleolus fractures, in particular posteromedial fracture mass fractures, can change the choice of surgical approach, fracture reduction sequence, and internal fixation [13]. The processing results of Die-punch bones are the key factors affecting the prognosis, and a wrong surgical approach may lead to difficulties in exposure and reduction of Die-punch bone, resulting in post-traumatic ankle arthritis [14].

Assal et al. [15] proposed a modified posteromedial approach for the treatment of complex pilon fractures, which includes a straight posteromedial incision of the lower leg that enters the space between the plantar flexor muscle and the posterior tibial blood vessels and nerve bundles. In this manner, posterolateral and posteromedial bone masses can be exposed through the lateral window and medial window, respectively. Further, the posterior metaphysis of the distal tibia, the posterior tibiofibular ligament, the posterior articular capsule of the ankle, the fibular notch of the tibia, and the posterior medial malleolus can be seen directly through this approach. The end of the modified posteromedial approach was extended and forwarded at the arc of the medial malleolus. Thus, the medial malleolus fractured mass and medial malleolus anterior edge could be fully exposed through the anterior edge of the posterior tibialis tendon. With better understanding of the posterior pilon fracture and accumulation of surgical experience, we increasingly intend to apply the extended modified posteromedial approach to reduce and fix fractured posterior pilon bone.

The posterior and medial structure of the ankle can be fully exposed through the extended and modified posteromedial approach. The Die-punch bone mass can be fully exposed using the book opening-like technique after the posterior articular capsule of the ankle is cut open. The posterior medial bone mass can be turned not only posteriorly and medially, but also distally to facilitate the reset of the Die-punch bone mass.

The Die-punch bone mass is displaced from the articular surface into the fractured bone space and is easier to reduce according to its morphology. To prevent the bone mass from being displaced again, the anterior articular surface of the distal tibial bone is used as the anatomical landmark for reduction and the reduced bone mass is cross-fixed with 1.0 mm Kirschner wire. The proximal metaphyseal end of the bone mass is impacted toward the talus to reduce the medial and posteromedial bone masses. According to the continuity of the proximal cortex of the fractured bone mass, the structural integrity of the medial and posterior ankle can be visually observed. Bone fracture reduction can be also evaluated based on the findings observed via the joint space through posterior joint capsule incision in extreme extension of the ankle. If a fracture of the anterior colliculi of the medial malleolus occurs, the fractured part and the anterior edge of the medial malleolus can be exposed at the anterior part of the posterior tibialis muscle tendon using the incision for fracture reduction. The extended and modified posteromedial approach provides full exposure of surgical field, which allows reduction and fixation of posterior pilon fractures under direct vision, and curative effect evaluation. This can effectively reduce the fluoroscopy and operation time, and the amount of blood loss, and provide good exposure of surgical field, which in turn allow good reduction and fixation and lays the foundation for long-term ankle joint function recovery.

In the treatment of fracture of posterior distal tibia, the degree of soft tissue injury caused by steel plate implantation is likely to be higher than that caused by screw insertion, which may cause contracture of the posterior flexor tendon [16]. However, Viberg et al., in their multicenter study on the complications and efficacy of distal tibia fracture fixation with bone plate, reported that because there is a large amount of soft tissue covering the posterior part of the distal tibia, the phenomenon of soft tissue agitation rarely occurs when steel plate is inserted into the posterior distal tibia [17]. As for internal fixation for posterior pilon fracture, internal fixation with screws inserted neither anteriorly nor laterally can achieve enough fixation strength. Early weight-bearing functional exercises likely lead to relocation of fractured bone and internal fixation failure. In this study, posterior pilon fracture was fixed with steel plate in all included patients. Fifty-nine patients received internal fixation with a T-shaped locking plate at the distal radius and eight patients underwent fracture fixation with a 3.5 mm-sized locking plate at the distal tibia on the healthy side. After surgery, patients were encouraged to perform early functional exercises of the ankle joint. Fracture replacement, collapse of Die-punch bone mass, or internal fixation failure was not observed during the follow-up period.

Several limitations of this study should be considered when interpreting its results. First, the number of included patients was relatively small. Second, this was a retrospective, single center research. Finally, the follow-up period was relatively short. Further larger-scale prospective studies are necessary to confirm obtained results.

Conclusion

Compared to posterolateral approach, the extended and modified posteromedial approach can provide good surgical field, enable reduction and fixation of posterior pilon fracture under direct vision and curative effect evaluation, and reduce operation time and the amount of blood loss. In addition, the extended and modified posteromedial approach combined with internal fixation with buttress plate enable patients to perform early functional exercise of the ankle joint, which can improve clinical efficacy of this approach for treating posterior pilon fractures.

