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Original Article

Analysis of the efficacy of a modified posteromedial approach for Klammer III posterior Pilon fractures

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ABSTRACT

Purpose: To analyze the curative effect and technical points of a modified posteromedial approach in the treatment of Klammer III posterior Pilon fracture.

Methods: A retrospective analysis of patients with Klammer III posterior Pilon fractures were conducted in our department from January 2018 to December 2019. Before the surgery, the patients were fully relieved of swelling and pain, and a comprehensive examination was carried out. The posteromedial approach exposed the posterior and medial fracture block of the distal tibia. According to the fracture of external malleolus, it is determined whether to combine a lateral incision and protect tendons and vascular nerves by a retractor, and then perform a fracture reduction and internal fixation. Postoperatively, the patients were treated with analgesia, detumescence, anticoagulation and rehabilitation exercise. The American orthopaedic foot and ankle society (AOFAS) score and visual analogue score were recorded at regular follow-up after surgery. A *t*-test was used for the comparison of the preoperative and final AOFAS score.

Results: There were 7 male and 13 female ($n = 20$) included in the study, aged 22 to 88 years (average age 54.2 years). The injury mechanisms were falling from a height ($n = 7$), traffic accident ($n = 6$), walking injury ($n = 2$) and heavy injury ($n = 5$). The postoperative follow-up duration was 12–24 months (mean 16.95 months). The AOFAS score of the 20 patients before and after surgery were compared. The preoperative AOFAS score was 38.90 ± 3.91, and the final AOFAS score was 80.55 ± 4.20, ($p < 0.001$). The mean final visual analogue scores at rest, active and weight-bearing walking were 0.30, 0.85 and 1.70, respectively. One patient reported poor postoperative wound healing and required a return to hospital for debridement and anti-infection treatment.

Conclusion: In the treatment of Klammer III posterior Pilon fractures, the modified posteromedial approach can fully expose the fracture block and the collapsed articular surface of the medial malleolus, achieve good reduction and internal fixation with limited injury of the tendon and vascular nerves, and have a better prognosis.

Introduction

Trimalleolar fracture is a clinically common type of traumatic fracture. The mechanism of damage is rotational violence. With the development of the construction industry, ankle lesions caused by falling are increasing. A special type of trimalleolar fracture is caused by a vertical merger force, as a result of which the fracture line of the posterior malleolus along the distal tibia coronal surface extends to the medial malleolus hill. Often ankle joint dislocations and injuries of the ankle joint cartilage surface are merged. Modern orthopaedic medicine has named these “posterior Pilon fractures”.[1]

The Klammer classification is commonly used to clinically evaluate such fractures.[2] The type I fracture involves the entire posterior malleolus and has a long oblique base towards the posterolateral side; the type II fracture line of the posterior malleolus extends to the inner side of the posterior colliculus; the type III consists of separate medial and lateral bone masses, involving the posterior and anterior hills of medial malleolus, which are accompanied by dislocation and serious soft tissue damage.[3]

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Because posterior Pilon fractures extend both backwards and forwards, the ankle commonly used in the posterolateral approach cannot be fully exposed.[4,5] Since 2013, our department has used the modified posteromedial approach to handle such fractures.

The author conducted a retrospective analysis of 20 patients with Klammer III posterior Pilon fractures who underwent improved internal fixation surgery in the author's department from January 2018 to December 2019. The summary analysis is as follows.

Methods

Clinical data

The general information

Inclusion criteria were: (1) meeting post-Pilon fracture diagnostic criteria; (2) meeting the Klammer III fracture classification; (3) preoperative and postoperative imaging data were available; (4) fully reducing swelling and improving soft tissue situation; (5) surgery at 3 days to 3 weeks from the time of injury; and (6) duration of follow-up at least 18 months. Exclusion criteria were: (1) the surgery was $\geq$3 weeks or < 3 days from the time of injury; (2) the follow-up time was less than 1 year; (3) patients were not able to tolerate surgery because of system diseases (e.g severe cardiopulmonary insufficiency, severe autoimmune diseases, severe coagulation dysfunction, etc.).

Twenty patients were aged 22 to 88 years (average 54.2 years), 7 cases were men and 13 were women. Among them, 7 patients fell from high places, 6 sustained injuries in traffic accidents, 2 sustained injuries while walking, and 5 were injured by heavy objects.

