Trans-syndesmotic versus Posterior Malleolar Fixation in Trimalleolar Ankle Fractures: A Prospective Randomized Clinical Trial

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Abstract

Background: Trimalleolar fractures, also known as posterior malleolar fractures, have been one of the most challenging aspects of ankle injury therapy for a very long time. This work purposed to measure influence of posterior malleolus fractures direct reduction and internal fixation on syndesmotic injuries reduction, compared to the direct syndesmotic fixation in trimalleolar ankle fractures, on the functional and short radiological outcomes.

Methods: This randomized prospective comparative study was on the effect of posterior malleolus fractures reduction and internal fixation on syndesmotic injuries reduction, compared to the direct syndesmotic fixation in trimalleolar ankle fractures, on the functional and short radiological outcomes. Two equal groups of patients were created: 15 patients in group A [posterior malleolus (less than 25% of articular surface) left untreated] and 15 patients in group B with posterior malleolar fragment (PMF) that was immediately fixed by screw or screw and plate.

Results: Operative duration was considerably higher in group B than group A ($p < 0.001$). Time to complete union and time to full ambulation were considerably higher in group B than A ($p < 0.001$, $= 0.002$ respectively). AOFAS score was substantially higher in group B than A (P-value $= 0.016$).

Conclusions: The results demonstrate longer operative time, higher AOFAS score in B than group A. In situations when the posterior malleolar fracture is fixed, transyndesmal screw fixation may not be necessary.

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

INTRODUCTION

Trimalleolar fractures are frequently termed as posterior malleolar fractures and have long been one of the most controversial issues in the treatment of ankle injuries. Henry Earle was likely the first to characterize a fracture of the posterior rim of the distal tibia in an ankle fracture-dislocation in 1828 1.

The posterior malleolus (PM), also known as the posterior articular rim of the distal tibia, is longer than its anterior counterpart. On the lateral radiograph of the ankle, the articular surface of the distal tibia looks concave in the sagittal plane. 1–2 mm is the thickness of articular cartilage 2. The origin of the powerful and tight posterior tibiofibular ligament is the posterior aspect of the distal tibia 1.

The PM should considerably contribute to ankle stabilization and load transmission in light of the aforementioned anatomical information. It is likely that avulsion of PM with a portion of the distal

tibial articular surface would impair load transfer in the tibiotalar joint and also the integrity of the tibiofibular syndesmosis 1.

Trimalleolar or trimalleolar-equivalent ankle fractures are naturally unstable and often result from accidents with higher power; hence, disruption of the syndesmosis may be observed. To repair the ankle joint complex and prevent the development of post-traumatic arthritis, surgical treatment is recommended for these injuries 3.

Included in the ligamentous sections of the syndesmosis are the anterior inferior tibiofibular ligament, PITFL, transverse ligament, interosseous ligament, and interosseous membrane 3.

The degree of the fibula fracture does not correlate consistently with syndesmosis stability, and intraoperative stress testing is essential in all operational ankle fractures 4.

PITFL is responsible for 42 percent of the ankle syndesmosis strength because the posterior malleolus is an essential soft tissue attachment for PITFL insertion and plays a significant function in syndesmotic stability 3.

Posterior malleolus fixation improves not just tibiotalar congruence, but also ankle rotational stability. There is a growing understanding of this issue, and posterior malleolar fractures fixation regardless of size or displacement for direct posterior stability of the syndesmosis is given increased attention 5.

In the majority of ankle fractures containing a posterior fragment, PITFL may be treated by reduction and fixation of the posterior malleolus, thereby establishing syndesmosis fixation and avoiding the requirement for syndesmosis trans fixation 6.

Anatomic stabilization of posterior tibiofibular ligament that has been avulsed will enhance syndesmotic stability and restore the integrity of the tibial incisura, hence permitting anatomic reduction of the distal fibula 1.

This study purposed to measure the influence of posterior malleolus fractures direct reduction and internal fixation on syndesmotic injuries reduction, compared to the direct syndesmotic fixation in trimalleolar ankle fractures, on the short and functional changes in radiographs.