Abbreviations

AOFAS: American Orthopaedic Foot & Ankle Society; VAS: Visual Analogue Scale

Declarations

Acknowledgements

Not applicable.

Ethics approval and consent to participate

This study was approved by the Ethics Committee of the Affiliated Hospital of Jining Medical University, China. The IRB approval number is 2015C001. All patients had signed informed consent prior to surgery.

Consent for publication

All authors have no conflict of interest and agree to the publication and authorization of the article.

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

Funding

This study was supported by the Jining Medical University Helin Academician Fund, No. JYHL2018FMS13; the Supporting Fund for Teachers' Research at Jining Medical University, grant No. JYFC2018FKJ048; the Jining Science and Technology Bureau Medical Health Fund, grant No. 2018SMNS002.

Authors' contributions

Writing – original draft: QMZ; Writing – review and editing: QMZ and BW; Case follow-up and data collection: QMZ, HBW, XYL, FLC, LH, BW; Statistical analysis: QMZ, XYL and DML.

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Figures

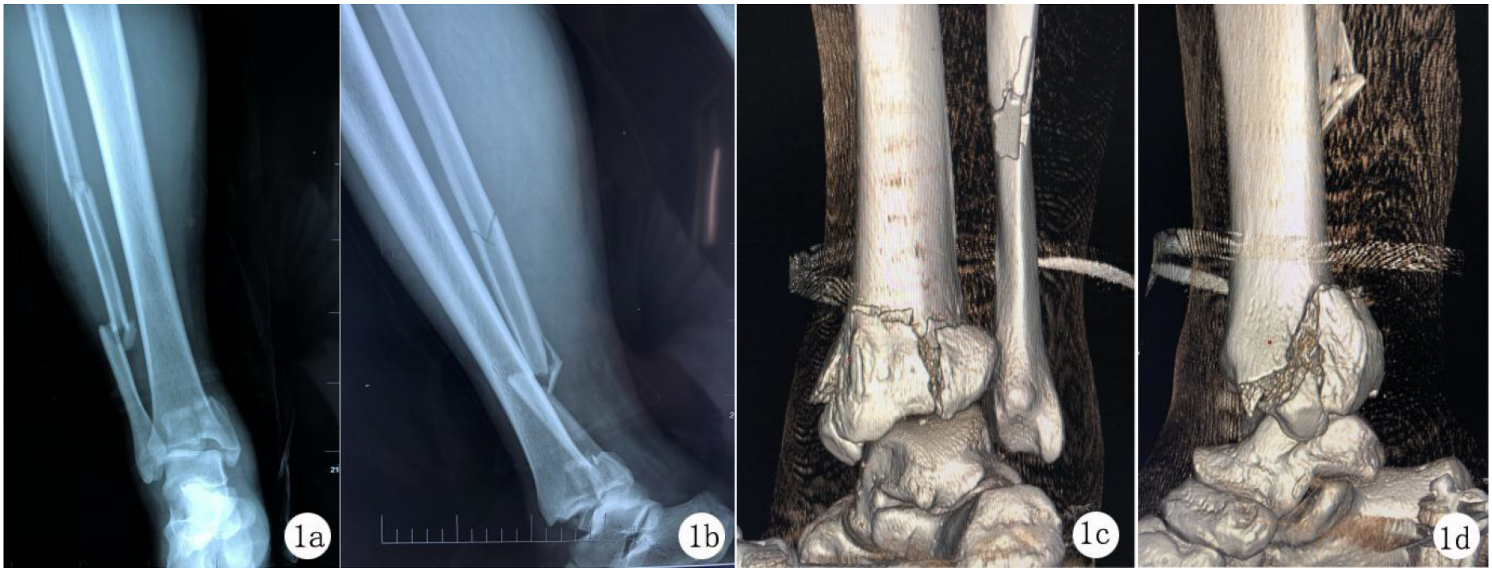

Figure 1

Images of a 52-year-old man treated for posterior pilon fracture. (a, b) Preoperative radiographs display a right fibular fracture, right medial malleolus and posterior malleolus fracture, and right posterior talus dislocation with “double contour sign”; (c, d) Three-dimensional computed tomography images display a right posterior pilon fracture, resulting in the formation of posteromedial and posterolateral bone blocks and the separation of the anterior from the posterior colliculus of the medial malleolus; (e) Posterior and medial malleolus fully exposed after surgery through the extended modified posteromedial approach; (f) Die-punch bone mass after the inward opening of the posterior medial bone mass; (g, h) Postoperative radiographs; (i, j) Functional phase of the ankle at 1 year after surgery