

# Comparison between buttress plate and anteroposterior screw internal fixation for posterior pilon fracture: a retrospective study

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## Research article

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# Abstract

**Background:** Posterior pilon fracture (PPF) is a serious ankle injury caused by combined vertical and rotational trauma. Surgical treatment includes buttress plate (BP), anteroposterior screw (APS) and posteroanterior screw (PAS) fixation. This study aimed to compare the therapeutic effects after PPF internal fixation with BPs and APSs.

**Methods:** From January 2015 to June 2018, 37 patients with PPFs underwent surgical treatment in our institution. The patients were divided into the BP (11 patients) and APS (26 patients) groups according to the internal fixation method. Bone healing time and postoperative complications were recorded. At the last follow-up, American Orthopedic Foot and Ankle Society (AOFAS) scores, visual analog scale (VAS) scores and Burwell-Charnley scores were used to evaluate ankle joint function, ankle joint pain, and fracture reduction on imaging, respectively.

**Results:** No significant difference in bone healing time was found between the two groups ( $P > 0.05$ ). Local necrosis of the posterolateral incision and chronic ankle pain occurred in 1 case each in the BP group. Chronic ankle joint pain occurred in 4 cases in the APS group. Two cases of soft tissue irritation were caused by screws that were too long. Local numbness of the posterolateral incision occurred in 1 case. At the last follow-up, no significant difference in VAS scores between the two groups at rest ( $P = 0.477$ ), but a significant difference during exercise was noted ( $P = 0.033$ ). AOFAS scores were better in the BP group than those in the APS group ( $P = 0.002$ ). According to the Burwell-Charnley scoring system, 11 cases were anatomically reduced in the BP group. In the APS group, anatomical reduction was achieved in 19 cases and fair in 7 cases.

**Conclusion:** Compared with APSs, BPs resulted in better reduction, ankle joint functional recovery and complication rates. BPs are recommended for internal fixation of PPFs.

## Background

Ankle fractures are among the most common fractures, accounting for approximately 9% of all fractures. A posterior malleolar fracture is involved in 7%-50% of ankle fractures.<sup>[1-4]</sup> For the first time in 1996, Huber<sup>[5]</sup> called a coronal fracture of the posterior malleolus with talus displacement a “trimalleolar pilon fracture”. In 2000, Henson<sup>[6]</sup> proposed the concept of “posterior pilon” fracture (PPF), which is a coronal fracture of the posterior malleolus as well as displacement of the posterior malleolus fracture fragment to the proximal end, with possible talus dislocation and articular cartilage injury. In recent years, awareness of PPFs has evolved, and unlike ankle fractures caused by rotation, adduction or abduction trauma, PPFs are currently generally believed to be caused by high-energy axial trauma combined with low-energy rotational trauma. However, the injury mechanism and fracture morphology cannot be accurately described by the Lange-Hansen classification of ankle fractures.<sup>[7-9]</sup>

Because the trauma suffered in PPFs is usually greater than that sustained in posterior malleolar fractures, such fractures are usually accompanied by collapse of the posterior tibial articular surface and articular cartilage damage. Therefore, unlike the traditional recommendation for surgical treatment when 25% of the articular surface is involved in posterior malleolar fracture, surgical intervention is recommended when 10% of the articular surface is involved in PPF or when ankle instability exists to restore ankle flatness and avoid traumatic arthritis.<sup>[10, 11]</sup> In 2013, Klammer<sup>[12]</sup> classified PPFs into 3 types and suggested adopting an appropriate surgical approach and internal fixation according to the type of fracture. For internal fixation of PPFs, surgeons may adopt different internal fixation methods, including buttress plate (BP) fixation, anteroposterior screw (APS) fixation, and posteroanterior screw (PAS) fixation. The above methods have advantages and disadvantages, and a consensus on the best method has not yet been reached.<sup>[12-15]</sup>

The purpose of this study was to evaluate whether BPs and APSs can effectively reduce and fix PPFs and to compare the clinical efficacy and postoperative complications of these two internal fixation methods.

