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The Efficacy of the Posteromedial Approach to the Distal Tibia in Tri-Malleolar Fractures

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Abstract

Background: Tri-malleolar injuries are complicated injuries, which entail a combination of medial, lateral (fibular), and posterior malleoli injury. In their treatment, they need operative fixation to provide the restoration of congruity within the articular structures and help to prevent post-traumatic osteoarthritis. Posterior malleolus The posteromedial approach to the distal tibia exposes the posterior malleolus directly with minimum disruption of adjacent soft-tissue.

Objective: The aim was to compare the clinical and functional outcome of tri-malleolar fracture treated surgically through posteromedial approach to the distal tibia.

Methods: A retrospective study was carried out with 17 patients who have been operated with the fixation during the period of January 2022 to December 2024. Some of the variables that were analysed were the length of the operation, period of follow-up, pre and post operative AOFAS ankle-hindfoot scores, VAS pain scores (rest, and ambulation), age of patient, and sex. Paired t-tests and Pearson correlation coefficients were used with Statistical IBM SPSS v.26.

Results: the average operating time recorded was 64.1/6.8 minutes with a follow up being 12.8/2.2 months. The AOFAS scores were significantly better during the postoperative period measured at 81.43 ± 4.7 compared with 38.53 during the preoperative period, which is an improvement of 42.92 with a standard deviation of 5.3. The rest and walking VAS scores were 0.35 and 0.94 respectively. No significant complications were noted.

Conclusion: The posteromedial method of the distal tibia is a safe, effective, and reproducible method of treating tri-malleolar fractures that provides remarkable functional outcome and has minimal post-operative pain.

Keywords: *posteromedial approach; tri-malleolar fractures; distal tibia; AOFAS score; functional recovery; posterior malleolus fixation*

Introduction

Tri-malleolar ankle fractures constitute one of the most difficult patterns of injuries in the orthopedic trauma, as the medial, lateral (distal fibula) and posterior malleolus of the distal tibia are simultaneously disrupted. Such injuries are normally caused by high power rotating forces which undermine the integrity of ankle mortise and cause severe articular instability (Redfern et al., 2003). Their Mult fragmentary nature requires meticulous operative planning that will enable the restoration of anatomical position as well as the re-establishment of joint congruity and early functional rehabilitation (Tejwani et al., 2010).

Inability to treat all the components of the injury effectively predisposes patients to malunion, chronic articular instability, and post-traumatic osteoarthritis- some of the complications that significantly reduce both mobility and the health related quality of life (Haraguchi et al., 2006). Based on this, the main target of operations is to have all three malleoli fixed in a stable manner by carefully reconstructing the arthroplasty.

The posterior malleolus has been underestimated but is currently recognised as a necessary stabiliser of the ankle joint. It has a significant role to play in tibio-talar contact mechanics and acts as a mechanical brace against talus posterior subluxation (Van den Bekerom et al., 2008). More recent evidence suggests that an anterior malleolar involvement more than 25 percent of the tibial plafond surface area should be surgically fixed to prevent degenerative sequelae in the long term (Vallier et al., 2013). The radiographic appearance of such injuries is common, and this is depicted in.

Historically, the posterior malleolar access was done through direct posterior or posterolateral approaches, but these approaches are linked to extensive soft-tissue dissection, sural nerve neuropraxia and poor wound healing (Egol et al., 2010). The posteromedial technique has become an attractive option, which takes advantage of the intermuscular position between flexor digitorum longus and tibialis posterior tendons to access the posterior malleolus with the minimum neurovascular impact (Koval and Helfet, 2007). The added operational benefit of this method is that it gives concomitant easy access to the medial malleolus in case of a need to fix it concomitantly- which is of special direct benefit in the environment of tri- malleolar injury (Buckley et al., 2006).

Although there is increased use of posteromedial approach by orthopaedic surgeons, there is still a dearth of outcome data related to the tri-malleolar fractures. The published literature covers most of the isolated posterior malleolar injuries or reporting on surgical technique without detailed functional outcome. The current study was thus aimed at assessing clinical and functional outcomes in patients with tri-malleolar fractures who had been treated through this mode with special consideration of the duration of operative, the intensity of post-operative pain (Visual Analog Scale [VAS]) and functionality of the ankle (American Orthopaedic Foot and Ankle Society [AOFAS] Ankle-Hindfoot Score) at a follow-up period of 9 to 16 months.

