Selection of Internal Fixation Method for Posterior Ankle Fracture

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***Tob Regul Sci.™ 2021;7(6-1):* 6663-6677**
DOI: doi.org/10.18001/TRS.7.6.1.1

Ankle fracture is one of the common lower limb fractures in clinic. Clinically, simple posterior malleolus fractures are unique, accounting for about 1% of ankle fractures [1, 2]. However, ankle fractures with posterior ankle fractures accounted for 14-44% [3, 4]. Some researchers found that compared with patients with ankle fracture without posterior malleolus, patients with posterior malleolus fracture had worse postoperative effect and higher risk of traumatic ankle arthritis. There are still many controversies about the surgical indications and internal fixation methods of posterior malleolus fractures. Presently, the widely accepted surgical indications for posterior malleolus fractures include: posterior malleolus fractures involving more than 25% of the articular surface, fracture block displacement more than 2 mm, ankle instability or posterior superior talar dislocation [11-13]. In clinical application, the internal fixation methods of posterior malleolus fracture mainly include lag screw fixation and supporting plate fixation. The results of biomechanical model experiment in vitro and finite element analysis of mechanical model showed that the most stable fixation strategy was the back support plate [14, 15]. However, so far, there is no clear standard about whether all posterior malleolus fractures need plate fixation [10, 14]. Most of the present studies have discussed the surgical indications of posterior malleolus fracture, but the clinical reports of individualized selection of posterior malleolus fixation are rare. Biomechanical theory proved that the size of the posterior malleolus is the key to fixation [14]. In clinical work, some surgeons advocate the use of high-strength plate fixation, and some surgeons prefer to use minimally invasive screw fixation. In addition, according to the experience of the surgical team, some surgeons fixed the smaller posterior malleolus with 2-3 screws and fixed the larger posterior malleolus with plates. Specifically, there are few clinical reports about the standard of bone block size and the choice of internal fixation.

Before 2013, the majority of posterior malleolus fractures in our trauma center tended to be fixed with lag screw, and some cases were selectively fixed with nail plate. In recent years, with the skilled application of posterolateral approach and posteromedial approach and the deepening understanding of biomechanics of posterior malleolus fracture, more and more patients with posterior malleolus fracture have been treated with plate and screw internal fixation. Therefore, this study retrospectively analyzed the ankle fracture cases of posterior malleolus fracture by measuring the area ratio of posterior malleolus fracture block to tibiotalar joint surface, selection of internal fixation and injury classification. We will focus on the clinical efficacy, in order to provide reference for the personalized selection of internal fixation methods and perioperative management of posterior malleolus fractures.

Pre-operative preparation

Before the operation, the affected limb of the patient was lifted by plaster immobilization. If there was a tendency of posterior talus dislocation, the patient was given reduction in time. The ankle joint was slightly flexed and plastic plaster was used to maintain the talus position. The patients with ankle instability after reduction were given calcaneal traction. The patients were routinely treated with detumescence and prevention of deep venous thrombosis. Generally, 7-10 days later, the operation can be performed after the appearance of dermatoglyphic sign on the ankle of the affected limb.

The preoperative examinations and X-ray films of adjacent joints in anteroposterior and lateral position, full-length position of leg and ankle acupoints were taken. All patients underwent 64 slice CT and three-dimensional reconstruction of ankle joint and distal tibia to expose the tibiotalar joint surface to confirm the posterior malleolus fracture and its classification. Ankle MRI was used to evaluate ankle ligament injury, and ligament repair was performed when necessary.

Measurement of the ratio of posterior malleolus fracture area to tibiotalar joint area: According to the methods described in the literature [1], the three-dimensional CT surface measurement method was used in the PACS system of our hospital [16]. The surface boundary of the residual articular surface (removing the medial malleolus) and the tibiotalar articular surface of the posterior malleolus were drawn manually. The surface areas were calculated automatically by the system and recorded as Si and Sii respectively. The ratio of the affected area of the posterior malleolus (R) was Sii / (Si + Sii) (Fig. 1).

