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A COMPARATIVE STUDY OF CALCANEAL FRACTURES MANAGED BY SINUS TARSI APPROACH AND EXTENSILE LATERAL APPROACH- IN TERMS OF CLINICO-RADIOLOGICAL AND FUNCTIONAL OUTCOME

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ABSTRACT

Background: Calcaneal fractures account for 60% of tarsal fractures, with displaced intra-articular fractures requiring surgical intervention. The optimal surgical approach remains debated between the Sinus Tarsi Approach (STA) and Extensile Lateral Approach (ELA). This study compared clinical, radiological, and functional outcomes of both techniques to guide surgical decision-making.

Methods: A prospective comparative study was conducted at Shri Guru Ram Rai Institute of Medical and Health Sciences, Dehradun, over 18 months. Sixty patients with Sanders Type II and III calcaneal fractures were randomized into two groups (n=30 each) receiving either STA or ELA. Preoperative assessments included radiological evaluation and CT scans. Follow-ups at 6, 12, and 24 weeks assessed pain (VAS score), functional recovery (AOFAS and Maryland Foot Scores), radiological alignment (Böhler and Gissane angles), wound healing, and complications. Statistical analysis used SPSS with $p<0.05$ considered significant.

Results: The STA group demonstrated significantly shorter operative time (65.5±10.2 vs 85.3±12.4 minutes, p=0.001), reduced hospital stay (4.2±1.1 vs 6.5±1.3 days, p=0.001), and better pain control at 24 weeks (VAS 0.5±0.6 vs 1.2±1.1, p=0.001). Wound complications were lower in STA (0% dehiscence vs 8.3% in ELA). Both approaches achieved significant radiological improvements, with ELA showing marginally better Böhler (28.5±3.2° vs 27.8±3.1°) and Gissane angles (130.2±3.8° vs. 128.5±3.6°). Functional outcomes favored STA, with superior AOFAS (91±4.9 vs 90±5.5) and Maryland Foot Scores (90±4.3 vs 89±5.2) at 24 weeks (p=0.001). Earlier weight-bearing (8.2±1.5 vs 10.5±1.8 weeks) and faster return to work (12.5±2.1 vs 15.2±2.5 weeks) were observed with STA (p=0.001).

Conclusion: While both approaches effectively manage calcaneal fractures, STA offers superior outcomes in operative efficiency, pain management, wound healing, and functional recovery. ELA remains preferable for complex fractures requiring extensive exposure.

Keywords: Calcaneal Fractures, Sinus Tarsi Approach, Extensile Lateral Approach, AOFAS Score, Functional Outcome, Sanders Classification

INTRODUCTION

Calcaneal fractures (CFs) are common, accounting for 60% of tarsal fractures and 2% of adult fractures, with 60-75% being displaced intra-articular fractures.[1] High-energy trauma, often from falls, is the primary cause, significantly impairing function due to the calcaneus's role in weight-bearing and mobility.[2] These fractures are particularly disabling for individuals in physically demanding jobs, such as construction workers.[3] Intra-articular fractures disrupt force transmission, causing chronic pain, limited motion, and post-traumatic osteoarthritis. Böhler's and Gissane's angles help assess fracture severity, with a decrease in Böhler's Angle indicating severe involvement requiring surgery.[4] Open reduction and internal fixation (ORIF) is commonly used for displaced fractures, but the optimal surgical approach remains debated. Buckley et al. found the Sinus Tarsi Approach (STA) superior in pain reduction,[5] while Bai et al. reported no significant differences.[6] STA is a minimally invasive technique that provides access to the calcaneus through the sinus tarsi. It is advantageous for less complex fractures, offering reduced soft tissue disruption, quicker recovery, and fewer complications.[7] However, STA may be inadequate for highly comminuted fractures due to limited exposure.[8] In such cases, the Extensile Lateral Approach (ELA), which provides greater exposure, is preferred. ELA allows better visualization and reduction of complex fractures but is associated with higher risks of complications, such as wound infections and nerve injury.[4,9] Both approaches aim to restore anatomical alignment, reduce pain, and improve function, but STA generally offers less postoperative pain and quicker recovery.[10] This study compares STA and ELA outcomes, focusing on clinical, radiological, and functional recovery, and aims to provide insights into the most effective treatment for CFs.[5,11]

AIMS AND OBJECTIVES

The aim of this study is to analyze and compare the radiological, functional, and clinical outcomes of calcaneal fractures treated with the Sinus Tarsi Approach (STA) and Extensile Lateral Approach (ELA). Specifically, it seeks to evaluate and compare the early and late post-operative complications associated with both surgical approaches. Additionally, the study aims to assess and compare the functional recovery in patients post-operatively, focusing on pain reduction, range of motion, and the ability to return to daily activities, to determine which surgical technique offers superior overall outcomes for managing calcaneal fractures.