Materials and methods

2.1 Study Design and Setting

It was a retrospective observational study that was carried out in one tertiary orthopaedic referral centre. The research sample included 17 consecutive patients who were operated on through posteromedial fixation of tri-malleolar ankle fractures in January 2022 to December 2024. The institutional review board gave ethical approval and all the processes were in accordance with the concepts of the Declaration of Helsinki (2013 revision).

2.2 Inclusion and Exclusion Criteria.

The inclusion criteria included: (1) patients had to have a tri-malleolar ankle fracture (radiographically confirmed with injury to the medial, lateral (fibular), and posterior malleoli); (2) operative treatment of the posterior malleolar fixation (posteromedial approach); (3) complete pre- and postoperative medical records including validated functional outcome scores and operative reports; and (4) at least nine months of follow-up.

The patients who were not followed up, incomplete clinical record especially AOFAS or VAS record, presented with pathological fractures, open wounds, or extensive soft-tissue loss that might confound the outcome results, or patient had a history of prior ipsilateral ankle surgery or pre-existing deformity were excluded in the study.

2.3 Pre-operative Assessment

Every patient was subjected to routine pre-operative imaging that includes anteroposterior and lateral plain cryptography of the ankle (Figure 1), with a computer tomography (CT) of the ankle to assess the fractures in detail. Routine CT imaging (Figure 2) was used to outline the size, morphology and articular extension of the posterior malleolar fragment that was directly correlated to operative planning and choice of implant.

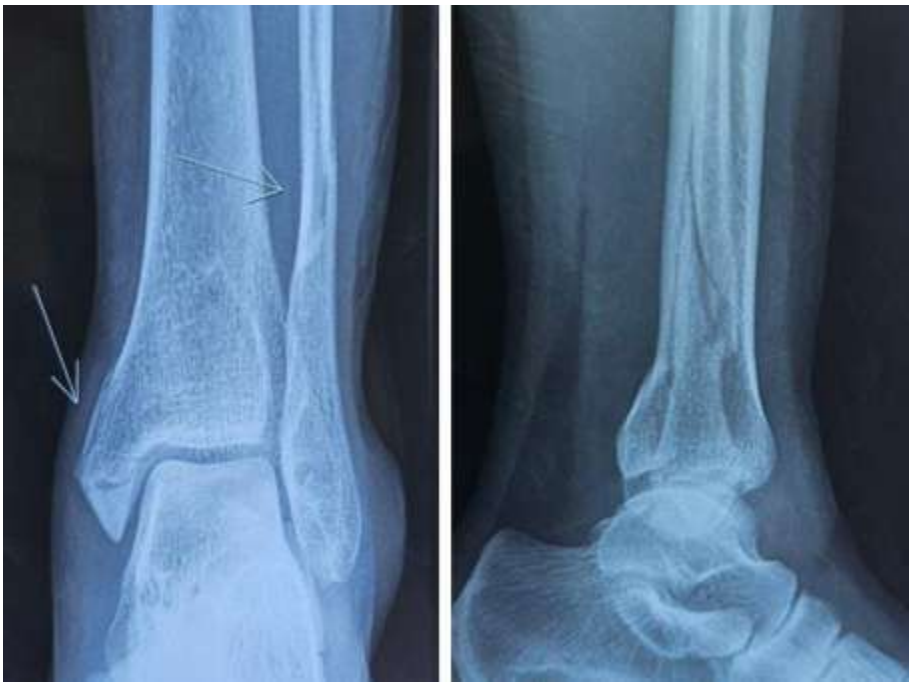

Figure 1. Anteroposterior (left) and lateral (right) plain radiographs demonstrating a tri-malleolar ankle fracture with involvement of the medial, lateral (fibular), and posterior malleoli. Note the disruption of the ankle mortise and displacement of the posterior malleolar fragment.

