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Trans-Syndesmotic Versus Posterior Malleolar Fixation Techniques for Trimalleolar Ankle Fractures: A Comparative Study

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ABSTRACT

Background: Extra-articular distal tibial fractures, often referred to as posterior malleolar fractures, have been a focus of ankle injury management. While direct syndesmotic fixation is considered the gold standard, the effectiveness of internal fixation and reduction of posterior malleolar fractures in improving syndesmotic reduction remains unclear.

Objective: This study aims to compare the outcomes of two approaches: transsyndesmotic screw fixation without posterior malleolus fixation versus direct internal fixation of posterior malleolar fractures, regardless of fragment size, in managing trimalleolar ankle fractures.

Patients and Methods: This randomized, prospective study included 30 participants with recent trimalleolar fractures, treated at Shebin El-Kom Teaching Hospital between December 2019 and June 2021. Participants were divided into two groups: Group A (n = 15) received transsyndesmotic screw fixation without direct fixation of posterior malleolar fragments, and Group B (n = 15) underwent direct fixation of the posterior malleolar fracture using screws or plates. Follow-up continued for six months post-operation.

Results: Group A achieved shorter times to complete union and full ambulation compared to Group B ($P < 0.001$ and $P = 0.002$, respectively). While VAS pain scores were comparable between groups, Group B demonstrated better AOFAS scores ($P = 0.016$). Some cases in Group A required additional syndesmotic fixation, highlighting challenges in achieving optimal outcomes without posterior malleolar fixation.

Conclusions: Direct fixation of posterior malleolar fractures provided better functional outcomes, as reflected by higher AOFAS scores, supporting the approach of fixing all posterior malleolar fractures except avulsion fractures, regardless of fragment size.

Keywords: Posterior Malleolar Fixation, Trans-Syndesmotic, Trimalleolar Ankle Fractures.

INTRODUCTION

The posterior malleolar fracture is another kind of ankle fracture that indicates a Tillaux fracture. The best way to treat this particular kind of ankle fracture has long been up for discussion. An ankle fracture-dislocation including a broken posterior rim of the distal tibia was initially described by Henry Earle, most likely in 1828 [1].

Contrasted with the anterior malleolus, which projects more anteriorly, the posterior malleolus of the distal tibia is longer and narrower on the superior aspect. Accordingly, when seen laterally from the ankle, the distal tibia's articular surface appears concave in the sagittal plane. Cartilage in the joints is typically between 1 and 2 millimeters thick and has a smooth surface [2]. An enormous and robust posterior tibiofibular ligament attaches to the back of the distal tibia [1].

On the basis of the above stated facts of the anatomical structure, the PM should play a major role in anchoring and bearing of loads at the ankle. It is logical to assume that the tibiotalar joint's load distribution and stability in the tibiofibular syndesmosis would be affected by this PM avulsion with part of the distal tibia's articular surface [1].

Trimalleolar or equivalent ankle fractures are inherently unstable and typically occur with greater force; as a result, syndesmosis disruption can be present. The distal carpal row, which is the third articulation of the proximal row of carpal bones at the wrist, is also known as the distal carpal row. In order to accomplish a good reduction of the ankle joint complex and to prevent unilateral arthrosis, surgical intervention is advised for the therapy of these injuries. The anterior inferior tibiofibular ligament (PITFL), transverse ligament (TL), interosseous membrane (IOM), and interosseous ligament (IL) are all ligamentous components of the tibiofibular syndesmosis [3].

It is important to note that the site of the fibular fracture does not always indicate the stability of the syndesmosis. Whenever a surgical ankle fracture is being treated, an intraoperative stress assessment should always be conducted [4].

Due to its crucial function in maintaining the syndesmosis and its soft tissue connection at the apex of the posterior malleolus, the ankle syndesmosis's strength is 42% attributable to the posterior inferior tibiofibular ligament (PITFL) [3].

Achieving proper alignment of the posterior malleolus with the tibia, tibiotalar joint, and ankle angular stability is essential.

This fact highlights the importance of focusing on the management of posterior malleolar fractures, regardless of their size and displacement, as they play a key role in providing direct posterior control of the syndesmosis [5].

As shown above, reconstructing the posterior interphalangeal ligament (PITFL) in ankle fractures with posterior fragments is possible through posterior malleolus fractures, which eliminate the need for

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syndesmosis fixation and syndesmotic trans fixation [6]. Restoring the incisura tibiae and stabilizing the avulsed posterior tibiofibular ligament allow for anatomic reduction of the distal fibula, which in turn enhances syndesmosis [1].