## Methods

From January 2015 to June 2018, 37 patients with PPFs underwent surgical treatment in our institution. The following inclusion criteria were used: older than 18 years; a clear preoperative X-ray, CT scan and three-dimensional reconstruction diagnosis; normal ankle joint function before injury; no previous surgery around the ankle joint; and a follow-up for more than 12 months. The following exclusion criteria were used: severe open fractures (Gustilo classification type II or III<sup>[16]</sup>), old fractures, pathological fractures, fractures with vascular and nerve injuries, poor cardiopulmonary function, inability to tolerate surgical treatment, and incomplete case data. According to the fracture internal fixation method, the patients were divided into the BP (11 patients, 6 males and 5 females) and APS (26 patients, 8 males and 18 females) groups. In the BP group, the average age was  $50.64 \pm 18.91$  (range, 21-81) years, and 5 fractures occurred on the left, while 6 fractures occurred on the right, with 5 high falling injuries, 4 traffic injuries and 2 falling injuries when descending stairs or exercising. According to the Klammer classification<sup>[12]</sup>, 3 type I, 2 type II and 6 type III fractures were sustained. One case had no medial or lateral malleolar fracture, 3 cases had lateral malleolar fractures and 7 cases had medial and lateral malleolar fractures. The average time from injury to surgery was  $5.73 \pm 3.29$  (range, 2-12) days. In the APS group, the average age was  $52.15 \pm 16.22$  (range, 20-74) years, and 13 fractures occurred on the left, while 13 fractures occurred on the right, with 8 high falling injuries, 13 traffic injuries and 5 falling injuries when descending stairs or exercising. Ten type I, 4 type II and 12 type III fractures were sustained. Two cases had medial malleolar fractures, 3 cases had lateral malleolar fractures, and 21 cases had medial and lateral malleolar fractures. The average time from injury to surgery was  $5.50 \pm 3.50$  (range, 1-16) days. The basic information of the patients is shown in Table 1. All patients signed informed consent forms.

**Table 1.** Baseline characteristics of the patients: Group BP (buttress plate) and group APS (anteroposterior screw).

	Group BP n=11	Group APS n=26	P Value
<b>Gender</b>			
Male	6	8	0.268
Female	5	18	
Average age, y	50.64±18.91	52.15±16.22	0.806
<b>Side</b>			
Lift	5	13	1.000
Right	6	13	
<b>Injury cause</b>			
High falling injury	5	8	0.673
Traffic accident	4	13	
Falling when descending stairs or exercising	2	5	
<b>Klammer Classification</b>			
I	3	10	0.809
II	2	4	
III	6	12	
<b>Medial/Lateral malleolar fracture</b>			
None	1	0	0.196
Medial malleolar fracture	0	2	
Lateral malleolar fracture	3	3	
Medial and lateral malleolar fracture	7	21	
Time from injury to surgery, d	5.73±3.29	5.50±3.50	0.855

## Surgical techniques

According to X-rays and local edema following the injury, manipulative reduction and plaster external fixation or calcaneal traction were performed, and then the affected limb was elevated to reduce swelling. All patients were treated surgically after local swelling subsided. The operation was performed under

general anesthesia or spinal anesthesia. Intravenous drip antibiotics were administered 30 minutes before the operation to prevent infection. All operations were performed by the same group of doctors.