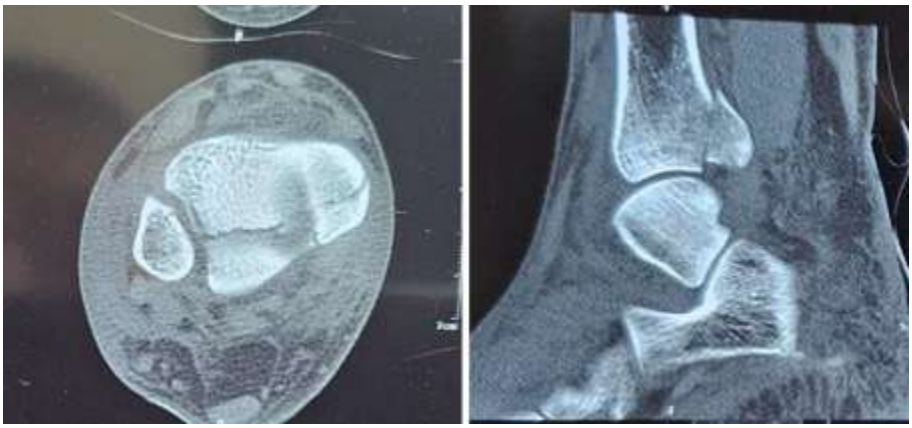

Figure 2. Pre-operative axial (left) and sagittal (right) computed tomography images of the posterior malleolar fracture. CT evaluation was essential to quantify the articular surface area involved and guide the choice of surgical approach and fixation construct.

2.4 Surgical Technique

All these works were done under general or spinal anaesthesia and the patient was in the prone position. The intermuscular interval between flexor digitorum longus and tibialis posterior tendons was used in the posteromedial to fix the posterior malleolar fixation, taking great care not to damage the posteromedial neurovascular bundle. The posterior malleolar fragment was anatomically minimised under direct visualisation and fixed with a low profile buttress plate or lag-screws based on fragment morphology (Figures 35). The fibular fracture was, then, treated using a standard lateral procedure and stabilized with a neutralisation or locking plate along with the medial malleolus being fixed with cannulated cancellous screws or a tension-band construct according to suitability.

Figure 3. Intraoperative fluoroscopic image demonstrating provisional reduction and temporary fixation of the posterior malleolar fragment using guide wires prior to definitive implant placement.

2.5 Outcome Measures

The major functional outcome measure was AOFAS Ankle-Hindfoot Score, an instrument that was valid and that was used to determine pain, function, and alignment on a 100-point scale, with the categories of: excellent (90100), good, (8089), fair, (7079) and poor (<70). The intensity of pain was measured with the help of VAS (0 = no pain; 10 = the worst imaginable pain) under two functional conditions rest and ambulation. The length of time (skin incision and wound closure) spent in the operation and the total length of time spent in the follow-up were also noted. Two investigators were used to undertake the verification of all data to ensure accuracy.

2.6 Statistical Analysis

All the demographic and clinical variables were calculated using descriptive statistics. Paired t-tests were used to compare the pre and post operative scores in AOFAS, and the level of statistical significance was set at $p = 0.05$. Pearson correlation coefficients were calculated to determine linear relationships between: (a) age and operative time; (b) age and AOFAS improvement; and (c) operative time and AOFAS improvement. All the analyses were done through the IBM SPSS Statistics, Version 26.

3. RESULTS

3.1 Patient Demographics

The study cohort consisted of 17 patients (9 male, 8 female) with a mean age of 43.5 years (range: 22–65 years). Follow-up ranged from 9 to 16 months, with a mean of 12.8 ± 2.2 months. Complete demographic and clinical data for each patient are presented in Table 1.