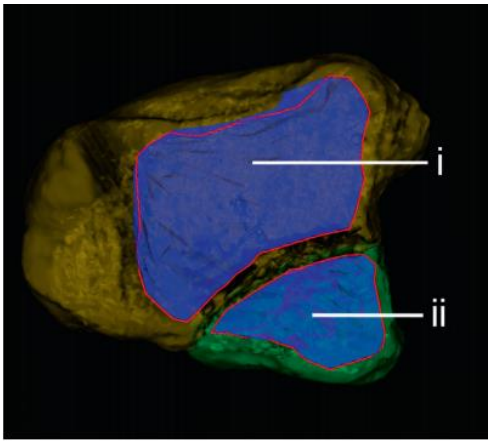

Fig. 1 Si: Surface area of residual articular surface (removal of medial malleolus); Sii: Surface area of tibiotalar joint surface of posterior malleolus

Anesthesia and posture

All patients received combined spinal epidural anesthesia. After anesthesia, the air tourniquet was put on the thigh root, and the supine position or floating position was used according to the operation needs.

Operation methods

Screw fixation group: The patients with medial and lateral malleolus fractures were treated by conventional surgical approach.When the fibula needs to be repositioned, the lateral approach should be slightly backward, and the fibula should be properly stripped to the back of the long and short fibular muscles to enter the exposed part of the

posterior malleolus. Generally, the reduction order is lateral malleolus, medial malleolus and posterior malleolus. The internal and external malleolus were fixed with steel plate or screw according to the injury situation. Usually, after anatomizing the external malleolus, the malleolus could be reduced by pulling the articular capsule ligament. It can also be reset by proper manipulation. After the ankle joint was extremely dorsiflexed, the posterior malleolus was reduced by pulling the surrounding ligaments and soft tissues, and the posterior malleolus was temporarily fixed with point reduction forceps in the anterior and posterior directions. When the reduction of some patients is not good, the posterior malleolus can be exposed through the lateral approach through the fracture space of lateral malleolus, and the fracture end can be cleaned under visual state. Two cannulated screws were inserted into the tibia at 1cm above the anterior lip of the tibia, perpendicular to the fracture line. For the high posterior malleolus, a cannulated pin was inserted into the proximal end of the bone block from front to back. The selection of vertical fracture line should not only consider the cross section, but also consider the sagittal direction. Otherwise, the posterior malleolus may shift to the proximal or distal when the screw is tightened. The C-arm fluoroscopy was used to determine the satisfactory reduction. A small incision of about 1cm was made in front of the ankle joint, and a 3.0 mm double head compression cannulated lag screw was used to fix the anteroposterior guide needle. When the medial posterior malleolus is thin or small, the cannulated lag screw should be inserted from front to back to make the thread pass through the fracture line as far as possible. The threaded part of the lag screw is completely located in the posterior malleolus fracture block. If necessary, the tip of the lag screw can be allowed to penetrate the bone cortex a little to increase the compression between the fracture blocks. Pull out the guide needle, loosen the reduction forceps, move the ankle joint, and check the reduction by X-ray fluoroscopy again to confirm the reduction of the posterior ankle and the length and position of the lag screw. The patients were treated with plaster or functional external fixation for 3 weeks.

Plate fixation group: A longitudinal incision about 10 cm long was made at the midpoint of the line between the posterior edge of lateral malleolus and Achilles tendon to expose and protect the saphenous vein and sural nerve. It should be noted that the sural God often accompanies the saphenous vein, and its surface projection is located on the line between the midpoint of popliteal fossa and the posterior edge of distal fibula. Incise the deep fascia of the leg, identify the space between the short fibular muscle and the flexor longus, identify and ligate the communicating branch of the peroneal artery, enter the space, pull the flexor longus and Achilles tendon to the inside, and the fibular tendon to the outside, and expose the posterior malleolus. If necessary, the posterior structure of ankle joint can be cut transversely to reset the bones. In visible state, the ankle bone block was restored, and 2-3 Kirschner wires were used to temporarily fix the ankle bone block from the back to the front. X-ray machine was used to observe the reduction and confirm the smoothness of the articular surface. The distal radius T-shaped plate was properly shaped, implanted and fixed with screws. When combined with lateral malleolus fracture, the lateral malleolus fracture was exposed by entering the peroneus longus muscle through this approach. The lateral malleolus fracture was reduced and fixed with posterolateral anatomical locking plate. Other ankle injuries were treated with routine treatment.

Postoperative management

After operation, the affected limb was raised and ice was applied for 72 hours. Ask the patient to strengthen the movement of each toe after anesthesia. After 3 weeks of screw fixation, the fixed braces were removed, and the ankle

plantar flexion and back extension function training was started. After 8-10 weeks, the limited weight-bearing rehabilitation training under protection was gradually carried out. After 2-3 months, the fracture healing was reexamined according to the X-ray film, and the patients were instructed to walk normally. Active and passive plantar flexion and dorsiflexion of ankle joint were started on the second day after plate fixation. The other rehabilitation training methods were the same as those of patients who received screw fixation.