Postoperative functional evaluation

According to the scoring system of the American association of foot and ankle society (AOFAS), combined with preoperative and postoperative imaging data, and some aspects of patient's pain, ankle joint activity, shoe requirements, maximum walking distance, ground requirements and gait feedback, it is comprehensively scored with 7 rating categories.[6] The score of 90–100 points as excellent, 75 - 89 points as good, 50 - 74 points as available, and < 50 points as poor. The healing quality of fracture reset is determined according to picture archiving and communication system imaging evaluation.[7] A visual analogue scale was used to evaluate ankle joint pain when walking and resting. Regular follow-ups were carried out at 4–6 weeks, 12–16 weeks, 6 months, 1 year and 18 months.

Statistical analysis is performed by means of SPSS 13. The ankle and back foot scoring criteria of AOFAS and are represented by the $\overline{X} \pm SD$ before and after follow-up. The two-mean comparison is based on *t*-test analysis and $p < 0.05$ is considered statistically significant.

Management

Surgical techniques

According to the symptoms and fracture displacement, all patients were treated with manual reduction and plaster fixation or calcaneal traction before surgery, then admitted to the hospital, and given symptomatic treatment such as ice compresses, detumescence and pain relievers. In patients with serious soft tissue injuries, such as exudate or hematoma blisters, the wounds will be rinsed and partially sutured in the first stage. Surgical treatment would be postponed until the swelling had subsided completely. For patients with open commuted Pilon fractures or with fracture-dislocations of the ankle, an external fixator was preferred to stabilize the fracture after a preliminary manual reduction, which facilitated the protection of soft tissue and secondary internal fixation.

Intraoperative anesthesia was performed using a laryngeal mask combined with a lower limb nerve block on the affected side. The patient was placed in the prone position, and a balloon tourniquet was used, then performing routine disinfection and laying a towel. For patients with fibula fractures, the distal lateral approach for open reduction and internal fixation was used first. A lateral longitudinal incision of about 6–8 cm was made to treat the lateral malleolus fracture (Fig. 1A). A longitudinal incision for a modified posteromedial approach was extended distally along the medial side of the Achilles tendon (AT), for about 8–10 cm in length (Fig. 1B). The soft tissue was separated layer by layer after the skin tissue was cut open, and the flexor hallucis longus (FHL) tendon was used as a “protective sleeve” of the vascular nerve bundle. The FHL tendon was pulled medially along with the vascular nerves, while the AT was pulled laterally to expose the distal tibia, posterolateral bone mass, and part of the posteromedial bone mass of the posterior malleolus (Fig. 1C). The FHL tendon and the neurovascular bundle together with the AT were pulled together to expose the medial bone mass of the posterior malleolus (Fig. 1D). The direction of pull force was determined by the size of the medial and lateral bone mass of the posterior malleolus. It also formed a “double window” exposure approach to assist with the reduction and

Fig. 1. Schematic diagram of surgical techniques. (A) Lateral incision for the treatment of fracture of lateral malleolus (fibula). (B) The posterior and medial fractures were treated by modified posteromedial incision. (C) The flexor hallucis longus tendon was pulled medially along with vascular and nerve and the Achilles was pulled laterally for exposing the posterolateral bone mass and part of the posteromedial bone mass. (D) The tendon of the flexor hallucis longus and the neurovascular bundle together with the Achilles tendon were pulled outward to expose the medial bone mass of the posterior malleolus.

Table 1
Scores of 20 patients with long-term follow-up.

Serial number	Follow-up (months)	VAS score			Preoperative AOFAS	Postoperative AOFAS
		Rest	Activity	Weight-bearing walking		
1	24	0	1	2	37	83
2	20	0	0	1	40	88
3	22	0	1	2	42	78
4	20	0	0	1	44	84
5	21	1	1	3	38	77
6	18	1	1	2	35	80
7	19	1	2	3	32	76
8	20	0	0	0	39	87
9	18	0	1	2	43	79
10	15	0	1	2	41	78
11	13	1	1	2	34	75
12	18	0	1	2	39	78
13	15	0	1	1	40	84
14	15	0	0	1	36	81
15	17	0	1	1	42	81
16	15	0	0	1	43	80
17	13	0	1	1	45	83
18	12	0	0	1	41	87
19	12	1	2	3	32	72
20	12	1	2	3	35	80