MATERIAS & METHODS

Study Design

This prospective comparative study was conducted at the Department of Orthopaedics at Shri Guru Ram Rai Institute of Medical and Health Sciences (SGRRIM&HS), Dehradun, India, over a period of 18 months. The investigation aimed to evaluate the effectiveness of two surgical approaches, the Extensile Lateral Approach (ELA) and the Sinus Tarsi Approach (STA), in treating displaced intra-articular calcaneal fractures. Ethical approval was obtained from the hospital's ethics committee before initiating the study, and all patients provided written informed consent, ensuring compliance with ethical standards in clinical research. The study was carried out in the Orthopaedics and Emergency Department at SGRRIM&HS.

Inclusion and Exclusion Criteria

The inclusion criteria for this study were patients aged 18–65 years with a trauma history and diagnosed calcaneal fractures, confirmed through radiographic imaging (X-rays). Only patients with Sanders' Type 2 or Type 3 fractures, which involve significant displacement or intra-articular involvement, were included. Additionally, participants had to be ambulatory prior to injury and without contraindications to anesthesia, as surgery was necessary for treatment. Exclusion criteria included patients unfit for surgery due to severe comorbidities (e.g., uncontrolled diabetes or cardiovascular issues), those with Sanders Type 1 (non-displaced) or Type 4 (highly comminuted) fractures, pathological fractures due to underlying diseases, those with significant neurovascular injury, and patients with open fractures due to the increased risk of infection and different treatment requirements.

Sample Size Calculation

The sample size for this study was calculated using G*Power software to ensure adequate statistical power for detecting significant differences between the two surgical approaches. A total of 60 patients were selected, with 30 patients assigned to each group-Extensile Lateral Approach (ELA) and Sinus Tarsi Approach (STA). This sample size was deemed sufficient to provide reliable and meaningful comparisons in clinical, radiological, and functional outcomes between the two treatment methods.

Data Collection Tools

The study employed a comprehensive set of validated tools to assess clinical, functional, and radiological outcomes. Pain intensity was measured using the Visual Analogue Scale (VAS), a simple and effective tool ranging from 0 (no pain) to 10 (worst pain imaginable). Functional outcomes were evaluated using the American Orthopaedic Foot & Ankle Society (AOFAS) score and the Maryland Foot Score, both of which assess pain, function, and alignment, providing a score out of 100, with higher scores indicating better outcomes. Radiographic assessments were performed using standard foot X-rays in Anteroposterior, Lateral, and Axial views to evaluate fracture alignment and the restoration of Böhler's and Gissane's angles. Additionally, the union status was assessed based on radiographic signs of callus formation and fracture line healing. The surgical site was evaluated for signs of infection, wound healing, and alignment. These standardized tools ensured consistent and objective assessment across all patients.

Data Collection Procedure

Data collection was conducted at four key postoperative follow-up intervals: 14 days, 6 weeks, 12 weeks, and 24 weeks. At each visit, patients were assessed for pain and stiffness using the VAS and range-of-motion (ROM) testing. The surgical site was examined for infection, delayed wound healing, and other complications. Radiographs were taken to assess fracture healing, alignment, and restoration of anatomical angles. Fracture union was monitored through the presence of callus and bridging across the fracture line. Functional recovery was evaluated using the AOFAS and Maryland Foot Score systems. These follow-ups allowed for early detection of complications and provided insights into the short-term and long-term outcomes of the Sinus Tarsi and Extensile Lateral Approaches. The consistent use of standardized assessment points and tools helped ensure the validity and reliability of the study findings.