Clinical data

General information

Case inclusion and exclusion criteria

Case inclusion criteria : 1. New closed ankle fracture with posterior malleolus; 2. Ankle fracture without vascular and nerve injury and without injury of other parts affect postoperative rehabilitation training; 3. There was no history of ankle fracture; 4. X-ray showed that there was no ankle arthritis on the affected side before injury; 5. Aged 18-65. Case exclusion criteria: 1.Poliomyelitis and other diseases that affect postoperative rehabilitation exercise; 2. The patients with mental illness can not follow the doctor's advice; 3. Abnormal limb development on the affected side; 4. Pilon fracture (AO-OTA 43C, AO-OTA 43C type) and comminuted fracture were treated with ankle fusion; 5. Pathological ankle fracture; 6. Patients with diabetes and hyperthyroidism may affect fracture and wound healing.

After screening, a total of 240 patients with posterior malleolus fracture were treated with internal fixation and whole followed up from January 2010 to October 2018. 6 patients failed to receive outpatient follow-up examinations and were excluded in this study. According to the ratio of posterior malleolus to distal tibial joint area (PMF%), they were divided into three groups: group A (PMF% ≤ 1 / 4), group B (1 / 4 < R ≤ 1 / 3), group C (1 / 3 < R), Each group was divided into two subgroups according to the way of screw fixation and plate fixation. The gender, average age, injury status and Denis Weber classification of patients in each group are listed in Table 1. There was no significant difference in age, gender, injury, fracture classification and other general information among the three groups (P > 0.05). The experimental grouping factors are comparable.

Table 1 general information of patients

Fixation methods	Groups	Average age (years)	Genders		Injury mechanism		Denis-Weber Types	
			male	female	High energy injury	Low energy injury	B	C
screw	A1	42.267±12.638	31	25	19	37	31	25
plate	A2	42.028±13.424	19	16	19	23	16	19
screw	B1	38.891±12.6354	21	15	19	27	22	24
plate	B2	38.9500±12.3971	21	19	18	22	21	19
screw	C1	41.2692±13.79147	12	14	16	10	11	15
plate	C2	40.9355±13.2663	19	12	20	11	13	18

Table 1 The basic information of patients

Postoperative follow-up and observation index

Observation index

Through outpatient follow-up, doctors evaluate the recovery of ankle function from subjective and objective aspects. All patients were followed up for 12-24 months, and all patients were regularly reviewed. The operation time, fracture healing time, incidence of wound related complications, curative effect evaluation and ankle function evaluation were recorded.

Efficacy evaluation

X-ray was used to analyze the fracture healing 12 months after the operation, including recording the loss of ankle bone after reduction, recording whether there were steps, joint space, ankle stability and other related changes caused by reduction loss. Evaluation of fracture healing: excellent, X-ray showed that the fracture achieved anatomical reduction and healing; Good,X-ray showed that the anatomical reduction and healing were similar, that is, the displacement of distal tibial articular surface ≤ 2 mm, the widening of ankle point ≤ 2 mm, the space of inferior tibiofibular syndesmosis ≤ 2 mm, and there was no inclination of talus; Poor, X-ray showed that the displacement exceeded the above criteria.

Evaluation of ankle function

AOFAS Ankle Hind Foot Scale was used. Excellent: 90-100 points; Good: 75-89 points; Average: 50-74 points; Poor: below 50 points.

Statistical methods

IBM SPSS 17.0 software was used for statistical analysis. Shapiro-Wilk test was used to judge the age and fracture healing time of the two groups, which were in accordance with normal distribution and homogeneity of variance. Mann Whitney U test was used to test the variance of operation time. The measurement data of normal distribution are calculated by means ± Standard deviation ($x \pm S$), and T test was used for comparison between groups. The counting data were expressed by rate, and the comparison between groups was performed by χ^2 test. $P < 0.05$ means the difference is statistically significant.