**BP group:** Klammer type I patients were treated using a posterolateral approach (prone position), and Klammer type II and III patients were treated using a combined posterolateral and posteromedial approach (floating position). Balloon tourniquets were applied to all patients to control hemorrhage. First, a longitudinal incision was made from the posterior edge of the fibula to the midpoint of the lateral Achilles tendon. Blunt separation was performed layer by layer. Care was taken to protect the sural nerve and the small saphenous vein. The peroneal muscles were pulled to the posterolateral side and fully separated to expose the lower fibula segment. In patients with lateral malleolar fractures, the fracture end was exposed, the stump hematoma was cleared, the lateral malleolus was reset by traction, and a lag screw was placed in the vertical fracture line. A lateral plate was then placed on the lateral malleolus to complete fixation of the lateral malleolar fracture. The posterior fracture block was exposed along the gap between the flexor pollicis longus tendon and the peroneal tendons. The posterior inferior tibiofibular ligament was used as a fulcrum, and the posterior fracture fragment was lifted to the distal and lateral sides. Next, the posterior articular surface of the ankle was explored, and the free cartilage and fracture fragment were removed. If the articular surface had collapsed, reduction and bone grafting were performed. Klammer type II and III fractures combined with a posteromedial bone block could not be completely exposed through the posterolateral approach and therefore required the use of a combined posteromedial approach. A 5-6 cm incision was made from the posterior inner edge of the distal tibia. After the incision was made layer by layer, the tissue in the ankle canal was pulled back to the medial side. At this time, the medial-lateral combined incision could fully expose the posterior fracture fragment. After both the posteromedial and posterolateral fracture fragments were anatomically restored, the posterior BP was placed through the posterolateral incision and fixed with locking screws. For medial malleolar fractures, 1-2 cannulated screws were inserted through the posteromedial incision for definitive fixation.

**APS group:** All fractures were fixated with the patient in the supine position. The posterolateral incision was the same as that used in the BP group. If a lateral malleolar fracture was also present, the lateral malleolus was fixated first according to the BP group method, and then the posterior fracture block was exposed by the same method. The free small bone block and cartilage debris on the articular surface were cleaned. Dorsal flexion of the ankle joint, pressing the posterior fracture block downward and forward, was performed to flatten the joint surface. Through the ankle joint anterior incision (1-2 cm), Kirschner wires were inserted from anterior to posterior to temporarily fix the posterior fracture block. After satisfactory reduction under fluoroscopy, cannulated screws (2-3) were inserted along the Kirschner wire with care to avoid irritating the soft tissues behind the ankle joint with screws that were too long. If the patient was also had a posteromedial fracture block, the APSs could not be fixed effectively. Therefore, a small posteromedial incision was made, and the posteromedial fracture block was fixed with screws from the posterior medial side. If the patient also had a medial malleolar fracture, the medial malleolus was fixed with 1-2 cannulated screws through a small incision in front of the medial malleolus. After fixation was completed, reduction and joint surface flatness were confirmed by fluoroscopy. The cotton test was

routinely used to check the stability of the lower tibiofibular syndesmosis, and a lower tibiofibular syndesmosis screw was used to fix an unstable tibiofibular syndesmosis. All patients had lower tibiofibular screws, and the screws were removed 12 weeks after the operation. All patients in the APS group received plaster immobilization for 4 weeks after surgery.

### **Postoperative management and follow-up**

Prophylactic antibiotics were administered for 24-48 hours after surgery, and elevation of the swollen affected limb was maintained. The drainage tube was removed 2-3 days after the operation, and the dressing was changed every 2-3 days to observe wound healing. Ankle functional exercise was started as soon as the patient could tolerate such movements (after the plaster was removed in the APS group), and the intensity of exercise and the weight-bearing time were determined according to fracture healing and ankle functional recovery. X-ray films were reexamined 2 weeks, 4 weeks and 3 months after the operation and then every 3 months from 3 to 12 months after surgery to observe bone healing and record complications.

At the last follow-up, ankle joint function was assessed using the American Orthopedic Foot and Ankle Society (AOFAS) score<sup>[17]</sup>. The visual analog scale (VAS)<sup>[18]</sup> was used to assess ankle joint pain during rest and exercise, where the score gradually increased from 0 to 10 with an increasing pain level. The Burwell-Charnley scoring system<sup>[19]</sup> was used to assess fracture reduction in imaging evaluations.