VAS: visual analogue score, AOFAS: American orthopaedic foot and ankle society.

fixation. The hematoma and bone fragments between the fracture sites were cleaned. Posterior Pilon fractures usually involve the posterior colliculus of the medial malleolus and are often broken into posterolateral and medial segments, resulting in larger and deeper bone mass. In order to move the periosteum as little as possible, the posterolateral bone block was turned outwards and laterally, and the posteromedial bone block was turned inwards and backwards to avoid injuring the inferior posterior tibiofibular ligament and deltoid ligament. After opening and cleaning the bone, the damage to the articular surface of the distal tibia and the posterior articular surface of the talus was assessed. Anatomical reduction was performed on the posterior malleolus bone block and temporarily fixated with a 1.5 mm K-wire. If there was compression or collapse of the articular surface, a small periosteum stripping device was used to pry the collapse gently. The C-arm was used to confirm that the articular surface of the distal tibia was smooth during the operation. After that, 2 locking support plates in appropriate size were selected to fix the bone blocks respectively. The incision was sutured layer by layer, the negative pressure drainage tube was inserted, and the incision was bandaged.

Postoperative management

To prevent infection, reduce swelling and relieve pain, anticoagulants were administered after surgery. Patients were further encouraged to move their toes and carry out functional training on the progressive ankle. Non-weight-bearing joint activity began at 2–3 weeks after surgery, and weight-bearing training began at 6–8 weeks. Some patients were assisted with weight-bearing training or orthopaedic shoes for support. Regular follow-up after surgery was necessary to monitor bone healing by X-ray and to adjust the training plan.

Table 2
Descriptive statistics of AOFAS and VAS score.

Variables	Minimum	Maximum	Average	SD
AOFAS score ($n = 20$)				
Preoperative	32.00	45.00	38.90	3.91
Postoperative	72.00	88.00	80.55	4.20
VAS score ($n = 20$)				
Rest	0.00	1.00	0.30	0.48
Activity	0.00	2.00	0.85	0.67
Weight-bearing walking	0.00	3.00	1.70	0.86

AOFAS: American orthopaedic foot and ankle society; VAS: visual analogue score.

Results

Postoperative telephone visits and hospital visits were performed for 12–24 months (mean 16.95 months). According to the picture archiving and communication system imaging evaluation criteria, the ankle surface of the all 20 patients met the standards for anatomical reduction. The medium foot and ankle-hind foot scales of AOFAS were used to evaluate the efficacy of the foot and

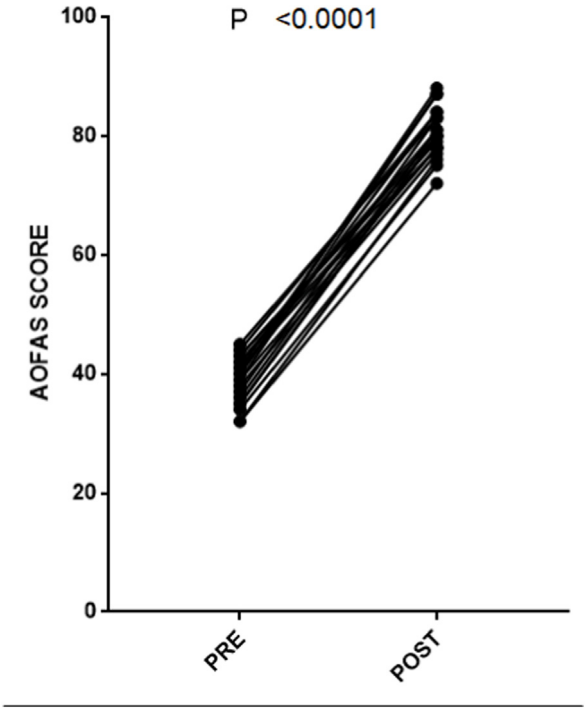

Fig. 2. Comparison of American orthopaedic foot and ankle society score pre- and post-operation.