Clinical results

Comparison of curative effect between two groups

Wound and fracture healing condition among groups

From table 2, it can be seen that the operation time of screw fixation between 1 / 4PMF, 1 / 3PMF AND 1 / 2PMF subgroups was significantly shorter than that of plate fixation ($P < 0.05$). In the 1 / 4 PMF group, in the screw fixation group, there was 1 case of superficial infection within one week, and 2 cases of skin edge necrosis and superficial infection around the wound. The wound healed through intensive dressing change, and did not deteriorate to deep infection. The incidence of wound complications was 5.4%; In the corresponding steel plate group, 2 patients had wound exudation and poor healing within one week, and the wound was healed by strengthening wound dressing change and delaying suture removal. In one week, there were 2 cases of skin edge necrosis and superficial infection around the wound, and 2 cases of local numbness in the distal posterolateral side of the affected leg. Considering the injury of sural nerve, the symptoms were not significantly improved after oral

administration of nutritional nerve drugs; One patient showed signs of deep infection within one week, and the wound was healed by timely secondary debridement and the steel plate was not removed. However, the patient later developed "horse rein" deformity due to scar adhesion of posterior tibial tissue including flexor digitorum tendon, and the daily walking function of the affected foot was significantly limited. After 8 months, the fracture healed, the internal fixation was removed, and the ankle release deformity of flexor longus was slightly improved，and the patient did not receive further release surgery; One patient had the symptoms of posterior tibial tendon irritation, and removing the plate after fracture healing relieved the symptoms. The incidence of wound related complications in the plate group was 22.9%, and that in the screw group was significantly lower than that in the plate group ($P < 0.05$). In the 1 / 3PMF screw group, 2 patients had a small amount of wound exudation and delayed wound healing. After dressing change in outpatient department, the wound healed. Within one week, 1 patient had superficial wound infection and peripheral skin necrosis. After dressing change, the wound healed. In the 1 / 3PMF plate group, there were 4 patients with superficial wound infection, skin edge necrosis due to excessive peeling or postoperative edema blistering, and the wound healed after prolonged dressing change time; One patient developed symptoms of sural nerve injury, but the symptoms were not improved after rehabilitation and oral nutrition; Three patients developed posterior tibial tendon irritation, and one of them had obvious posterior tibial tendon defect; One patient had adhesion around ankle joint, leading to ankle joint stiffness and function limitation. The complication rate of 1 / 3PMF screw group was 6.5%, which was significantly lower than that of plate group (22.5%). ($P < 0.05$)

In the 1 / 2PMF screw group, there were 2 cases of superficial wound infection and delayed healing, and the wounds healed at last. In the 1 / 2 PMF plate group, there were 2 patients with wound complicated by excessive peeling and partial skin edge blackening and necrosis, and the wound was healed by dressing change in outpatient department; Two patients had a lot of blisters on the edge of the wound until the wound healed delayed, and the suture was removed completely about 3 weeks after the operation; One patient was considered to have symptoms of gastrocnemial nerve contusion, and the symptoms were improved in about 2 months by taking nutritional nerve drugs; Two patients complained of strong ankle discomfort during activity, and considered the symptoms of posterior tibial tendon irritation. One patient had obvious posterior tibial tendon dysfunction, and the internal fixation device was removed after fracture healing, and the symptoms were relieved; Two patients had adhesions around the ankle joint, which led to ankle stiffness. One patient had contracture of the first, second and third toes, and the function was significantly limited (Fig. 2). The incidence of wound related complications in patients with 1 / 2 screw fixation was 7.7%, compared with 29.0% in patients with plate fixation, the difference was statistically significant ($P < 0.05$).