### **Statistical analysis**

SPSS 22.0 (SPSS, Chicago, IL, USA) software was used for statistical analysis. The measurement data were expressed as the mean±standard deviation ( $\bar{x}\pm s$ ). The follow-up time, bone healing time, VAS scores during rest and exercise, and AOFAS scores were compared by an independent samples *t* test. The enumeration data were expressed as rates. *P* values < 0.05 were considered significant (bilateral test).

## **Results**

***Clinical and radiological outcomes.*** The follow-up time was 19.91±7.13 (range, 12-28) months in the BP group and 21.83±8.86 (range, 12-36) months in the APS group, with no significant difference between the groups (*P* = 0.307). All fractures healed, and the bone healing time ranged from 10 to 13 weeks in the BP group and from 9 to 14 weeks in the APS group, with no significant difference in bone healing time between the groups (*P* = 0.104). At the last follow-up, the VAS score was 0.27±0.47 (range, 0-1) in the BP group and 0.46±0.81 (range, 0-3) in the APS group when the ankle joint was at rest. During exercise, the VAS score was 0.64±0.67 (range, 0 to 2) in the BP group and 1.38±1.02 (range, 0-3) in the APS group. No significant difference in VAS scores at rest were found between the groups (*P* = 0.477). However, a significant difference during exercise was noted (*P* = 0.033). The AOFAS score was 89.45±4.99 (range, 85-97) in the BP group and 83.92±4.47 (range, 74-96) in the APS group, with significantly higher AOFAS scores in the BP group than those in the APS group (*P* = 0.002). According to the Burwell-Charnley scoring

system, 11 cases were anatomically reduced in the BP group. In the APS group, anatomical reduction was achieved in 19 cases and fair in 7 cases. Clinical outcomes are shown in Table 2.

**Table 2.** Clinical outcomes of the two groups after the follow-up. Abbreviations: BP, buttress plate; APS, anteroposterior screw; VAS, visual analog scale; AOFAS, American Orthopedic Foot and Ankle Society. <sup>a</sup>*P* < 0.05.

	Group BP n=11	Group APS n=26	<i>P</i> Value
Follow-up, month	19.91±7.13	21.83±8.86	0.307
Bone healing time, week	10.82±0.98	11.58±1.36	0.104
VAS score			
Rest	0.27±0.47	0.46±0.81	0.477
Active movement	0.64±0.67	1.38±1.02	0.033 <sup>a</sup>
AOFAS score	89.45±4.99	83.92±4.47	0.002 <sup>a</sup>

**Complications.** Local necrosis of the posterolateral incision occurred in 1 patient in the BP group after surgery, and the incision healed after 4 weeks of local dressing changes. Chronic ankle pain in 1 patient may have been related to irritation of the posterior tibial tendon by the BP. The BP was removed 14 months after the operation, and the pain in the ankle disappeared. In the APS group, 4 patients had chronic joint pain that worsened during exercise and were treated with oral drugs. Two patients suffered from soft tissue irritation on the posterior side of the ankle joint caused by screws that were too long, and the discomfort disappeared 15 months after screw removal. One case of local numbness in the posterolateral incision may have been related to local cutaneous nerve injury during the operation. Two typical cases are shown in Figure 1 and Figure 2.

## Discussion

The injury mechanism in PPF differs from that in an ankle fracture caused by rotational trauma. Amorosa<sup>[8]</sup> found that when the ankle joint is in the plantar flexion position, high-energy vertical trauma acts on the talus, causing it to impact the posterior articular surface of the distal tibia to produce axial compression and split fracture, which may be accompanied by cartilage damage to the talus roof. The fracture line may extend to the posterior side of the medial malleolus and may even be accompanied by medial malleolar fracture. On an anteroposterior X-ray film, a specific double-layer cortical shadow above

the medial malleolus is visible, which is known as a “double contour sign”. The fracture line can be observed on a lateral X-ray film on the coronal plane, and the fracture block of the posterior malleolus moves towards the proximal end, presenting a “double joint line sign”.<sup>[2, 20]</sup> Therefore, preoperative CT examination may be helpful for clarifying the fracture morphology and guiding treatment.<sup>[21]</sup> CT examination after an operation can confirm the relative position of internal fixation and fracture reduction.