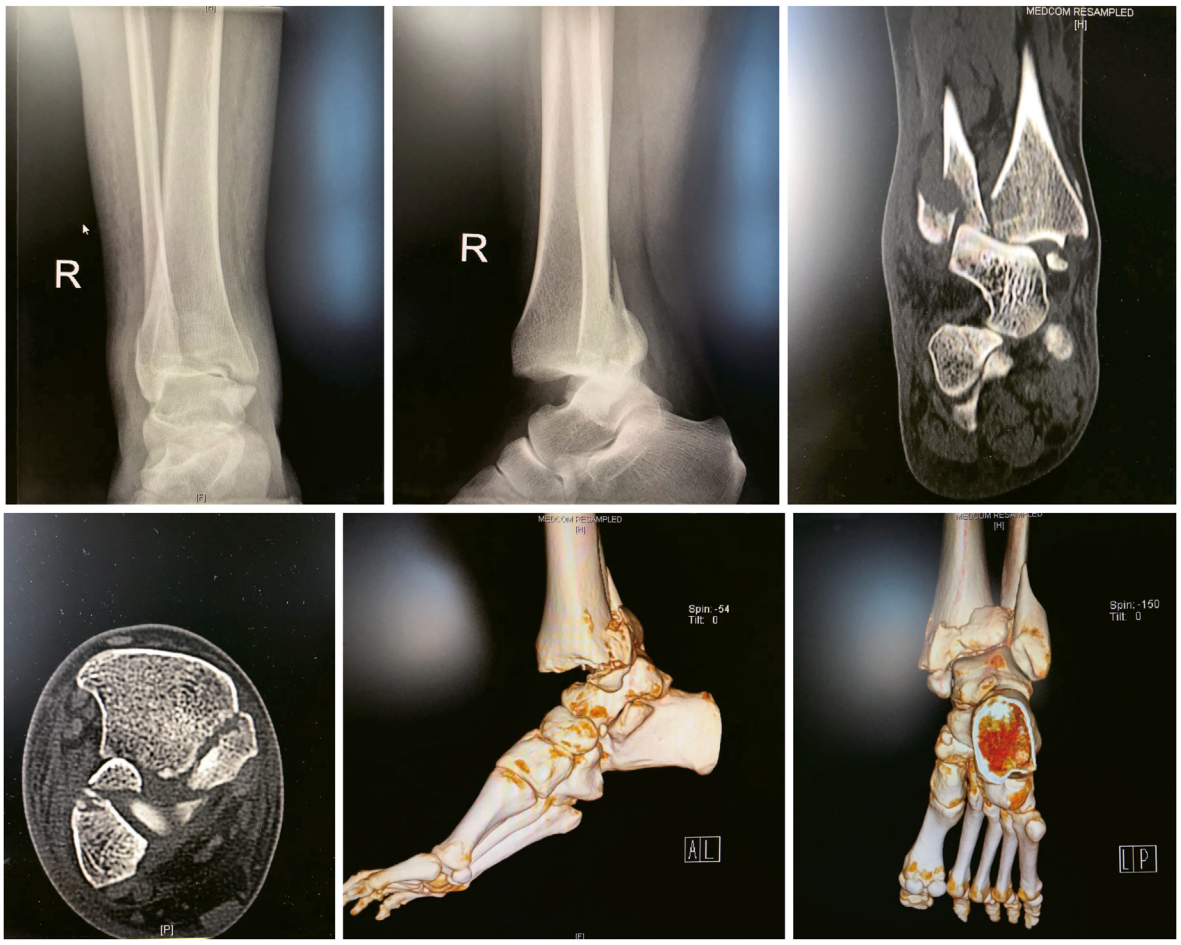

Fig. 3. Preoperative imaging data (anteroposterior and lateral radiographs of the ankle joint, CT plain scan and 3D reconstruction).

ankle functions of patients. According to Table 1, the results of 18 cases were good and 2 cases were adequate. The preoperative AOFAS score of the 20 patients with the long-term follow-up was 38.90 ± 3.91, and the final score was 80.55 ± 4.20, which was higher than that of the preoperative score ($p < 0.01$), indicating a statistically significant difference (Table 2 and Fig. 2). The final visual analogue score at rest, active and walking was 0–1, 0–2 and 0–3, with an average score of 0.30, 0.85 and 1.70, respectively. One case of poor wound healing due to infection had to return to hospital for debridement and anti-infection treatment (previous history of diabetes mellitus, poor blood glucose control, and failure to follow doctor's advice to take care of the incision on return home after surgery). Postoperative screw loosening occurred in 1 case, and the loose screw was re-fixed in hospital. There were no other postoperative complications, such as bone nonunion, implant foreign body reaction, and so on.