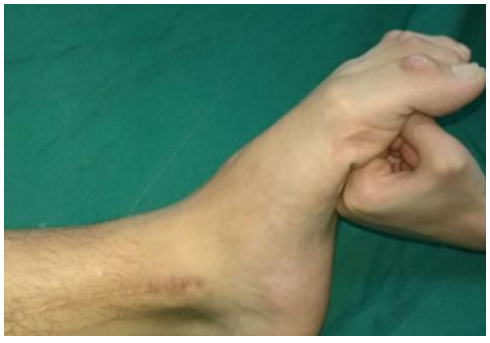

Fig. 2 Contracture of the first, second and third toes

Table 2 Postoperative follow-up results

Group / total		Operation time (min)	Healing time (weeks)	Complication rate% / n	Excellent (healing)	Good (healing)	Poor (healing)	Excellent and good rate % (healing)	Excellent (AOF)	Good (AOF)	General(AOF)	Poor (AOF)	Excellent and good rate (AOF)
A1	56	33.5286±6.1557	10.8107±1.413	5.4% (3)	42	11	3	0.946	40	13	2	1	0.946
A2	35	46.4686±7.72474	11.5686±1.41707	22.9% (8)	26	7	2	0.943	26	6	1	2	0.914
t/χ , P value		t=-8.834;;0.000	t=2.486;;0.015	0.031 ; ; 4.670				0.000 ; 1.000					0.028 ; 0.867
B1	46	33.9283±5.77599	11.3522±1.4562	6.5% (3)	36	7	3	0.935	36	6	3	1	0.913
B2	40	47.2475±8.17736	12.7075±1.68438	22.5% (9)	27	10	3	0.950	27	8	4	1	87.5%
t/χ , P value		t=-8.603 ; ; 0.000	t=4.002 ; ; ; 0.000	0.033 ; 4.549				0.000 ; 1.000					0.49 ; 0.825
C1	26	37.3654±8.40052	13.1769±0.97501	7.7% (2)	13	6	7	0.731	13	5	5	3	69.2%
C2	31	46.1149±8.53205	12.7935±1.10933	29.0% (9)	20	9	2	0.96.8	22	6	2	1	90.3%
t/χ , P value		t=-4.028 ; ; 0.000	t=1.372 ; ; 0.175	4.135 ; 0.042				4.764 ; 0.029					4.039 ; 0.044

Table 2 The Postoperative follow-up results of different groups

Discussion

The anterior edge of the distal tibia and the posterior malleolus form a domed articular surface, which enlarges the contact surface of the tibiotalar joint. At the same time, the posterior lip of tibia fixed the talus from back to front to prevent posterior dislocation [17, 18]. The lower tibiofibular ligament starts from the posterior tibia (posterior ankle) to the distal fibula. Although it is relatively weak, it is the support structure behind the ankle point, which is the most important in all the tibia fibular ligament in the ankle, accounting for 42% of the whole effect of the tibia fibula ligament in the ankle [19]. As the starting point of the posterior tibiofibular ligament, the posterior malleolus is very important to maintain the tension of the posterior tibiofibular ligament and the stability of the ankle joint. Some scholars suggest that the displaced posterior malleolus block, regardless of its size, can restore the matching relationship of the tibiofibular syndesmosis and the tension of the posterior tibiofibular ligament. By restoring the stability of the tibiofibular syndesmosis, it can replace the tibiofibular screw, and less use of the tibiofibular screw [13, 20, 21]. Garnder and other scholars confirmed through biomechanical experiments that the placement of the syndesmosis screw during the operation can only maintain 40% of the stability strength of the lower tibiofibular joint, and the posterior ankle fixation can make the syndesmosis strength reach about 70% [22].

Traditionally, it is believed that the posterior malleolus will be indirectly reset with or without fixation [22-24]. Posterior malleolus fracture is usually ignored, because it is considered that the fracture can be reduced by the pulling of the posterior tibiofibular ligament in the process of open reduction of lateral malleolus. The posterior malleolus Achilles tendon and limited posterior space can maintain the position of the posterior malleolus. In recent years, with the development of orthopaedic technology and the deep understanding of the postoperative rehabilitation treatment concept, open reduction with strong internal fixation, and internal fixation assisted early ankle function exercise is currently accepted by most orthopedic doctors for the treatment of posterior ankle fracture. However, the specific treatment of posterior malleolus fracture is still controversial, including the standard of open reduction and internal fixation of posterior malleolus fracture. At present, the treatment of posterior malleolus mainly includes manipulative reduction, plaster or external fixation for a long time; Cannulated screws were used to fix the posterior malleolus from front to back or from back to front; Plate and screw internal fixation. Because of its unreliable fixation and inconsistent with the principle of early postoperative functional exercise, the application of plaster or brace external fixation for posterior malleolus is less, mainly used in some Haraguchi III and very small posterior malleolus fractures. There are two types of cannulated screw fixation [14, 25], and the strength of posterior anterior screw fixation is better than that of anterior and posterior screw fixation. It has also been reported in literature [26, 27], that closed reduction and screw fixation have less trauma and fewer complications, and satisfactory results have also been obtained. In our hospital, closed reduction and percutaneous anterior posterior screw fixation were used in all patients who received posterior ankle screw fixation. From the perspective of biomechanics, posterolateral plate screw fixation is a stronger fixation method than anteroposterior lag screw fixation [15, 28], and indirect reduction method can't always achieve satisfactory reduction effect. Therefore, some scholars prefer to use plate and screw to fix the posterior malleolus. It is worth noting that in terms of fracture healing time, the fracture healing time of screw fixation group was significantly shorter than that of plate fixation group in 1 / 4PMF and 1 / 3PMF subgroups, and there was no significant difference in the excellent and good rate of fracture healing efficacy evaluation and AOFAS score one year later. In the 1 / 2 PMF group, there was no significant difference in fracture healing time. The