This study aimed to evaluate the efficacy of direct syndesmotic fixation with that of posterior malleolus fracture reduction and reduction of syndesmotic injuries in trimalleolar ankle fractures treated with internal fixation, with functional and short-term radiological outcomes serving as endpoints.

PATIENTS AND METHODS

This study was a randomized prospective comparative analysis involving thirty patients who presented with recent trimalleolar ankle fractures. Participants were selected from the emergency room and outpatient clinic at Shebin El-Kom Teaching Hospital. The research was conducted between December 2019 and June 2021, undergoing surgery often have a six-month follow-up at Shebin El-Kom Teaching Hospital.

The inclusion criteria for the study comprised patients with trimalleolar ankle fractures that occurred within the last three weeks, aged between 18 and 55 years. Both isolated and polytraumatized patients with closed fractures were included.

On the other hand, this research did not include patients who had any neurovascular impairment, ignored fractures (those older than 4 weeks), ankle fracture-dislocations, fractures of anterior tibial plafond, or any fractures that had not been properly treated.

Randomization

Group A (n=15): Only transyndesmal screw fixation was performed on a posterior malleolar fracture (less than 25% of the articular surface) that had not been treated with direct reduction and internal fixation, and Group B (n=15): Only posterior malleolar fragment fixed directly by screw or plate and screws regardless the size.

All patients underwent a thorough evaluation that included a detailed medical history and clinical assessment. The history collected included personal information such as age, gender, and occupation, as well as relevant medical habits like smoking and any associated comorbidities, such as diabetes (DM) and hypertension (HTN). Additionally, information about the present illness was gathered, including the affected side, time since the injury, previous treatments, and any sensory or motor deficits in the injured limb. Clinical assessments involved checking blood sugar levels and HbA1c for diabetes management, complete blood count (CBC) for baseline hemoglobin, and imaging studies like X-rays and CT scans to characterize the fractures. Inflammation markers such as ESR and CRP were also evaluated to rule out infection. The length of hospital stay was determined based on clinical improvement and radiological evidence of fracture healing. The study did not include patients who had any neurovascular impairment, ignored fractures (those older than 4 weeks), ankle fracture-dislocations, fractures of anterior tibial plafond, or any fractures that had not been properly treated.

Surgical technique:

Anesthesia was delivered using either spinal or general anesthesia. Plates, Kirschner wires, stainless-steel tension wires, 3.5-mm cortical screws, and 4-mm cancellous screws were among the instruments used in the investigation.

Surgical procedure:

Group I had lateral and medial malleolar fracture reduction and stabilization using standard techniques. After a lateral translation stress test was performed during the operation and the external rotation stress mortis was examined using fluoroscopy, the possibility of trans syndesmotic fixation was considered. We did not conduct the transsyndesmotic fixation on cases that had sufficient rotational stability attained with fracture fixation alone; these cases were thus not included in the analysis. Specifically, in accordance with the AO principles of fracture therapy, one tricortical 3.5-mm cortical screw was inserted across the syndesmosis, about 2 cm above the tibiotalar joint line. The posterior malleolar and fibular fractures in Group II were treated using a posterolateral technique, which allowed for easy reduction. Through a medial approach, the medial malleolus was secured with screws that were either 4-mm cancellous or 3.5-mm cortical in diameter, with the use of K-wires and stainless-steel tension wires.

Postoperative follows up:

Postoperative care included obtaining X-rays in anteroposterior, lateral, and mortise views. A complete blood count was performed, and patients were provided with parenteral antibiotics and oral analgesics for three days post-surgery. Patients were discharged the day after surgery. Until they could begin bearing weight, they were prescribed oral anticoagulants and a five-day course of oral antibiotics. A short-leg splint was used for six weeks after the operation. After six to eight weeks, patients were advised to begin partial weight-bearing by touching their toes while using a walker or crutches, with full weight-bearing permitted upon confirmation of complete healing. Follow-up assessments, both radiological and clinical, were conducted at 1, 2, 4, 8, 12, 16, 18, and 24 weeks post-surgery. A postoperative CT scan was performed immediately after the surgery to evaluate the reduction of syndesmosis and assess its impact on the rate of complications and functional outcomes.