Typical case (Figs. 3–6)

A 32-year-old female was admitted to the hospital due to swelling and pain in her right ankle because of traffic accident occurred 5 h ago. The patient suffered a trimalleolar fracture combined Klammer III posterior Pilon fracture. Open reduction and internal fixation was performed 5 days after admission with a modified postromedical and lateral approach in the prone position. The tibiofibular screw was removed 8 weeks after surgery. After 1 year of follow-up, the final AOFAS score was 87 points.

Discussion

Ankle joint fracture is a common fracture type in clinical settings, commonly occurring in sports field or accidents, which accounts for 9% of all fractures.[8] A person suffers from an ankle fracture, always relating to severe pain, swelling, deformity and secondary subcutaneous congestion. About 46% of the ankle fractures are Weber B or C type ankle fractures and dislocations of posterior distal tibial fracture,[9] which are considered to be posterior malleolus fracture or posterior Pilon fracture.[10,11]

Damage mechanism and imaging features of posterior Pilon fracture

The concept of a Pilon fracture was first proposed by Destot in 1911,[12] and the concept of the posterior Pilon fracture was first proposed by Hansen in 2000.[1] These refer to intra-articular fractures of the distal posterior tibia caused by the combination of a vertical compressive force and a horizontal rotational force. Gardner et al.[13] believed that the posterior Plion fracture was caused by a vertical force in the plantar-flexion position of the ankle, Wang et al.[14] suggested that the combined effect of a rotational and vertical force in the plantar-flexion position of the ankle joint can lead to a medial ankle bone block after it separated from the medial malleolus. When the ankle joint was hit by a strong vertical and rotational combined violence in the protonation position, the high-energy injury can cause the fracture block and fracture line of the posterior ankle to extend to the medial malleolus. All these