excellent and good rate of fracture healing efficacy evaluation and AOFAS score one year later in the plate fixation group was better than that in the screw fixation group, and the difference was statistically significant. Previous studies and clinical cases showed that [29-32], the fracture healing time of plate fixation was shorter than that of screw fixation, and the poor healing rate of screw fixation was higher than that of screw plate fixation. After 12 months, there was no significant difference in AOFAS score between the two fixation methods. Dong Jingming's research report that the posterolateral approach was used to treat posterior malleolus fractures.Screws were used to fix the posterior malleolus less than 1 / 3 of the articular surface, and metacarpal T-plate was used to fix the posterior malleolus more than 1 / 3 of the articular surface. The mean AOFAS score was 90.75 one year after operation, but the author did not analyze and compare the clinical observation indexes of the patients. Li Yongdi [15] and others measured the posterior malleolus before operation. If the area of the posterior malleolus is more than 1 / 4 of the articular surface, internal fixation with steel plate should be carried out. If the area of the posterior malleolus is less than or equal to 1 / 4, screw fixation should be carried out. In this way, the posterior malleolus can be stably fixed to meet the needs of early functional exercise. The excellent and good rate of fracture healing evaluation of patients is 100%.

A large number of scholars have reported that there is no statistical difference in AOFAS score, VAS score, arthritis score and patient satisfaction score between anterior and posterior screw fixation and posterior approach plate and screw fixation. Generally speaking, they have achieved satisfactory clinical results [31, 33,34].

Through reading a large number of clinical reports, the author found that the vast majority of clinicians prefer to divide the area ratio of posterior ankle fracture block and tibiotalar joint surface into 1 / 4, 1 / 3 and 1 / 2 when describing, measuring and predicting the postoperative clinical curative effect. In order to meet the convenience of clinical work and work habits, this study is also divided into same groups. In clinical application and scientific research, there are many methods to measure the area ratio of posterior malleolus fracture block to tibiotalar joint surface. This study referred to the three-dimensional surface measurement method of Kun Zhang and other scholars. The measurement method is reliable and repeatable for predicting the prognosis of ankle bone mass, and it does not depend on the experience of the operator. It is convenient for practical application. The measurement can be completed within 1 minute in PACS system after 3D reconstruction and cutting.

In this study, through retrospective analysis, according to the ratio of posterior malleolus fracture block and tibiotalar joint surface area, the clinical effect of percutaneous anterior posterior screw and posterior plate in the treatment of posterior malleolus fracture was compared. When the area ratio of posterior malleolus fracture mass to tibiotalar joint surface (PMF%) was less than 1 / 3, both percutaneous closed reduction and anteroposterior lag screw fixation (AP position) and open reduction and plate fixation (ORIF) achieved satisfactory results. There was no significant difference in AOFS ankle hindfoot score and excellent or good rate of fracture healing between the subgroups ($P > 0.05$); However, the incidence of wound related complications in the screw fixation group was significantly less than that in the plate fixation group ($P < 0.05$); In fracture healing time and operation time, screw fixation group was shorter than plate fixation group, with statistical difference ($P < 0.05$). When PMF% was more than 1 / 3, the excellent and good rate of fracture healing, AOFS ankle hindfoot score and the overall excellent and good rate of fracture healing in screw fixation group were lower than those in plate fixation group ($P < 0.05$); There was no significant difference in fracture healing time between the two groups ($P > 0.05$); The incidence of wound related