Ethical considerations:

The study was done after being accepted by the Research Ethics Committee, Shebin El-Kom Teaching Hospital. All patients provided written informed consents prior to their enrolment. The

consent form explicitly outlined their agreement to participate in the study and for the publication of data, ensuring protection of their confidentiality and privacy. This work has been carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans.

Statistical analysis:

All of the data that were collected, were imported, coded, and edited using the Statistical Package for the Social Sciences (SPSS v20 for Windows). Quantitative data were displayed as mean and standard deviation (SD). It is common practice to display qualitative data using percentages and frequencies. When analyzing quantitative data, tools like the Mann Whitney U-test or Student T-test were employed. When analyzing qualitative data, tools like the Fisher extract test was employed. Statistical significance was declared at a p-value of 0.05.

RESULTS

Baseline parameters, Weber and Lauge-Hansen classifications, delay between injury and surgery, as well as the duration of hospitalization were not significantly different across the groups that were evaluated. When comparing groups, A and B, the difference in fragment size (%) was statistically substantial. Group A had a considerably shorter operational period compared to group B ($p < 0.001$) **(Table 1)**.

Table 1: Baseline characteristics, fractures and surgical characteristics in the studied groups

		Group A (n =15)	Group B (n =15)	p value
Age (years)		37.87 ± 10.59	40.27 ± 10.44	0.537
Gender	**Male**	9 (60%)	11 (73.33%)	0.7
	Female	6 (40%)	4 (26.67%)	
Smoking	**Smoker**	2 (13.33%)	5 (33.33%)	0.389
	Non-smoker	13 (86.67%)	10 (66.67%)	
Diabetes mellitus	**Diabetic**	3 (20%)	2 (13.33%)	1
	Non-diabetic	12 (80%)	13 (86.67%)	
Baseline Hb		11.93 ± 1.71	13 ± 1.73	0.101
Fractures characteristics				
Weber classification	**Type B**	3 (20%)	2 (13.33%)	1
	Type C	12 (80%)	13 (86.67%)	
Lauge-Hansen classification	**PER**	11 (73.33%)	12 (80%)	1
	SER	4 (26.67%)	3 (20%)	
Fragment size (%)		14.47 ± 3.93	18.93 ± 5.06	0.011
Surgical characteristics				
Time from injury to operation (days)		2.6 ± 1.06	2.47 ± 0.99	0.724
Operative duration (minutes)		99.67 ± 7.89	122 ± 4.55	**<0.001**
Length of hospital stay (days)		1.87 ± 0.91	2.13 ± 0.99	0.45

Data are presented as mean ± SD or as frequency (%), PER: Pronation external rotation, SER: supination external rotation.

In terms of procedural complications, just one patient (6.67%) in group B experienced infection, but no patient in group A did; similarly, no patient in group A experienced mechanical irritation. No patients in either group A or B experienced nerve damage, re-operation, or osteoarthritis **(Table 2)**.

Table 2: Potential complication of procedures in the studied groups

	Group A (n =15)	Group B (n =15)
Infection	0	1 (6.67%)
Nerve injury	0	0
Re-operation	0	0
Mechanical irritation	1 (6.67%)	0
Osteoarthritis	0	0

Group A had a considerably shorter time to complete union and full ambulation compared to group B **(Table 3)**.

Table 3: Time to complete union and full ambulation in the studied groups.

	Group A (n =15)	Group B (n =15)	P value
Time to complete union (weeks)	6.33 ± 0.62	7.6 ± 0.98	<0.001
Time to full ambulation (weeks)	7.6 ± 0.63	8.5 ± 0.83	0.002

Data presented as mean ± SD

The analysis showed that there was no substantial difference in the Scale of Visual Analog (VAS) scores among the two groups. However, Group A had significantly lower American Orthopaedic Foot and Ankle Society (AOFAS) ratings than Group B **(Table 4)**.

Table 4: VAS and AOFAS score in the studied groups

	Group A (n =15)	Group B (n =15)	P value
VAS	3.4 ± 0.63	3.4 ± 0.63	1.000
AOFAS score	79.67 ± 6.39	85.67 ± 6.51	0.017

Data presented as mean ± SD**,** VAS: Visual analog scale, AOFAS: American Orthopedic Foot and Ankle Society.

DISCUSSION

Because the surgery is so straightforward, orthopedic surgeons often use plates to treat lateral malleolus fractures and screws to mend medial malleolus fractures in ankle fractures. The lack of necessity for surgical exploration is due to the fact that both malleoli remain just beneath the skin. As a result, the posterior malleolus remains loose [7].