Materials and Methods

This was a randomized prospective comparative study on the effect of posterior malleolus fractures reduction and internal fixation on syndesmotic injuries reduction, compared to the direct syndesmotic fixation in trimalleolar ankle fractures, on the functional and short radiological outcomes. The study was conducted at Helwan university hospital and Benha Health Insurance Hospital from December 2019 till June 2021. The mean follows up period was 6 months' post-operative. The study was done upon the acceptance of protocol from the institutional ethical committee and all the studied patients have approved an informed consent.

30 patients were involved in the study, selected from their attendance in emergency room or outpatient clinic that suffers from recent trimalleolar ankle fractures.

Patients were split into two groups of equal size: Group A: [posterior malleolus (less than 25% of articular surface) left untreated]. Group B: Only PMF fixed directly by screw or plate and screw.

Inclusion criteria were age 18 - 55 years old, trimalleolar ankle fractures, recent fractures (within three weeks), isolated or polytraumatized patients and closed fractures.

Exclusion criteria were neglected fracture (more than four weeks), ankle fracture – dislocation, anterior tibial plafond fractures and neurovascular compromised.

Patients were subjected to careful history taken including [personal data as age, gender, occupation, and special habits of medical importance as smoking and associated co-morbidities as DM, HTN, and

history of present illness as side affected, time since injury, previous treatment, sensory and motor power affection in the injured limb. Clinical Assessment: Assessment of diabetes by random blood sugar and HA1C, CBC for baseline Hb, (x-ray and CT) for fracture character, (ESR and CRP) for infection, length of hospital stays by clinical improvement and x ray for time of union. Clinical examination identifies abnormalities in soft tissue, such as edema, skin tenting, open wounds, and blanching. Additionally, a neurovascular state evaluation should be undertaken prior to initiating reduction efforts.

Radiological assessment: Before ankle reduction, all patients received immediate anteroposterior, lateral, and mortise radiographs. In addition to preoperative computed tomography (CT), CT images were used to design the procedure. CT postoperatively to evaluate syndesmosis reduction and its effect on complication incidence and functional outcome.

Surgical technique: Patients underwent either general anesthesia or spinal anesthesia.

Study tools: 3.5-mm cortical Screws, plates, Kirschner wires and stainless-steel tension wire.

Surgical procedure: In Group A, the lateral and medial malleolar fractures were reduced and fixed using traditional lateral and medial ankle techniques. Based on an intraoperative lateral translation stress test and the fluoroscopic observation of external rotation stress mortis, a trans syndesmotic fixation was discovered. When rotational stability was obtained with fracture fixation alone, the trans syndesmotic fixation was not used and the patient was omitted from the trial. Specifically, A single tricortical 3.5-mm cortical screw was put across the syndesmosis about 2 cm just above tibiotalar joint line, in accordance with AO fracture care recommendations. A posterolateral ankle approach was employed to treat posterior malleolar fractures and accompanying fibular fractures in group B, there was no difficulty in reduction. Using a medial technique, medial malleolus fixation was accomplished.

Post-operative Follow up: Postoperative x-ray AP, Lateral views and mortise view, postoperative complete blood count, patient discharged on the next day after surgery on parenteral antibiotics and oral analgesics for 3 days followed by oral antibiotics for 5 days and oral anticoagulant till bearing weight.

Postoperatively, a short-leg splint was applied to patients for 6 weeks. The patients were mobilized toe-touch weight-bearing with a walker or double crutches after the 6-8 weeks after complete healing. Patients were followed up radiological and clinically at 1st, 2nd, 4th, 8th, 12th, 16th, 18th, 24th week.

Statistical analysis:

Utilizing Statistical Package for Social Science, the obtained data were modified, coded, calculated, and loaded into a computer (SPSS v20 for windows). Data provided as Mean and Standard Deviation (±SD) for Median, Interquartile range for quantitative non-parametric data and quantitative parametric data. Utilizing percentage and frequency to display qualitative data. According to the kind of data collected, an appropriate analysis is performed. To assess quantitative data, we utilized Student T Test or the Mann Whitney test, whilst to study qualitative data we used the chi-square test and the fisher extract test. P-value 0.05 was generally regarded statistically critical.