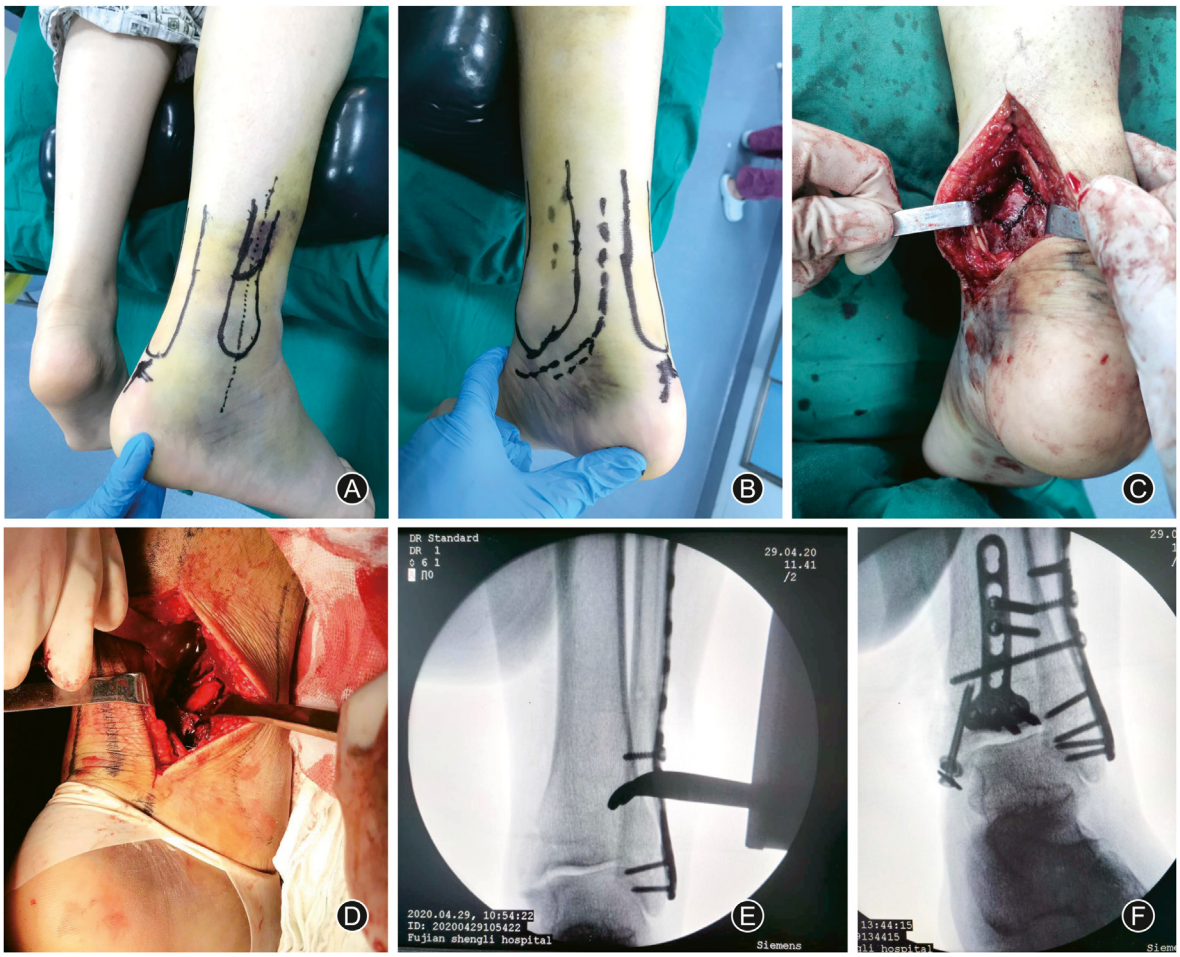

Fig. 4. Intraoperative condition: (A, B) surgical incision design (modified posteromedial and lateral approach); (C, D) intraoperative posteromedial incision to expose the fracture and complete reduction and fixation; (E, F) intraoperative fluoroscopy.

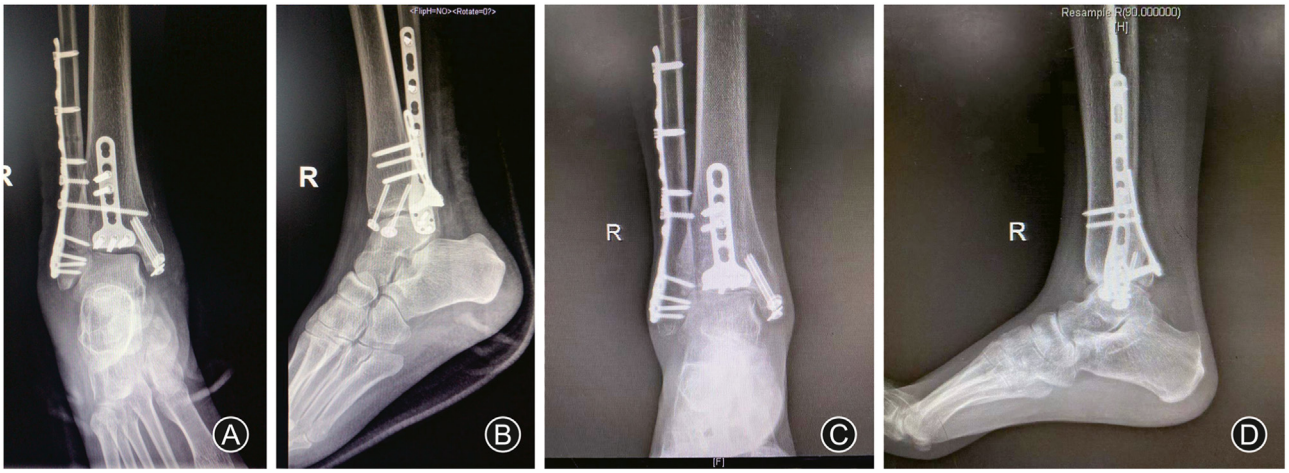

Fig. 5. Postoperative imaging reexamination: postoperative (A) anteroposterior and (B) lateral radiographs of the ankle joint; (C) anteroposterior and (D) lateral radiographs of the ankle joint at the 1 year postoperatively.

characteristics of ankle fractures are not caused by purely violent rotation. Unlike most high-energy Pilon fractures that cause fractures of the distal tibia articular surface, the soft tissue damage is significantly more serious. Zhao et al.[15] suggested that a vertical and rotational force can be both a single and compound function, and the specific effect of these 2 energies can cause a variety of clinical manifestations in posterior Pilon fractures.

