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Original Article

Functional Outcomes in Calcaneal Fracture Treated with Calcaneal Perimeter Plating

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ABSTRACT

***Objective*:** to compare the Lateral Extensile Approach with the less invasive Sinus Tarsi Approach regarding functional outcomes and wound complications**.**

***Study Design*:** Quasi-experimental study.

***Place and Duration of Study*:** Department of Orthopaedic Surgery, Combined Military Hospital, Rawalpindi Pakistan, from Dec 2023 to Nov 2024.

***Methodology*:** Forty-four patients with a closed, isolated calcaneal fracture with optimal skin condition were sequentially enrolled into two groups. All patients underwent open reduction internal fixation with the same calcaneal perimeter plate using the Lateral Extensile Approach in Group-A patients and the Sinus Tarsi Approach in Group-B patients. Clinical outcome was assessed by The American Orthopedic Foot and Ankle Society Score at 6 months. The adequacy of reduction was evaluated by Calcaneal Width, Bohler's, and Gissane's angle via post-operative radiograph. Patients were followed up at 2 weeks, 3, and 6 months for documentation of soft tissue complications.

***Results*:** Patients in both Groups demonstrated satisfactory reduction of fractures with no significant difference in Calcaneal Width, Bohler's or Gissane's angle. Similarly, no substantial variance was observed in the American Orthopedic Foot and Ankle Society score at 6-months follow-up. The lateral extensile Group had two superficial and one deep flap-related complication, while none was noted in the sinus tarsi Group.

***Conclusion*:** The current study suggests that the Sinus Tarsi Approach should be the preferred technique for treating DIACFs, as it produces similar results and fewer complications.

Keywords: Calcaneal Fractures, Intra Articular, Perimeter Plating, Wound Complications.

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INTRODUCTION

The calcaneum is the largest and most commonly fractured tarsal bone in the human body, constituting up to 60% of all tarsal fractures.[1] Calcaneal fractures comprise up to 2% of whole-body fractures, and 90% of these occur in the age Group of 25 to 41-year-old patients after high-velocity injury, including road traffic accidents and falls from height.[2] Seventy-five percent of all calcaneal fractures have the intra-articular extension and displacement of fracture fragments; hence, they are commonly termed Displaced Intra Articular Calcaneal Fractures (DIACFs).[3]

Calcaneal fractures are one of the most challenging fractures to treat for trauma surgeons.[4] Despite the availability of extensive literature regarding these fractures, their management remains controversial. Historically, these fractures have been treated in casts with strict non-weight bearing protocol, but clinical outcomes reported in conservative management are mostly unsatisfactory.[5] Closed reduction not only aggravates soft tissue trauma but also often results in the malreduction of articular fragments. On the other hand, prolonged immobilization leads to stiffness, sub-talar arthrosis, and malunion.[6]

Currently, abundant clinical evidence supports surgical intervention of these fractures as it provides a quicker return to work and better functional results.[7] Conventionally, the approach used for the fixation of DIACF is the Extensile Lateral Approach (ELA). It provides excellent exposure for fracture reduction but has been notorious for wound-related complications.[8] Although "no-touch techniques" and the creation of a musculocutaneous flap of maximum thickness have been implemented, the incidence of complications associated with this approach has been reported by some studies to be as high as 43%.[8]

These complications, specifically necrosis of the flap and surgical site infection, have driven the

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development of minimally invasive surgical approaches for the fixation of DIACFs.[9] Several clinical studies have shown different minimally invasive approaches being practiced by surgeons in many centers worldwide, such as external fixation, percutaneous fixation, arthroscopic reduction and fixation, and sinus tarsi approach.[10] Among these, the Sinus Tarsi Approach (STA) has demonstrated promising results in decreased wound infection and necrosis and fewer reoperation rates. This approach has widely been adopted as the access to fracture visualization is not hindered.[2,9]

Opponents of STA have repeatedly hypothesized that anatomical reduction is not achievable due to intrinsic technical difficulty, limited exposure, and room for manipulation, ultimately leading to poor radiological and functional outcomes.[10] This study aimed to assess whether similar radiological parameters and functional scoring grades are attainable with STA with reduced complication rates compared to ELA.