Results

No critical differences in baseline parameters were observed (gender, age, smoking, diabetes mellitus, and baseline hemoglobin) between the studied groups. Table 1

No critical difference was observed in Weber and Lauge-Hansen classifications between the studied groups. Fragment size (%) was considerably lower in group A than group B ($p = 0.011$). Table 2

Operative duration was critically higher in group B compared to group A ($p < 0.001$). Figure 1

Time to complete union and time to full ambulation were considerably higher in group B when compared to group B ($p < 0.001$, $= 0.002$ respectively). Table 3

AOFAS score was substantially higher in B than A group (P-value =0.016). Figure 2

Table 1: Baseline characteristics in the studied groups

		Group A (n =15)	Group B (n =15)	P-value
Age		**37.87 ± 10.59**	**40.27 ± 10.44**	**0.537**
Gender	**Male**	**9 (60%)**	**11 (73.33%)**	**0.699**
	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**

Data were presented as mean ± standard deviation (SD), number (%), Hb: Hemoglobulin

Table 2: Fractures characteristics in the studied groups

		Group A (n =15)	Group B (n =15)	p value
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***

Data were presented as mean ± standard deviation (SD), number (%), PER: Pronation external rotation, SER: supination external rotation, *: significant as p value < 0.05.

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

	Group A	Group B	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 were presented as mean ± standard deviation (SD), *: significant as p value < 0.05.