complications in lag screw fixation group was less than that in plate fixation group, and the difference was statistically significant ($P < 0.05$); The operation time of screw group was significantly shorter than that of plate fixation ($P < 0.05$). According to this analysis, percutaneous closed reduction and lag screw fixation of posterior malleolus fracture has less secondary damage to the soft tissue of posterior malleolus, protects the blood circulation of posterior malleolus fracture, and also protects the periosteum, which is conducive to fracture healing. Posterolateral approach for open reduction requires extensive dissection of the soft tissue of the posterior malleolus, which can cause great damage to the soft tissue around the posterior malleolus, destroy the blood supply of the bone mass, and affect the fracture healing. Some scholars found that the level of inflammatory factors in the screw group was significantly lower than that in the plate group by comparing the changes of inflammatory indexes after closed reduction and screw internal fixation and open reduction and plate internal fixation in the treatment of ankle fracture, and further verified that closed reduction and screw fixation had less damage to the soft tissue around the ankle [35] . In this study, PMF% 1 / 4 and PMF% 1 / 3 groups, the fracture healing time of screw group was significantly shorter, and the incidence of wound related complications in screw fixation group was significantly lower than that in plate fixation group, which further verified that closed reduction and percutaneous screw fixation was more in line with the concept of minimally invasive. It should be noted that closed reduction requires experienced surgeons. Reduce repeated manual traction reduction to avoid damage to the soft tissue of the posterior malleolus, avoid crushing the large bone mass of the posterior malleolus, and reduce the reliability of screw fixation; For the patients with lateral malleolus fracture, anatomical reduction of lateral malleolus fracture is beneficial to the reduction of posterior malleolus fracture, while maintaining the tension of posterior tibiofibular ligament; CT and three-dimensional reconstruction should be improved before operation to make sure the direction of fracture line. The direction of screw placement during operation should be perpendicular to fracture line in cross-section and sagittal plane as far as possible. For those with high bone block height, screw fixation should be performed at the proximal end of posterior ankle bone block to form a triangular fixed bone block; During the operation, it is necessary to ensure that the threaded part of the lag screw completely passes through the fracture line and is located in the posterior malleolus, allowing the tip of the screw to protrude a little from the bone cortex, so as to maximize the tensile force of the lag screw and ensure the reliability of screw fixation; Closed reduction and internal fixation is different from open reduction in that it can be reduced under direct vision and the quality of reduction can be checked. It is suggested that multi-directional c-ray fluoroscopy should be performed after reduction to ensure the quality of reduction; For older patients with osteoporosis, screw fixation should be cautious. In this analysis, 1 / 4 PMF% group and 1 / 3 PMF% group had a 62 year old woman and a 64 year old postmenopausal woman for more than 10 years. During the operation, multi-directional C-shaped X-ray machine fluoroscopic reduction was ideal. After screw fixation, plaster external fixation was performed. On the third day after operation, the X-ray film showed that there were steps, and the screw fixation was unstable due to osteoporosis; In addition, for Haraguchi II type with PMF% less than 1 / 3 but with multiple bone fragments, it may be necessary to clean part of the bone fragments during the operation, and the bone fragments need to be fixed with plates and screws. In the screw fixation group, there were 2 cases of bone fragment displacement, one of them had walking ankle pain, VAS score was 5 points, X-ray analysis showed that the bone fragment was stuck in the fracture space. Although Haraguchi II PMF% is less than 1 / 3, combined with multiple bone fragments is relatively rare in clinic, it is recommended to

consider open reduction and plate internal fixation. It has been reported that there is a risk of penetrating into the tibiofibular syndesmosis joint when closed reduction and screw fixation is used [31]. In our follow-up, X-ray film is used routinely, and no screw is inserted into the tibiofibular syndesmosis joint, and no related chief complaint symptoms are recorded.