METHODOLOGY

The quasi-experimental study was conducted in the Department of Orthopedic Surgery at Combined Military Hospital, Rawalpindi Pakistan, from November 2023 to October 2024. Institutional Ethical Review Board (IERB No. 493/11/2023) approval was sought before the study commencement. Informed written consent was taken from each patient before enrolment in the study. The sample size was calculated using SPSS version 28. By keeping the power of the study at 80% and α at 0.05, the mean of the extensile lateral Group was 82.58±6.0, and that of the sinus tarsi approach was 89.58±6.9.[11] For the hypothesis with a Group size ratio of 1, a sample size of 22 per Group was obtained, making the total number of enrolled patients 44.

Inclusion Criteria: All patients between the ages of 18 to 60 years, presenting with isolated Sanders type II and Type III Calcaneal fractures within 7 days of injury, with optimal skin conditions such as no blistering, bruising, edema, and no other co-morbidity that affects wound healing were included.

Exclusion Criteria: Patients with multiple or open fractures, neurovascular injury, previous pathology of the foot causing pain and limiting mobility, or any disease that halts or delays bone healing presenting after the trial of conservative management or more than a week after trauma, were excluded.

All patients enrolled were classified according to Sanders Classifications and assigned either STA or ELA Group in odd-even order of their hospital admission, making two Groups with 22 patients in each Group. All patients were thoroughly examined clinically and radiologically as part of preoperative planning. All surgeries were performed in spinal anesthesia, with a properly applied tourniquet inflated to optimal pressures and the patient positioned in lateral decubitus posture. Standard Extensile Lateral Approach was used to treat fractures in Group A patients. Synthetic bone grafting was utilized where necessary to support reduction and alleviate bone loss in both Groups. The provisional reduction was held with K wires and confirmed under fluoroscopy. Afterward, it was fixed by a multi-hole calcaneal plate and screws.

Fractures in Group-B were fixed using the Sinus Tarsi Approach after closed or percutaneous reduction with K wires or Steinman pins. A longitudinal incision from the base of the 4th metatarsal to the tip of the fibula was made. Peroneal tendons and sural nerve were protected inferiorly, and the subtalar joint was exposed to attain reduction. Along the lateral border Achilles tendon, a small incision was made to introduce the calcaneal plate with its positioning and fixation with screws assessed under the C-arm. A combination of absorbable and non-absorbable sutures in both Groups undertook meticulous wound closure (Figure).

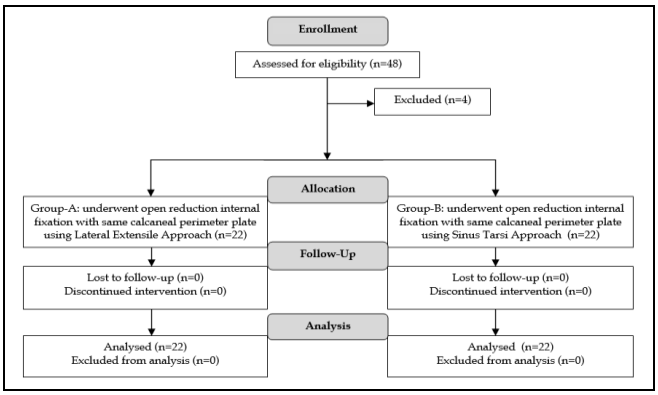

Figure: Patient Flow Diagram (n=44)

Patients in both Groups were discharged after 72 hours with strict non-weight bearing protocol and gentle active range of motion exercises at the tibiotalar joint. All patients were followed up at 2 weeks, 3 months and 6 months. Radiological outcomes were measured regarding restoration of calcaneal width,

Bohler's and Gissane's angle. Other parameters compared included demographic data of patients, duration of surgery, post-operative pain at 48 hours and 3 weeks, and soft tissue complications. Clinical Outcomes were assessed by The American Orthopedic Foot and Ankle Society (AOFAS) Score at 6 months.