Table 1. Baseline and Operative Profile of Included Patients

Patient ID	*Age (Years)*	*Gender*	*Follow-up Duration (Months)*	*Surgery Duration (Minutes)*	*AOFAS Score (Preoperative)*	*AOFAS Score (Postoperative)*	*Pain Score at Rest (VAS)*	*Pain Score (VAS)*
P01	*65*	*Female*	*13*	*61*	*33*	*76*	*0*	*1*
P02	*42*	*Male*	*15*	*64*	*40*	*80*	*0*	*1*
P03	*34*	*Male*	*11*	*55*	*35*	*82*	*0*	*1*
P04	*60*	*Female*	*14*	*70*	*33*	*74*	*1*	*1*
P05	*55*	*Female*	*16*	*75*	*34*	*78*	*1*	*1*
P06	*45*	*Male*	*12*	*65*	*38*	*84*	*0*	*1*
P07	*43*	*Male*	*13*	*59*	*45*	*88*	*0*	*2*
P08	*40*	*Male*	*14*	*55*	*42*	*86*	*0*	*1*
P09	*52*	*Female*	*10*	*67*	*40*	*78*	*1*	*1*
P10	*25*	*Male*	*15*	*71*	*42*	*80*	*0*	*1*
P11	*48*	*Female*	*11*	*54*	*36*	*76*	*1*	*2*
P12	*62*	*Female*	*9*	*66*	*43*	*74*	*1*	*2*
P13	*51*	*Male*	*10*	*68*	*42*	*80*	*0*	*1*
P14	*40*	*Female*	*13*	*59*	*39*	*82*	*0*	*0*

Patient ID	*Age (Years)*	*Gender*	*Follow-up Duration (Months)*	*Surgery Duration (Minutes)*	*AOFAS Score (Preoperative)*	*AOFAS Score (Postoperative)*	*Pain Score at Rest (VAS)*	*Pain Score (VAS)*
P15	*36*	*Female*	*12*	*75*	*32*	*84*	*0*	*0*
P16	*27*	*Male*	*16*	*59*	*36*	*88*	*0*	*2*
P17	*22*	*Male*	*13*	*60*	*45*	*90*	*0*	*1*

3.2 Functional Outcomes: AOFAS Ankle-Hindfoot Score

Surgery via the posteromedial approach produced a clinically and statistically significant improvement in ankle function across the entire cohort (Table 2). The mean pre-operative AOFAS score was 38.5 ± 4.1 (range: 32–45), categorising all patients in the 'poor' functional range pre-operatively. Following surgical fixation, the mean post-operative AOFAS score rose to 81.4 ± 4.7 (range: 74–90), placing the majority of patients in the 'good' functional category, with one patient achieving an 'excellent' result (Patient 17, score: 90) and three patients achieving 'excellent' or 'good' scores above 86. The mean absolute improvement was 42.9 ± 5.3 points. Paired t-test confirmed the statistical robustness of this change: $t(16) = -16.6$, $p < 0.001$.

Table 2. Descriptive Statistics of Clinical and Functional Outcomes (n = 17)

Variable	*Average Value ± Standard Deviation*
AOFAS Score (Before Surgery)	*38.5 ± 4.1*
AOFAS Score (After Surgery)	*81.4 ± 4.7*
Change in AOFAS Score	*+42.9 ± 5.3*
Duration of Surgery (min)	*64.1 ± 6.8*
Length of Follow-up (months)	*12.8 ± 2.2*
Pain Level at Rest (VAS)	*0.35 ± 0.49*
Pain Level (VAS)	*0.94 ± 0.46*

3.3 Post-Operative Pain Assessment

Post-operative pain was consistently minimal across the cohort, as assessed at final follow-up. Mean VAS at rest was 0.35 ± 0.49 (range: 0–1), and mean VAS during walking was 0.94 ± 0.46 (range: 0–2) (Table 2, Figure 6). The near-absent resting pain and very low ambulatory pain scores suggest effective and durable analgesia, attributable in part to the minimally disruptive nature of the posteromedial approach. No patient reported a VAS score exceeding 2 during walking at final follow-up.

3.4 Operative Duration and Reproducibility

The mean operative time was 64.1 ± 6.8 minutes (range: 54–75 minutes), demonstrating a narrow range indicative of technical consistency. No statistically significant correlation was identified between operative duration and patient age ($r = 0.13$, $p = 0.61$), nor between operative duration and post-operative AOFAS improvement ($r = 0.04$, $p = 0.88$). These findings suggest that the posteromedial approach is technically reproducible and that individual variation in patient complexity did not materially affect procedural efficiency within this cohort.