Ankle syndesmosis stability is thought to revolve on the PITFL complex [8]. A syndesmosis between the tibia and fibula might be unstable because of fractures of the posterior malleolus [9]. Even if the posterior malleolus breaks, the ligaments that link it to the bone may be unbroken. In most cases, a failure through bone indicates that the PITFL is intact [10].

If the fragment covers more than 25% of the joint surface, some experts recommend using internal fixation to stabilize the posterior malleolar joint [8]. Following the displacement of a posterior malleolar fracture, the biomechanical model developed [11] indicated that the contact stresses moved to a medial and anterior position.

Studies on posterior malleolus fractures have involved only a small number of patients, leaving room for ongoing debate regarding the classification of these fractures, the criteria for surgical intervention, optimal surgical strategies, and operative techniques. In a study by **Bois and Dust** [12], two patients with posterior malleolar fractures were treated using a single posteromedial approach, with both undergoing open reduction and internal fixation. Additionally, radiographic evidence of Grade II or III osteoarthritis was observed in 6.7% of cases where fractures were managed using a combination of posteromedial and posterolateral approaches, with these findings appearing 9.4 years after the initial injury. The authors concluded that while radiographic signs of ankle osteoarthritis may develop over time, they may remain clinically manageable in the early stages of the disease.

Park *et al.* [13] placed a posterior malleolar piece in 29 cases of ankle fracture. Fifteen cases were treated with syndesmotic screw fixation and fourteen with posterior malleolar fixation. No statistically meaningful difference was observed among the groups with regard to reduction quality, ankle arthrosis grade, or clinical ratings.

The surgical duration was much shorter in group A in relation to group B. This difference in time was statistically substantial, and it showed up in the end outcomes. This is not surprising, given that group A just needed a syndesmotic screw, whereas group B had to deal with ORIF posterior malleolus.

Lee et *al.* [14] assessed eleven cases of fractures involving the triangular bones. Following its internal fixation and open reduction, the posterior malleolar portion, every single patient in their series achieved a good AOFAS score.

Chung *et al.* [15] handled fifteen patients involving fractures of the posterior malleolus, with five cases showing outstanding results and seven reporting satisfactory results. Clinical results, satisfactory anatomical reduction, and stable fixation may be achieved with posterior approaches to posterior malleolar fractures, according to additional study. This is especially true for fractures with imprisoned pieces or those have been comminuted. As part of our research, we adopted a posterior method, and this was in line with our findings.

Our study found that group A had a considerably shorter time to complete union and full ambulation compared to group B. Additionally, only 1 patient in group B (6.67%) experienced a complication, reported

infection, whereas none of the patients in group A did, this patient received an antibiotic therapy based on culture and sensitivity test and resolved within 2 weeks. One patient (6.67%) in group A had mechanical discomfort, but no such occurrence was seen in group B.

Miller *et al.* [6] hypothesized that, in comparison to trans-syndesmotic fixation alone, fixing the posterior malleolus fracture would more reliably restore syndesmosis stability. Nearly half of the syndesmosis strength is attributed to the PITFL, according to **Ogilvie-Harris *et al.* [16]**.

The flexor hallucis longus and peroneal muscles can be seen on an actual intranervous plane when the posterolateral ankle approach is used. However, there is a continuous danger of iatrogenic damage to the sural nerve, which runs immediately beneath the skin, along the whole incision. Taking a posterolateral view, **Jowett *et al.* [17]** On their study of cadavers, they found that the sural nerve runs somewhere between 56.7% and 61.0% of the way from the posterolateral incision's center, about midway between the lateral malleolus and the Achilles tendon. Considering the limited sample size, this study does have several drawbacks. Quick postoperative radiographs were used to evaluate articular reduction. Comparisons between lateral radiography and postoperative CT for assessing reduction quality suggest that the latter may be more sensitive.

Conclusions

Internal fixation for syndesmotic injury reduction and direct syndesmotic fixation for trimalleolar ankle fractures were the two treatment modalities examined in the study, as well as for posterior malleolus fractures. The results showed that group B had a higher AOFAS score compared to group A. The success of the healing of the posterior malleolar fracture determines whether transyndesmal screw fixation is necessary. Because of this, we advise fixing all posterior malleolar fractures, irrespective of size, with the exception of avulsion fractures.

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