Statistical Package for Social Sciences software version 28 was used for data analysis. The threshold for a statistically significant *p*-value was ≤0.05. For comparison, independent sample and paired sample t-test was used, along with their nonparametric counterparts (e.g., Mann-Whitney U Tests) for non-normal data.

RESULTS

Group A consisted of 17 male and five female patients, while 18 male and four female patients were in Group B. The mean age in Group A was 39.73±10.12 years, and that of Group B was 40.68±12.46 years. Fall from height was the predominant mechanism of injury in both Groups, followed by road traffic accidents and blunt trauma [Table-I].

Table-I: Summary of Baseline and Demographics Data (n=44)

		Extensile Lateral Group (n=22)	Sinus Tarsi Group (n=22)
Age (Years)		39.73±10.12	40.68±12.46
Gender	Male	17(77.3%)	18(81.8%)
	Female	5(22.7%)	4(18.2%)
Mode of Injury	Road Traffic Accident	7(31.8%)	7(31.8%)
	Fall from height	13(59.1%)	12(54.5%)
	Blunt Trauma	2(9.1%)	3(13.6%)
Side	Right	10(45.5%)	14(63.6%)
	Left	12(54.5%)	8(36.4%)
Sanders Classfication	Sanders II	19(86.4%)	16(72.7%)
	Sanders III	3(13.6%)	6(27.3%)

Although both approaches yielded substantial restoration of radiological parameters such as calcaneal width and Bohler's and Gissane's angle individually [Table-II] (p<0.001), none were observed to be better than others in the aforementioned post-operative measurements. (p=0.08, p=0.12, p=0.56). In addition, Fewer soft tissue complications and a considerably shorter mean duration of surgery were noted in the STA Group. (p<0.001) [Table-III]. Neither of the two approaches was found superior to the other in terms of clinical outcome assessed by the American Orthopedic Foot and Ankle Score (AOFAS) at the 6-month follow-up (p=0.42).

However, patients in Group B who underwent calcaneal fixation by the sinus tarsi approach compared to the extensile lateral approach in Group A reported significantly less pain. This difference was documented at 48 hours and 3 weeks post-operative.

Table-II: Restoration of Bohler and Gissane Angles in Extensile Lateral Approach and Sinus Tarsi Approach (n=44)

	Pre Operative Findings	Post Operative Findings	*p*-value
Bohler's Angle			
Extensile Lateral Approach	13.07±1.65	31.14±2.97	<0.001
Sinus Tarsi Approach	14.83±1.75	32.59±2.73	<0.001
Gissane's Angle			
Extensile Lateral Approach	149.86±1.80	135.01±3.19	<0.001
Sinus Tarsi Approach	150.11±2.90	134.50±2.57	<0.001
Calcaneal Width			
Extensile Lateral Approach	47.53±0.89	42.51±1.55	<0.001
Sinus Tarsi Approach	48.85±1.47	41.76±1.30	<0.001

Table-III: Comparison of Clinical and Radiological Outcomes Between Extensile Lateral Group and Sinus Tarsi Approach (n=44)

Parameters/ Approach	Extensile Lateral Approach (n=22)	Sinus Tarsi Approach (n=22)	*p*-value
Duration of Surgery (mins)	152.18±18.89	114.64±17.43	<0.001
Post-Operative Bohler's Angle (degree)	31.14±2.97	32.59±2.73	0.12
Post-Operative Gissane's Angle (degree)	135.01±3.19	134.50±2.57	0.56
Post-Operative Calcaneal Width (mm)	42.51±1.55	41.76±1.30	0.08
VAS at 48 Hours Post Op	7.00(7.25–6.00)	5.00(7.00-3.00)	0.002
VAS at 3 weeks Post Op	5.50(7.00–4.00)	4.00(5.00-3.00)	0.005
AOFAS Score at 6 months	86.50(90.00–81.75)	87.20(91.20–83.45)	0.42