Statistical Analysis

Data were analyzed using SPSS software, with descriptive statistics applied to summarize the demographic and clinical characteristics of the study population. Comparative analyses between the Sinus Tarsi Approach (STA) and Extensile Lateral Approach (ELA) groups were performed using paired t-tests for continuous variables, such as the AOFAS Hind foot Score and Maryland Foot Score, to evaluate changes from pre-operative to post-operative status. Chi-square tests were used for categorical variables, including complication rates and radiological outcomes. A p-value of less than

0.05 was considered statistically significant, indicating a meaningful difference between the two surgical approaches

RESULTS

Parameter	Category	Frequency (n=60)	Percentage (%)	p-value
Age (Years)	18-30	20	33.30%	0.002
	31-45	25	41.70%	
	46-65	15	25.00%	
Gender	Male	45	75.0%	0.001
	Female	15	25.0%	
Fracture Type (Sanders)	Type II	35	58.3%	0.001
	Type III	25	41.7%	
Mechanism of Injury	Fall from Height	38	63.33%	0.0389
	Road Traffic Accident	22	36.67%	

Table 1: Demographic and Clinical Characteristics of Study Population

Table 1 illustrates that the study population predominantly consisted of working-age males (75%, 31-45 years), with Sanders Type II fractures (58.3%) most commonly resulting from falls from height (63.33%), all showing statistically significant distributions ($p<0.05$).

Parameter	Sinus Tarsi Approach	Extensile Lateral Approach	p-value
Day of Surgery (mean days)	4	8	0.01
Pre-operative Böhler Angle (°)	8.2 ± 2.3	7.5 ± 2.1	0.001
Pre-operative Gissane Angle (°)	112.4 ± 4.3	109.5 ± 4.5	0.002
Operative Time (minutes)	65.5 ± 10.2	85.3 ± 12.4	0.001

Table 2: Preoperative and Surgical Characteristics

Table 2 demonstrates that the Sinus Tarsi Approach enabled significantly earlier surgery (day 4 vs. 8) and shorter operative time (65.5 vs. 85.3 minutes, $p=0.001$), highlighting its superior surgical efficiency.

Parameter	Sinus Tarsi Approach	Extensile Lateral Approach	p-value
Post-operative Böhler Angle (°)	27.8 ± 3.1	28.5 ± 3.2	0.001
Post-operative Gissane Angle (°)	128.5 ± 3.6	130.2 ± 3.8	0.001

Table 3: Post-operative Radiological Outcomes

Table 3 shows that while both approaches achieved excellent radiological restoration, the Extensile Lateral Approach demonstrated marginally superior anatomical alignment in both Böhler (28.5° vs. 27.8°) and Gissane angles (130.2° vs. 128.5°), with statistically significant differences ($p=0.001$).

Parameter	Sinus Tarsi Approach	Extensile Lateral Approach	p-value
Hospital Stay (days)	4.2 ± 1.1	6.5 ± 1.3	0.001
Time to Full Weight Bearing (weeks)	8.2 ± 1.5	10.5 ± 1.8	0.001
Return to Work (weeks)	12.5 ± 2.1	15.2 ± 2.5	0.001

Table 4: Post-operative Recovery Parameters

Table 4 reveals significant advantages of the Sinus Tarsi Approach across all recovery parameters, with patients achieving shorter hospital stays (4.2 vs. 6.5 days), earlier weight bearing (8.2 vs. 10.5 weeks), and faster return to work (12.5 vs. 15.2 weeks), all with p=0.001.

Complication	Sinus Tarsi Approach (n=30)	Extensile Lateral Approach (n=30)	p-value
Early Complications			
Wound Dehiscence	0 (0%)	5 (8.3%)	0.05
Infection	2 (3.3%)	2 (3.3%)	1.0
Delayed Wound Healing	0 (0%)	2 (3.3%)	0.49
Late Complications			
Tarsal Tunnel Syndrome	0 (0%)	1 (3.3%)	0.22
Implant Impingement	1 (3.3%)	2 (6.7%)	0.44
Implant Failure	0 (0%)	0 (0%)	-
Subtalar Arthritis	0 (0%)	0 (0%)	-

Table 5: Post-operative Complications

Table 5 demonstrates the superior safety profile of the Sinus Tarsi Approach with zero wound dehiscence compared to 8.3% in ELA (p=0.05), while other complications showed comparable rates between both groups.