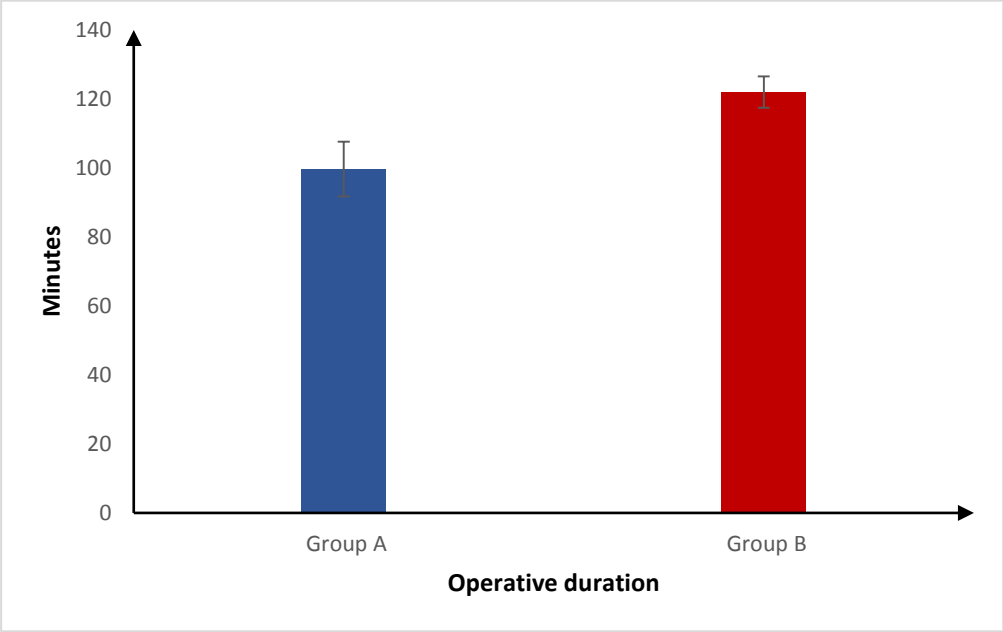

Figure 1: Operative duration in the studied groups

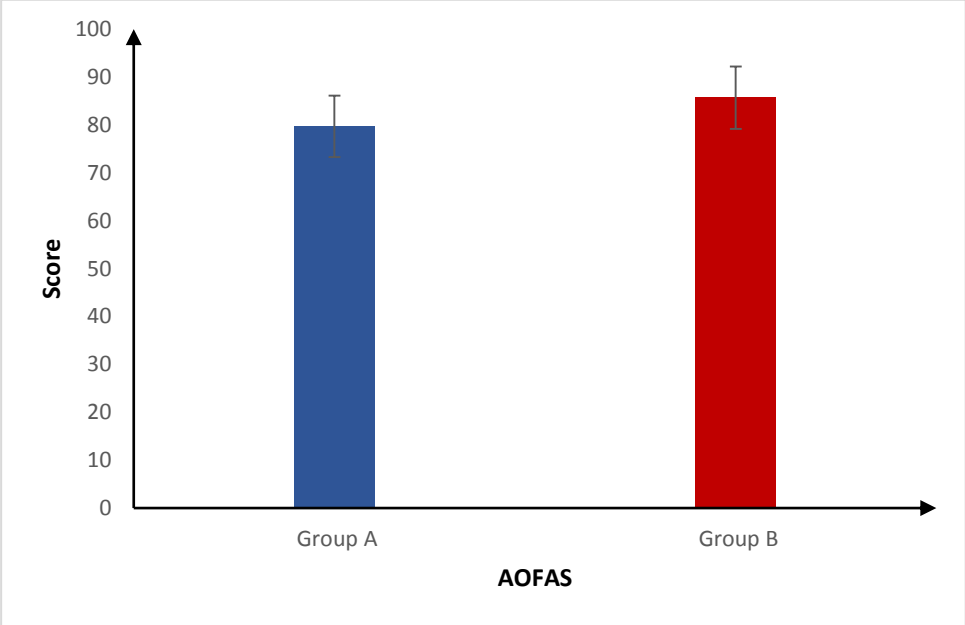

Figure 2: AOFAS score in the studied groups

AOFAS: The American Orthopedic Foot & Ankle Society

Discussion

Fractures of the ankle are prevalent, accounting for 3.92 percent of all fractures experienced by the body. 7–44 percent of ankle fractures are accompanied by posterior malleolus fractures. The injury caused by pronation or supination of the foot and external rotation of the talus beneath the tibial plafond [7].

For the ankle syndesmosis's stability the PITFL complex is considered essential [8]. Fractures of the posterior malleolus influence the stability of the tibiofibular syndesmosis [9]. The posterior syndesmotic ligaments may remain intact and connected to the fragment when the posterior malleolus is broken. Failure within the bone often indicates the PITFL's integrity [10]. Tight stabilization of the fibula accompanied by reduction and stabilization of the posterior malleolar fracture may fully restore the PITFL ligamentous strain and secure the syndesmosis without trans-syndesmotic fixation. In a

biomechanical study of Gardner et al., Reducing and stabilising the posterior malleolus restored 70 percent of the distal tibiofibular articulation's rigidity, compared to 40 percent with the use of a syndesmotic screw [10].

Various authors recommend posterior malleolar stabilization with internal fixation when the fracture affects more than 25 percent of the articular surface [7]. Van den Bekerom et al. reported that using a biomechanical model, he identified a change in the site of the contact stresses to a more anterior and medial region following a displaced posterior malleolar fracture [11].

Numerous writers discussed ankle fractures involving the posterior malleolus. Rigid fixation of the lateral malleolus may result in a reduction of the posterior malleolus that is almost anatomical. Although the posterior malleolus may be reduced with a closed reduction, sustaining the reduction without a firm fixation may prove impossible. Traditionally, the choice to surgically treat the posterior malleolus is predicated on its size, and tiny avulsion fractures are often left unfixed. Larger pieces comprising over 25 percent of the tibial plafond need surgical reduction and fixation [7]. Nevertheless, modern research does not depend on post malleolus size for fixing. Heim asserted that, with the exception of avulsion lip fractures, all posterior pieces should be repaired internally [12]. Evers, J. [13] conducted a study and examined the effects of a tiny PMF comprising less than 25 percent articular surface area on ankle joint stability using CT scanning during full weight bearing in a human cadaver ankle fracture model. And find that further reduction and fixation of a tiny PMF appears to counteract ankle rotational stresses more efficiently than a solo syndesmotic screw. This becomes clinically significant at certain parts of the gait cycle.

The patient populations investigated in studies of posterior malleolus fractures have been quite limited. These fractures classification, surgical intervention indication, surgical strategy, and operational technique continue to be a matter of contention. In the study by Bois and Dust All patients except two received open reduction and internal fixation of the posterior malleolar fracture through a single posteromedial route. In two instances, a combination posteromedial and posterolateral surgical approach to the ankle was employed. And identified Grades II or III radiographic osteoarthritis in 67 percent of their series an average of 9.4 years following ankle fracture. In the early stages of the illness, radiographic abnormalities associated with ankle osteoarthritis may be well managed [13].