3.5 Pearson Correlation Analysis

Pearson correlation analysis revealed no statistically significant associations among age, operative time, or magnitude of AOFAS improvement (Table 3, all $p > 0.05$). Specifically: age versus operative time ($r = 0.13$, $p = 0.61$); age versus AOFAS improvement ($r = -0.18$, $p = 0.49$); and operative time versus AOFAS improvement ($r = 0.04$, $p = 0.88$). These results indicate that functional outcomes following the posteromedial approach are not significantly influenced by the patient's age or the duration of the surgical procedure, supporting the technique's broad applicability.

Table 3. Correlation Analysis Between Key Study Variables (n = 17, non-significant correlations)

Variables Compared	*Correlation Coefficient (r)*	*Significance (p-value)*
Age vs. Operative Duration	***0.13***	***0.61***
Age vs. AOFAS Score Change	***−0.18***	***0.49***
Operative Duration vs. AOFAS Gain	***0.04***	***0.88***

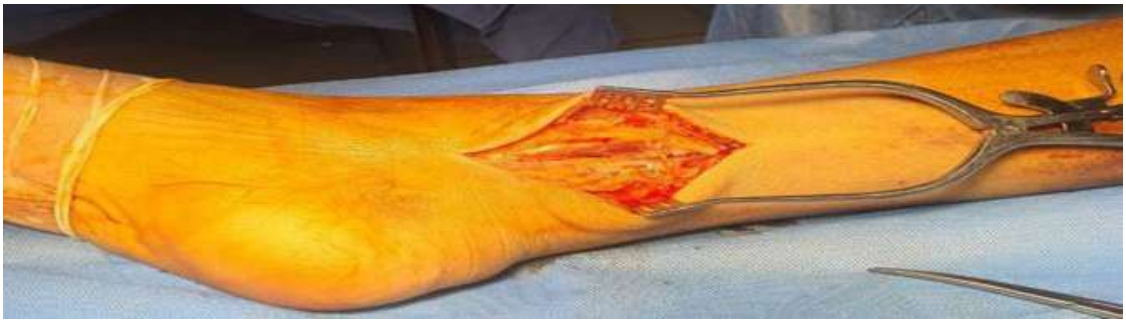

Figure 4. Intraoperative photograph of the posteromedial approach showing the anatomical corridor between the tibialis posterior tendon (medially) and the flexor digitorum longus (FDL) (laterally). The posteromedial neurovascular bundle is identified and protected throughout the procedure.

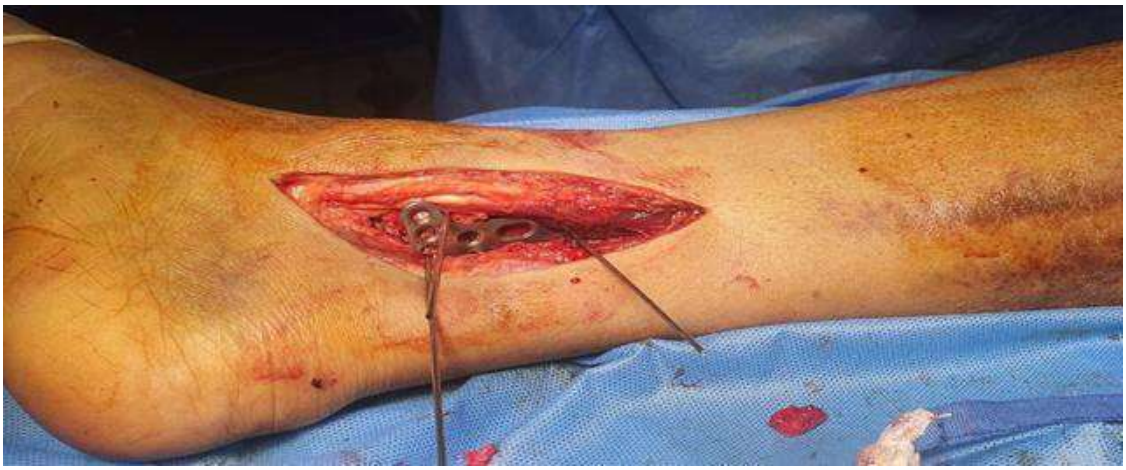

Figure 5. Intraoperative photograph demonstrating definitive low-profile plate fixation of the posterior malleolar fragment through the posteromedial approach. Anatomical reduction of the articular surface is confirmed under direct vision.