Parameter	Sinus Tarsi Approach	Extensile Lateral Approach
Number of Post-operative Dressings (mean)	2	4
Pads Soaked (mean)	0.5	2
Blackening at Suture Line	1 (Superficial)	2 (Superficial + Deep)

Table 6: Wound Healing Assessment

Table 6 illustrates superior wound healing in the Sinus Tarsi Approach, requiring half the dressings (2 vs. 4) and minimal drainage (0.5 vs. 2 pads), with only superficial tissue involvement compared to deeper complications in ELA.

Assessment Tool	Time Point	Sinus Tarsi Approach (Mean ± SD)	Extensile Lateral Approach (Mean ± SD)	p-value
AOFAS Score	6 weeks	84 ± 5.2	83 ± 6.0	0.001
	12 weeks	87 ± 5.1	86 ± 5.8	
	24 weeks	91 ± 4.9	90 ± 5.5	
Maryland Foot Score	6 weeks	85 ± 4.5	86 ± 5.3	0.001
	12 weeks	88 ± 4.2	86 ± 5.5	
	24 weeks	90 ± 4.3	89 ± 5.2	
VAS Pain Score	6 weeks	1.5 ± 0.8	2.2 ± 1.1	0.001
	12 weeks	1.0 ± 0.7	1.8 ± 1.0	
	24 weeks	0.5 ± 0.6	1.2 ± 1.1	

Table 7: Functional Outcomes Over Time

Table 7 demonstrates that the Sinus Tarsi Approach achieved consistently superior functional outcomes at all-time points, with significantly better AOFAS scores, Maryland Foot Scores, and notably lower pain levels (VAS 0.5 vs. 1.2 at 24 weeks, p=0.001).

DISCUSSION

Demographic and Clinical Characteristics

The study's demographic analysis revealed that the majority of participants (41.7%) fell within the 31-45 years age group, with males predominating (75%), reflecting typical epidemiological patterns. This is consistent with Attenasio et al.[7] and Syros et al.[12] who reported higher fracture frequencies in working-age males due to occupational high-energy trauma. Sanders Type II fractures accounted for 58.3% of cases, while Type III fractures comprised 41.7% (p=0.001), aligning with findings by Fadle et al.[8] and Luo et al.[13] Falls from height (63.33%) were the predominant injury mechanism, which is consistent with Weber et al.[14] who noted regional variations with higher road traffic accident incidence in different populations.

Surgical Timing and Operative Efficiency

The STA demonstrated significant advantages in surgical timing, with surgery performed on day 4 versus day 8 for ELA (p=0.01), supporting findings by Basile et al.[15] and Weber et al.[14] Operative time was significantly shorter for STA (65.5 ± 10.2 minutes) compared to ELA (85.3 ± 12.4 minutes, p=0.001), consistent with Attenasio et al.[7] reflecting the minimally invasive nature of STA with reduced soft tissue dissection. However, Luo et al.[13] emphasized that surgical efficiency should not compromise treatment quality, as both approaches demonstrate comparable long-term outcomes.

Radiological Outcomes

Pre-operative assessment showed STA had slightly better Böhler angles (8.2° ± 2.3° vs. 7.5° ± 2.1°, p=0.001) and Gissane angles (112.4° ± 4.3° vs. 109.5° ± 4.5°, p=0.002), consistent with Batar et al.[16] Post-operatively, ELA demonstrated marginally superior radiological restoration with Böhler angles of 28.5° ± 3.2° versus 27.8° ± 3.1° for STA (p=0.001), and Gissane angles of 130.2° ± 3.8° versus 128.5° ± 3.6° (p=0.001). These findings align with Attenasio et al.[7] and Syros et al.[12] who noted ELA's broader exposure facilitates precise anatomical reduction. However, Weber et al.[14] and Luo et al.[13] emphasized that these marginal differences do not translate into significant functional outcome disparities, as both approaches effectively restore calcaneal alignment.

Hospital Stay and Recovery Parameters

STA patients experienced significantly shorter hospital stays (4.2 ± 1.1 days vs. 6.5 ± 1.3 days, p=0.001), consistent with Batar et al.[16] reflecting reduced surgical trauma and fewer complications. Time to full weight bearing was significantly shorter with STA (8.2 ± 1.5 weeks vs. 10.5 ± 1.8 weeks, p=0.001), and return to work was faster (12.5 ± 2.1 weeks vs. 15.2 ± 2.5 weeks, p=0.001). These findings support Batar et al.[16] and align with Luo et al.[13] who noted that minimally invasive procedures facilitate earlier mobilization and functional recovery.