Traditional trimalleolus or posterior malleolus fractures are the result of torsional violence. Posterior malleolus fracture is avulsion fracture, and articular cartilage injury is mild. In coronal plane,

Fig. 6. Ankle dorsiflexion and talar flexion functional phases 1 year postoperatively.

posterior malleolus fracture has no direct relation with medial Pilon fractures, which is not rare clinically. Forberger et al.[16] found a significant proximal displacement in the posterior half of the talus. On anteroposterior and lateral radiographs of the ankle, the fracture line can be seen at the posterior margin of the tibia, with or without compression leading to a collapse of the distal articular surface of the tibia. The characteristic image of the posterior Pilon fracture can be seen in the medial malleolus, which is called "bilateral sign", but neither the anteroposterior nor lateral radiographs can clearly show the direction of the fracture line, as well as the size and number of fracture fragments. In such instances, a CT examination should be performed after the presence of a posterior Pilon fracture has been confirmed by X-ray. Switaj et al.[17] summarized the characteristics of the posterior Pilon fractures: (1) The posterior malleolus fracture extends along the coronal plane to the posterior colliculus of the medial malleolus, and can be divided into posteromedial and posterolateral fracture blocks; (2) Proximal displacement of the posterior malleolus fracture with posterior dislocation of ankle joint may occur; (3) Osteochondral collapse and displacement of the posteromedial tibia may present. The lateral line shows that the osteochondral mass of the posteromedial tibia collapse is often embedded in the fracture space.

Modified posteromedial approach

For Klammer type III posterior Pilon fractures, the lack of ligaments in the medial posterior malleolus bone block means that the posterolateral approach requires removal of the posterior medial soft tissue, resulting in large soft tissue injury and difficulty in reduction and fixation. The improved posteromedial approach, combined with the advantages of the posteromedial approach and the posterolateral approach is more effective. The incision was made along the inner margin of the AT, and the FHL tendon was served as a "protective sleeve" of the vascular nerve plexus. The FHL tendon and the vascular nerve bundle were lifted and pulled medially, and the internal and posterolateral bone blocks were measured after full exposure. With this approach, the entire posterior end of the distal tibia is in the field of vision, and the direction of the fracture line, the number of fracture fragments and the displacement can be clearly observed.[17,18] Since the fracture can be corrected and reduced under direct vision, the uneven articular surface can be better reduced, thereby reducing the incidence of postoperative complications such as traumatic arthritis.[19] For the collapse of the articular surface, the posterior malleolus bone block can be gently pried up and the articular surface can be reduced by using a lever under direct vision. Therefore, for trimalleolar fractures combined with posterior Pilon fractures, we adopted the posteromedial approach combined with the lateral approach for reduction and fixation, the lateral approach for the fibula fracture, and the posteromedial approach for the posterior bone mass (both posteromedial part and posterolateral part). The effect of reduction and fixation was good, and a sufficient skin bridge was beneficial to the healing of the postoperative incision.

In summary, posterior Pilon fractures are severe ankle fractures caused by a combination of rotational and vertical forces. The Klammer III type covers the entire posterior malleolus, and the fracture line extends even to the anterior colliculus of the medial malleolus. Surgical treatment for this kind of fracture is difficult and cannot be accomplished effectively by the previous surgical approach used.[20] A modified posteromedial approach exposes the posterior internal and external fracture fragments and completes reduction smoothly, reducing soft tissue injury and postoperative complications. In this paper, 20 patients with Klammer III type fractures were included and the modified posteromedial approach was adopted to complete the exposed reduction and internal fixations. Through follow-up statistics, the postoperative AOFAS

scores were found to be significantly improved compared with the preoperative scores. Referring to the literature at home and abroad, the incidence of postoperative complications of traditional posterolateral approach combined with the medial approach is 4%–13%, and the low incidence of the modified posteromedial approach was similar to the traditional approach, further indicating that this surgical technique is worthy of promotion.

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Nil.

Ethical statement

This study was approved by the Fujian Provincial Hospital in Fuzhou.

Declaration of competing interest

All authors confirm that they have no financial and personal relationships with any commercial party. No financial relationships with any organizations that might have an interest in the submitted work in the previous five years.

Author contributions

Zheng-Chao Zhang: Manuscript data Collection and analysis, manuscript writing and revision. Wu-bing He: Control the theory, surgical techniques and put forward specialist guidance. Hao Lin: Data analysis and English writing guidance.

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