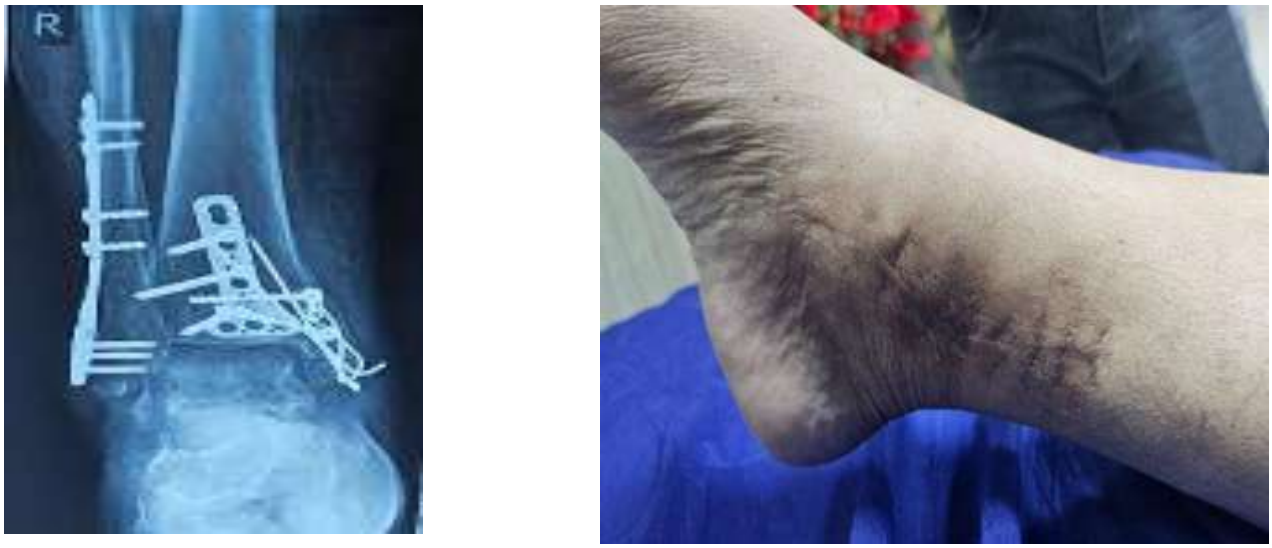

Figure 6. Post-operative imaging and clinical findings. (A) Anteroposterior radiograph of the ankle demonstrating excellent anatomical reduction and stable implant positioning across all three malleoli, with restoration of the ankle mortise. (B) Clinical photograph of the posteromedial incision at follow-up, confirming satisfactory wound healing with no dehiscence, infection, or scar-related complications.

Discussion

This retrospective study presents the evidence of the posteromedial approach to the distal tibia as a strong and technically reproducible way of treating tri-malleolar ankle fractures. The main observation was a statistically and clinical significant improvement in AOFAS Ankle-Hindfoot Score and a mean improvement of about 43 points, and a consistently low post-operative pain scores indicating both satisfactory articular recovery and a low soft-tissue morbidity.

The AOFAS mean of 81.4 after the operation is in the range of good functional range and it agrees with the results reported in the literature of similar techniques. Redfern et al. (2003) found the average AOFAS score to be around 83 in patients who were undergoing an anterior malleolar fixation through the use of minimal invasive procedures, confirming that proper anatomical reduction is a key action that can be used to determine functional outcome. In the same way, Tejwani et al. (2010) have also shown that operative fixation of posterior malleolar fragments of more than 25 percent of the tibial plafond, as measured before surgery using CT images (Figure 2), has much better functional outcomes in the short term than no operative intervention. On the other hand, Haraguchi et al. (2006) reported the negative effects of poor fixation of big posterior fragments such as low functional scores and progressive articular degeneration. These are collective findings that are supported by our results, and are consistent with the need of direct visualisation and stable fixation of the posterior malleolus, as presented intraoperatively in Figures 4 and 5.