PPFs are complex ankle fractures, and backward talus movement will lead to severe soft tissue injury in front of the ankle. For patients with severe soft tissue injury, improper operative timing may lead to severe complications, including wound infection, skin necrosis, and delayed fracture healing. Therefore, for patients with Tscherne-Gotzen scale II-III injury, we believe that surgery should be performed after local edema subsides and a “wrinkle sign” appears on the skin. Klammer<sup>[12]</sup> believed that a simple posterolateral approach can be used to reduce the vast majority of posterolateral fracture blocks, but the posterolateral approach can expose only 40% of the posterior ankle joint surface<sup>[22]</sup>. Therefore, for fractures combined with posterolateral fracture blocks, combined posterolateral approaches may be necessary to provide a better visual field<sup>[20]</sup>. In our study, we followed the above principles by adopting a single posterolateral approach for a single posterolateral fracture block or PPF combined with a lateral malleolar fracture, or a combined posterolateral and posterolateral approach for patients with both a posterolateral fracture block and medial malleolar fracture. During the process of operative incision and exposure, we believe that the following points should be considered. First, injury to the sural nerve and saphenous vein must be avoided with the posterolateral approach, the sural nerve should be carefully identified, and excessive traction should be avoided during surgery to avoid postoperative skin sensory disturbance on the lateral foot and posterior leg. In addition, the small saphenous vein originates on the lateral side of the dorsalis pedis vein arch and ascends through the posterior aspect of the lateral malleolus. Attention must be dedicated to protecting this vein during the operation, and ligation should be performed if necessary. Furthermore, attention must be dedicated to protecting the posterior tibial artery and tibial nerve when using the posteromedial approach to avoid postoperative complications.

The treatment principle for PPFs is rigid internal fixation. The degree of reduction is closely related to the long-term function of the ankle joint.<sup>[23, 24]</sup> Avoiding articular surface steps is the key to preventing postoperative traumatic arthritis. For a traditional pilon fracture and trimalleolar fracture, we usually follow the principle of “from outside to inside, from back to front”, with a reduction sequence of the lateral malleolus, posterior malleolus and medial malleolus. However, in PPF fixation, the reduction sequence is controversial. Some surgeons believe that fixation of the lateral malleolus may affect the evaluation of posterior fracture block reduction. Therefore, reducing the posterior malleolar fracture first and then the lateral malleolar fracture has been suggested. However, our experience shows that compared with posterior and medial fractures, lateral malleolar fractures are usually relatively simple. After reduction of the lateral malleolus, traction of the anterior and posterior ligaments of the lower tibiofibular can be implemented, and the posterior bone mass can be satisfactorily reduced.

BPs and APSs are used to fix PPFs.<sup>[13]</sup> Theoretically, lag screw fixation is mainly maintained by pressure on the fracture block, which may be less stable than BP fixation. APS fixation may not be able to effectively resist shear stress on the posterior malleolus when the ankle joint is in the plantar flexion position, resulting in fixation failure. Ten patients with PPFs treated with BPs by Chen achieved satisfactory clinical results during an average follow-up of 36.2 months.<sup>[15]</sup> Sukur<sup>[3]</sup> treated 14 cases of PPF; 3 cases were fixed with BPs, and 11 cases were fixed with PASs. All patients exhibited satisfactory reduction, and Sukur therefore believed that PASs can also stabilize PPF fixation. In Amorosa's study,<sup>[8]</sup> PPFs fixated with PASs had no complications of fracture redisplacement and internal fixation failure. Our results suggest that compared with APSs, BPs can provide better stability and prevent redisplacement after the operation. However, BP placement requires extensive stripping of the soft tissue off the posterior malleolus, which may affect the blood supply at the fracture site and delay bone healing. Additionally, the large volume of the plate and the numerous tendons, vessels and nerves on the posterior side of the ankle joint easily lead to irritation of the posterior tibial tendon. In our study, one patient had irritation of the posterior tibial tendon, but the symptoms subsided following plate removed. In APS fixation, the length of the screw should be carefully determined to prevent the screw from being too short, which results in the bone block not being tightly held, or too long, which leads to soft tissue and skin irritation. Our results suggest that the main factor affecting the screw fixation effect before and after surgery is inaccurate reduction, which leads to joint surface abrasion and pain during exercise. However, no postoperative fracture redisplacement was observed.