DISCUSSION

Despite abundant clinical trials on optimal treatment of displaced intra-articular calcaneal fractures, a consensus has yet to be developed. Advocates of the old school still favour a conservative approach, but the majority of clinicians are inclined towards surgical fixation.[4] The conventional lateral extensile approach has been practiced all around the globe since its development, but It is also notorious for its soft tissue-related complications.[8] This has led surgeons to search for alternative minimally invasive

approaches to reduce and stabilize calcaneal fractures adequately.[3] One of the most widely adopted techniques is the sinus tarsi approach.[11] In our study, we utilized this surgical invention, which has not been widely studied in our country until now, and compared it with historical methods.

There is a massive shift towards minimally invasive surgeries in foot and ankle surgeons, particularly for displaced calcaneal fractures. This has resulted from notably decreased complications with these techniques and comparable results to extensile approaches.[12-14] The most important aspect of opting for an approach for a procedure is the severity and classification of injury. Sanders type 4 fractures have universally poor functional outcomes, irrespective of the dissection technique used.[15] Conversely, Sanders type 2 and 3 fractures give comparable functional results with both extensive and minimally invasive approaches. This has been witnessed in multiple other studies, including ours.[14]

We used radiological parameters like Bohler's and Gissane's angle to assess the degree of satisfactory anatomical reduction in both approaches. We should remember that these measurements dictate the need for surgical intervention and the intensity of the fracture. Hence, their restoration signifies the optimum restoration of fracture fragments.16 We achieved a similar extent of radiological outcomes with no statistical difference in both Groups. Moreover, calcaneal width, another approximate scale for fracture alignment, yielded statistically similar readings in both Groups.[17] Numerous clinical trials done previously across the globe have documented equal and optimal restorations of these angles and reduction in calcaneal width with both approaches.[18,19]

The American Orthopedic Foot and Ankle Society (AOFAS) Score is a reliable and valid scoring system depicting patients' comfort and ease after hindfoot and ankle surgeries.[20] We used it to gauge the clinical effect of different ORIF techniques in our study. Patients were evaluated by a blind investigator at 6 months follow-up. In our study, no difference was observed in scores reported by patients of both Groups. A study conducted in Romania by Cursaru *et al.*, demonstrated no difference in AOFAS scores at 3 and 6 months in patients who underwent extensile lateral or sinus tarsi approach.[21]

Following open reduction internal fixation, the risk of wound complications from displaced intra-articular calcaneal fractures is significant.[22] The skin on the lateral side of the heel derives its nutrition from the peroneal artery and its terminal branches, which are susceptible to injury in the extensile lateral approach.[23] This vessel and its tributaries tend to be spared in the Sinus Tarsi Approach, as evidenced by fewer flap infections and necrosis as in our study. A similar study that compared these two approaches with a comparatively more significant sample size also reported significantly less incidence of wound complications.[24] Moreover, a minimally invasive approach leads to less soft tissue disruption and a shorter duration of surgery, which translates into mild post-operative pain and quicker recovery, as shown in the present study and previous literature.[25]

CONCLUSION

Except for the Extensile Lateral Approach provides better exposure for fracture reduction, none of the factors affecting clinical or radiological outcomes after open reduction internal fixation of displaced intraarticular calcaneal fractures seems to be affected by the choice of dissection technique used. Minimally invasive approaches such as sinus tarsi yield similar results with fewer complications and faster rehab. Even with the not-so-ideal direct visualization of fracture fragments, equivalent post-operative calcaneal angles show that we never needed extensive soft tissue stripping in the fixation of DIACF after all.

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Authors' Contribution

Following authors have made substantial contributions to the manuscript as under:

AMH & MSA: Conception, study design, drafting the manuscript, approval of the final version to be published.

BAQ & NUT: Data acquisition, data analysis, data interpretation, critical review, approval of the final version to be published.

Authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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