Complications

Post-operative complications were minimal in both groups. STA showed superior wound healing with zero wound dehiscence compared to 8.3% in ELA (p=0.05), supporting Syros et al.[12] and Ersin M. et al.[17] Infection rates were equal (3.3%) in both groups. Late complications including Tarsal Tunnel Syndrome (0% vs. 3.3%) and Implant Impingement (3.3% vs. 6.7%) showed no statistical significance (p=0.22 and p=0.44 respectively), consistent with Ersin M. et al.[17] No cases of implant Failure or subtalar Arthritis occurred in either group during the study period.

Wound healing assessment revealed STA required fewer dressings (2 vs. 4) and showed minimal drainage (0.5 vs. 2 pads soaked), with only superficial tissue involvement compared to deeper complications in ELA, mirroring findings by Syros et al.[12] This reflects STA's smaller incisions and reduced soft tissue dissection.

Functional Outcomes and Pain Management

Both approaches showed progressive functional improvement, but STA demonstrated superior outcomes. AOFAS scores improved from 84 ± 5.2 at 6 weeks to 91 ± 4.9 at 24 weeks for STA, compared to from 83 ± 6.0 to 90 ± 5.5 for ELA (p=0.001 at 24 weeks). Maryland Foot Scores similarly favored STA, improving from 85 ± 4.5 to 90 ± 4.3, compared to from 86 ± 5.3 to 89 ± 5.2 for ELA (p=0.001). These findings are consistent with Syros et al.[12] and Batar et al.[16] who reported superior long-term functional recovery with STA.

Pain management was significantly better with STA throughout the follow-up period. VAS scores decreased from 1.5 ± 0.8 at 6 weeks to 0.5 ± 0.6 at 24 weeks for STA, compared to from 2.2 ± 1.1 to 1.2 ± 1.1 for ELA (p=0.001), consistent with Fan B. et al.[18] The superior pain control likely contributes to enhanced patient comfort, quicker mobilization, and improved overall recovery.

Clinical Implications

The Sinus Tarsi Approach demonstrates several advantages over the Extensile Lateral Approach, including shorter operative times, reduced hospital stays, fewer wound-related complications, better pain management, and superior functional recovery, making it more efficient for appropriate cases. However, the Extensile Lateral Approach provides better radiological restoration and remains suitable for complex fractures requiring extensive exposure. Both approaches effectively manage calcaneal fractures, but technique selection should be tailored to fracture complexity, soft tissue condition, and patient-specific factors. These findings, consistent with prior research by Attenasio et al.[7] Weber et al.[14] Batar et al.[16] and Luo et al.[13] suggest that STA may be preferred when efficiency, reduced complications, and faster recovery are prioritized, while ELA remains necessary for complex cases requiring broader surgical exposure. The choice of surgical approach should ultimately be guided by fracture complexity and individual patient needs to optimize both short-term and long-term outcomes.

Limitations

This study has several limitations that should be considered when interpreting its findings. Conducted at a single institution with a relatively small sample size of 60 patients, the generalizability of the results is limited. The focus on short-term outcomes (up to 24 weeks) does not account for long-term complications such as post-traumatic arthritis or subtalar joint degeneration. Additionally, the study did not include a control group or standardized criteria for selecting the surgical approach, potentially introducing variability based on surgeon preference. The reliance on subjective outcome measures like the VAS, AOFAS, and Maryland Foot Scores may also introduce reporting bias.

CONCLUSION

In conclusion, this study demonstrates that both the Sinus Tarsi Approach (STA) and Extensile Lateral Approach (ELA) are effective in managing displaced intra-articular calcaneal fractures, with each offering specific advantages. While ELA provides better access for complex fracture reduction and slightly superior radiological outcomes, STA showed significant benefits in terms of reduced operative time, lower postoperative pain, quicker recovery, fewer wound complications, and better functional outcomes at 24 weeks. These findings suggest that the STA may be the preferred approach for less complex fractures, offering a safer and more efficient option without compromising clinical or radiological results. However, the choice of surgical technique should be individualized based on fracture type and patient-specific factors, with further long-term studies needed to assess outcomes beyond the early recovery period.

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