This study had the following limitations. First, this was a retrospective study with a low evidence level. Second, the numbers of patients in the two groups were small, and the follow-up time was limited. Lastly, we did not calculate sample size statistics and the results may be biased. However, we believe that these results will provide a reference for PPF treatment for other researchers.

## Conclusions

PPFs are caused by the combined effect of rotational and axial trauma to the ankle joint. Although the incidence is relatively low, the trauma is severe, and the joint surface damage can be substantial. Surgical treatment and anatomical reduction are the main methods applied to avoid joint dysfunction. BPs and APSs can effectively fix PPFs, but the reduction effect of APSs is worse than that of BPs, and the incidence of postoperative complications is higher for APSs. Therefore, BPs are recommended for internal fixation of PPFs.

## Abbreviations

PPF: Posterior pilon fracture; BP: Buttress plate; APS: Anteroposterior screw; PAS: Posteroanterior screw; VAS: Visual analog scale; AOFAS: American Orthopedic Foot and Ankle Society.

## Declarations

## **Ethics approval and consent to participate**

Not applicable.

## **Consent for publication**

Not applicable.

## **Availability of data and materials**

The datasets used and 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.

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## **Authors' contributions**

LYZ, ZQL and YTW carried out the studies, participated in collecting the data, and drafted the manuscript. CY, CX and FXL completed the surgery on all patients. JT and YHS performed statistical analysis and participated in its design. ZAZ helped to draft the manuscript. All authors read and approved the final manuscript.