The almost zero levels of post-operative pain (mean VAS of 0.35 at rest and 0.94 when walking) could be explained by the anatomical benefits of the posteromedial approach. The technique eliminates the far-reaching soft-tissue stripping and sural nerve mobilisation involved in posterolateral techniques, so risk of neuropraxia and wound-related issues is minimised (Egol et al., 2010). Such benefits are also in line with the findings of Koval and Helfet (2007) who have shown that less invasive methods are associated with an earlier onset of weight-bearing and a lower need of analgesics after operation. Buckley et al.

(2006) also found that early mobilisation following surgery on ankle fracture is positively correlated with reduced level of pain and increased levels of satisfaction among patients.

The limited span of operative times (54 75 minutes) in this group demonstrates the technical reliability of the posteromedial approach and is consistent with the findings by Vallier et al. (2013), who observed that an experienced surgeons should take less than 70 minutes to fix the posterior malleolar. Van den Bekerom et al. (2008) also observed that recent methods to the posterior malleolus, such as posteromedial corridor, can expose the bone expediently as compared to the traditional methods of exposing the posterior part. Despite the warning issued by Court-Brown and Caesar (2006) that the risk of infection and deep venous thrombosis increases proportionate to the duration of the operation, the efficiency of the procedure that was observed in the current cohort would indicate that the posteromedial approach has a favourable complication profile in the hands of seasoned surgeons.

The lack of any meaningful relationships between the age of patients, the time of operation, and the improvement in the patient functions has a considerable clinical implication. It shows that the posteromedial method is highly versatile in terms of its application across a broad age range, including older patients that often appear with more complicated fracture patterns, reduced physiological potential, and high comorbidity load. Koval et al. (2007) noted that older patients usually have lower baseline functional scores, but when they are treated using a proper surgery plan, they are still able to make similar post-operative functional improvement. Tornetta et al. (2011) also came to the same conclusion that in the case of optimised surgical fixation, there are no significant differences in final functional outcomes between younger and older groups of patients. This data suggests the posteromedial approach as a multifunctional operative choice regardless of the age of patients.

This study has several shortcomings that should be mentioned. The sample size was quite small (17), and the retrospective design is prone to inherent selection and documentation bias. Although the follow-up is adequate to document early functional recovery, it might not be adequate to document late degenerative alterations as post-traumatic osteoarthritis. Also, the study has shortcomings on generalisability due to the single-centre nature of the study. It eliminates direct technique specific comparisons due to the lack of a comparative cohort treated using alternative methods (e.g. posterolateral or direct anterior). Future, multi-centre, randomised controlled studies that involve long term follow-ups need to be conducted to further prove these results and determine the long term superiority or equivalence of the posteromedial approach compared to other surgical methods.

Conclusion

The posteromedial approach of the distal tibia is a safe, successful, and can be technical reproducible operative method of management of the tri-malleolar fractures of the ankle. The method offers straightforward visualisation and anatomical reduction of the posterior malleolar fragment (Figures 365), the fixation is stable (Figure 6A), and adjacent neurovascular structures remain intact with the result of minimal morbidity of the soft-tissue (Figure 6B, p. 24). These findings confirm statistically significant and clinically significant improvement in AOFAS ankle-hindfoot scores, similar, and low steady levels of post-operative pain at rest and during ambulation, consistent operative time times indicative of technical reproducibility, and similar functional outcome at a large age range and across a wide range of surgical times. Collectively, these results justify using the posteromedial technique as a regular tool in the arsenal of the operative intervention of complex tri-malleolar trauma. Additional prospective multicentre studies

with follow-up are justified to collectively confirm such results as well as to quantify the protective effect of the approach on the prevention of post-traumatic articular degeneration.

DECLARATIONS

Conflict of Interest: The author declares no conflicts of interest pertinent to this research.

Financial Support: This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Ethical Approval: Ethical approval was granted by the Institutional Review Board. All procedures were performed in accordance with the ethical standards of the 2013 Declaration of Helsinki.

Informed Consent: Informed consent was obtained from all individual participants included in the study.

Data Availability: The data supporting the findings of this study are available from the corresponding author upon reasonable request.

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