In this study, there was no significant difference between the two groups in the PMF% 1 / 2 group. The excellent rate of fracture efficacy evaluation and AOFS ankle hind foot scoring screw group were inferior to the plate fixation group one year later. Analysis of the reasons: compared with screw fixation, plate fixation can more effectively resist the stress in the posterior superior direction of talus and the traction of tibiofibular ligament, increase the stability after fracture surgery, and maintain the position of bone block. Studies have shown that with the increase of the posterior malleolus [14, 15], the joint contact area is smaller, and the strength required for posterior malleolus fixation increases. However, the specific relationship between the size of the bone block and the strength required for bone block fixation has not been reported. Compared with the two internal fixation methods, the advantage of plate and screw internal fixation through posterolateral approach is that it can provide reliable holding force and stronger internal fixation. For the patients who received screw fixation, we used neutral position plaster posterior branch fixation for 3 weeks. A systematic analysis [36] found that early functional exercise after ankle internal fixation has a positive effect on restoring work as soon as possible and improving ankle joint short-term (12 weeks later) range of motion, but there is no evidence that it can improve joint specific outcome score or range of motion after one year. It should be noted that early functional exercise may lead to the increase of wound infection rate. At the same time, the article does not elaborate the influence of early activity on the stability of ankle bone block after different internal fixation. At present, there is no high-intensity evidence to support early weight-bearing training after ankle internal fixation, and we need to be cautious about early weight-bearing functional exercise [37]. At present, most scholars recommend that the patients with trimalleolar fractures should be treated with plaster or brace fixation for 2 weeks, 8 weeks of protective weight-bearing training or no weight-bearing training. For the postoperative treatment, we used plaster or ankle external fixation for 2-3 weeks in the screw group. On the one hand, it can reduce the incidence of incision infection, and at the same time, it can play a protective role in stabilizing the ankle. From our follow-up results, the wound related complications in the posterolateral approach group were higher than those in the percutaneous screw fixation group, and the difference was statistically significant. The surgical approach for patients with nail plate fixation is posterolateral approach. Extensive dissection during the operation is easy to cause ankle stiffness, and even "Horse Bridle" deformity. Among the patients included in this study, there were 4 patients with this kind of situation, and the limb function was significantly limited. These 4 patients were all in the plate group. We know that bridle deformity is a very difficult complication, and the effect of surgical release is often not ideal. Some scholars have proposed that plaster fixation for 2-3 weeks after operation can avoid the occurrence of postoperative toe flexion contracture to a certain extent in patients with high risk of forming "Horse Bridle" foot [31]. This may explain that there is no flexion contracture in the screw fixation group. Can the screw provide enough holding force for the active or passive training of the ankle joint without weight bearing? According to the results of this study, lag screw can provide enough strength to fix the posterior malleolus for the posterior malleolus fracture with PMF% less than 1 / 3, so as to provide active and passive functional exercise of the ankle three weeks after operation. Although some scholars have proposed through in vitro biomechanical model test that the stability of

plate fixation is better than that of screw fixation in resisting vertical pressure, especially when the bone mass is larger. However, these model tests do not conform to the stress of ankle joint in normal patients after operation, and the loading force of this kind of method is far greater than the stress of ankle joint in neutral position after operation [38]. And in clinical work, surgeons or rehabilitation doctors do not recommend active or passive training of the affected ankle joint before the bone mass is healed. For the posterior malleolus fracture with PMF% more than 1 / 3, screw fixation is not enough to provide immediate stability and ankle functional exercise three weeks after operation in terms of biomechanical stability, while plate fixation with limited contact pressure can provide better anti sliding effect to provide enough holding force to support postoperative functional training.

Closed reduction and percutaneous lag screw fixation has the advantages of short operation time, less incision related complications, no need for excessive stripping of the posterior malleolus soft tissue, small secondary injury, fully in line with the concept of minimally invasive. But its fixation strength is not as good as that of steel plate fixation, and it is not enough for the larger posterior malleolus. In addition, the position of the screw and the multi-directional perspective of c-ray machine are needed to ensure the reduction of the anatomy, which requires high surgical skills and long learning time. Through the posterolateral approach plate internal fixation, stripping the posterior tibial soft tissue can anatomically reduce the fracture under direct vision, and the larger bone block can also obtain enough strong internal fixation. Of course, its disadvantages are also worth noting. Incision related complications include soft tissue adhesion around ankle joint, scar adhesion of flexor digitorum tendon, sural nerve injury and posterior tibial tendon irritation. In addition, fracture healing often requires removal of the internal fixation device, for patients is to accept a larger injury. The surgeon should be familiar with the anatomical knowledge of posterolateral approach of ankle joint, mark the course of sural nerve before operation, and understand the variation. We found that the symptoms of sural nerve injury in this data were mainly distributed in the first half of the cases, and the incidence of nerve injury familiar with this approach could be further reduced. At the same time, in order to identify the gap between the short fibular muscle and the flexor longus muscle after deep fascia incision, it is necessary to carefully identify the muscle gap, enter from the muscle gap, operate carefully and gently during the operation, avoid excessive traction of the flexor digitorum muscle group, and minimize the occurrence of postoperative contracture of the flexor digitorum muscle.

It is hoped that this retrospective analysis can provide some reference for surgeons to choose individualized internal fixation methods for posterior malleolus fractures. This study is a retrospective analysis, the number of samples in each group is small. In the next step, we will fully respect the patients' right of informed choice, and divide the patients into two groups: PMF% no more than 1 / 3 and PMF more than 1 / 3. We will prospectively collect the clinical efficacy of different internal fixation methods for different patients, obtain further research conclusions, and guide the choice of surgical scheme.

Conflicts of Interest

the authors declare that they have no conflicts of interest.

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