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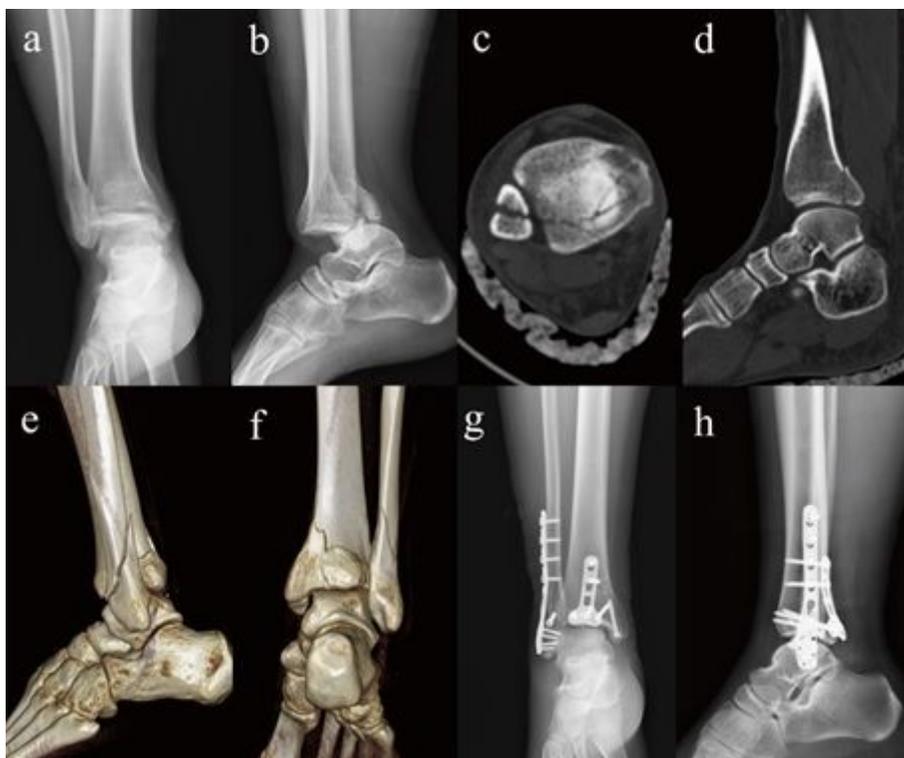
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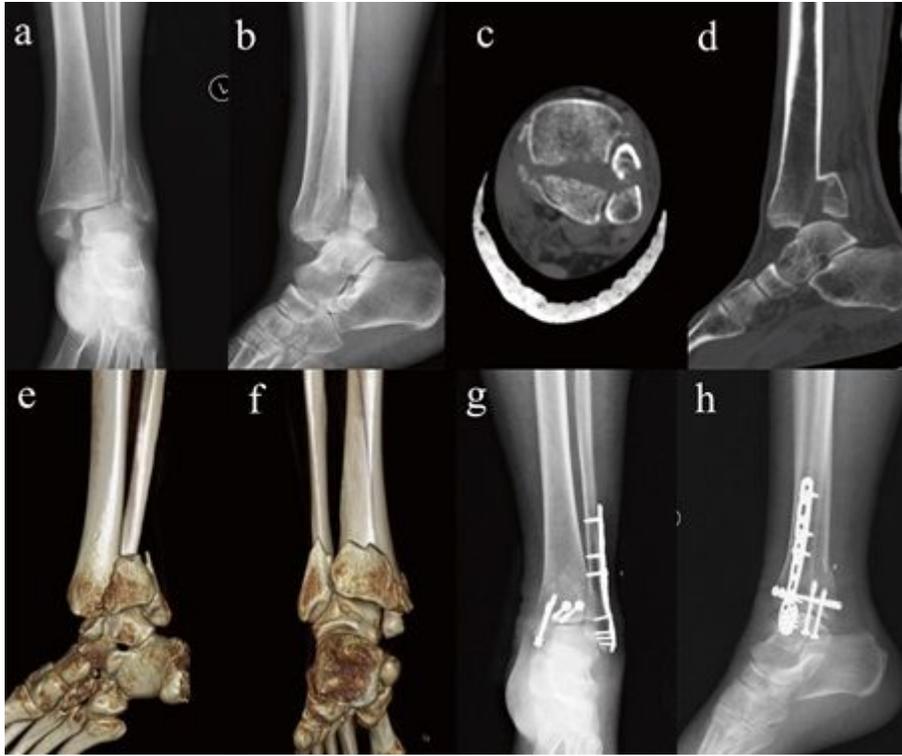
## Figures



**Figure 1**

A 33-year-old man was admitted to the hospital with pain in the right ankle due to a fall during exercise. (a, b). An x-ray plain film shows a posterior fracture of the distal tibial articular surface. (c, d). A CT scan shows a posterior fracture of the distal tibial articular surface and a fracture line involving the medial malleolus. (e, f). Three-dimensional reconstruction shows the posterior malleolar fracture block and lateral ankle fracture. (g, h). Postoperative X-ray shows the buttress plate used to fix the posterior fracture

block, the anatomical plate used to fix the lateral malleolus, and the hollow nail used to fix the medial malleolus, with restoration of the normal anatomic structure of the ankle joint.



**Figure 2**

A 64-year-old female was admitted to the hospital with pain in the left ankle due to a traffic accident. (a, b). X-ray shows a fracture of the posterior side of the distal tibial articular surface, with displacement of the fracture block and backward displacement of the talus. (c, d). CT scan shows a posterior fracture of the distal tibial articular surface. (e, f). Three-dimensional reconstruction shows the posterior malleolar fracture block and lateral malleolar fracture block. (g, h). X-rays showing two anteroposterior screws used to fix the posterior fracture block, an anatomical plate used to fix the lateral malleolus, and two hollow screws used to fix the medial malleolus. The normal anatomy of the ankle joint was restored.