Park et al. [14] managed 29 PMF ankle fractures. 15 patients were treated with syndesmotic screw fixation, whereas 14 cases were managed with posterior malleolar fixation. They discovered no significant difference between groups in terms of reduction quality, ankle arthrosis severity, or clinical assessments. This was in agreement with our result in which no critical difference is detected in baseline characteristics and no critical difference in Weber and Lauge-Hansen classifications between the studied groups. No critical difference is detected in time from injury to operation and hospital stay length between the studied groups.

Operative duration was considerably higher in group B than A. The statistical significance of short time of group A reflected on the final results because the less time of group A is expected because it is only syndesmotic screw while in group B it is ORIF post. Malleolus.

In a study done by Xu et al. [15] , There was no statistically significant difference in the effects of therapy on 42 cases of fixed and 60 cases of unfixed posterior malleolus fragments. The average AOFAS score was 95.9, the rate of excellence was 92.2 parcent, and the average VAS scores for the degree of fracture pain during rest, active movement, and weight-bearing walking were 0.15, 0.31, and 0.65, respectively. This was in opposition to our result. The VAS score did not change substantially across groups, however the AOFAS score was considerably lower in group A (65 – 90) than in group B (75 – 95).

Ten cases of trimalleolar fractures were investigated by Lee et al. and following open reduction and internal fixation of PMF, all individuals in their series got good AOFAS scores [16].

15 cases of posterior malleolus fracture, yielding 7 good outcomes and 5 excellent were treated by Chung et al. [17]. And concluded that a posterior technique for posterior malleolar fractures, particularly those with imprisoned fragments and comminuted fractures, may be an effective strategy for anatomical reduction, secure fixation, and excellent clinical outcomes. This was in agreement with our study in which we used posterior approach.

In Gardner et al. 52 percent of patients treated for syndesmotic instability with standard trans-syndesmotic stabilization procedures exhibited mal-reduction, compared to standard radiography, CT evaluation reveals well-reduced fractures [18]. This was in disagreement with our result in which re-operation and osteoarthritis didn't occur in any patients in group A or group B.

In our study the time to complete union and time to full ambulation were considerably higher in B than A group and complication reported infection occurred in only 1 (6.67%) patient in group B and didn't occur in group A, and mechanical irritation occurred in only 1 (6.67%) patient in group A and didn't occur in group B.

Miller et al. stated that posterior malleolus fracture fixing is much more assuredly to regain syndesmosis integrity than trans-syndesmosis fixation alone [6]. Ogilvie-Harris et al. demonstrated that the PITFL alone accounts for 42 percent of the syndesmosis's strength [19]. Gardner et al. assessed the integrity of PITFL after ankle fractures accompanied by posterior malleolar fracture and concluded that this type of fracture had an undamaged PITFL [10]. On the basis of these studies, it is possible to conclude that, in the majority of ankle fractures that included a posterior fragment, PITFL can be fixed by reduction and fixation of the posterior malleolus, thus supplying fixation of the syndesmosis and reducing necessity for syndesmotic trans fixation.

The posterolateral ankle approach offers a genuine intermuscular plane between the flexor hallucis longus and peroneal muscles. Furthermore, the sural nerve, that runs immediately under the skin, is at danger of iatrogenic damage across the whole length of the incision with the posterolateral technique. Jowett et al. [20] in their cadaveric investigation, the researchers revealed that the sural nerve goes through the middle 56.7 mm to 61 mm of the posterolateral incision halfway between the lateral malleolus and the Achilles tendon. When doing a posterolateral ankle technique, special attention should be paid to the middle of the incision.

Due to the very small sample size, there are several limitations to this research. On the radiographs taken immediately after surgery, articular reduction was evaluated. Postoperative CT may be more accurate than lateral radiography in assessing reduction efficiency. As a result of its significant radiation exposure, it was not employed as a tool.

Conclusions

By comparing posterior malleolus fractures direct reduction and internal fixation on syndesmotic injuries reduction, with direct syndesmotic trimalleolar ankle fractures fixation. The findings indicate longer operative time, higher AOFAS score in group B than group A. In certain instances, transyndesmal screw stabilization may not be necessary if the posterior malleolar fracture has been stabilized. For these reasons, we urge that all posterior malleolar fractures, except avulsion fractures, must be treated.

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Running title: Trans-syndesmotic vs. Posterior Malleolar Fixation

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