Research Article

A Comparative Study of Clinicoradiological and Functional Outcome of Calcaneal Fractures Managed by Sinus Tarsi and Extensile Lateral Approach

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Abstract

Background: Displaced intra-articular calcaneal fractures (CFs) pose significant challenges in management. This prospective comparative study aimed to evaluate and compare the clinicoradiological and functional outcomes of the sinus tarsi approach (STA) versus the extensile lateral approach (ELA) in Sanders type II and III fractures.
Methods: Between February 2022 and August 2024, 120 patients aged 18-65 years with closed displaced intra-articular CFs (Sanders type II/III) were prospectively enrolled and randomly allocated to undergo open reduction and internal fixation (ORIF) via STA or ELA (60 patients each). Outcomes included time to surgery, operative duration, restoration of Böhler's and Gissane's angles, complications, and functional scores [American Orthopedic Foot and Ankle Society Score (AOFAS) and Maryland Foot Score (MFS)] at 6, 12, and 24 weeks.
Results: The STA group had significantly shorter time to surgery (mean 4 vs. 6 days, $P = 0.01$) and operative time (65.5 ± 10.2 vs. 85.3 ± 12.4 minutes, $P = 0.001$). Both approaches achieved good radiological restoration, with ELA showing marginally better postoperative Böhler's ($28.5° \pm 3.2°$ vs. $27.8° \pm 3.1°$) and Gissane's ($130.2° \pm 3.8°$ vs. $128.5° \pm 3.6°$, $P = 0.001$ for Gissane's) angles. Complication rates were low and comparable. At 24 weeks, STA demonstrated superior AOFAS (91.0 ± 4.9 vs. 90.0 ± 5.5, $P = 0.001$) and MFS (90.0 ± 4.3 vs. 89.0 ± 5.2, $P = 0.001$).
Conclusion: Both approaches yield satisfactory outcomes, but STA provides advantages in operative efficiency and long-term functional recovery with similar complication rates. STA may be preferred for most Sanders type II and III fractures, reserving ELA for complex cases requiring greater exposure.

Keywords: Calcaneus; Sinus Tarsi; Bone Fractures; Internal Fracture Fixation

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Background

Calcaneal fractures (CFs) are common, and account for 60% of tarsal fractures and 2% of adult fractures, with 60-75 percent being displaced intra-articular fractures. High-energy trauma, often from falls, is the primary cause, impairing function due to the role of calcaneus in weight-bearing and mobility. These fractures are especially disabling for individuals in physically demanding jobs, like construction workers, who face financial hardship if unable to work (1).

The calcaneus is crucial for foot function and stability, and intra-articular fractures can 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 intra-articular involvement requiring surgery (2). Gissane's angle is also affected but is less significant (3).

Surgical treatment, particularly open reduction and internal fixation (ORIF), is required for displaced intra-articular CFs (3).

While ORIF is common, the best surgical approach remains debated. Buckley and Tough found sinus tarsi approach (STA) superior in pain reduction (4), while Bai et al. reported no significant differences (5). Further studies comparing clinical, radiological, and functional outcomes are needed (6).

The aim of surgery is to restore the normal anatomical alignment of the calcaneus and its joints to prevent long-term complications such as arthritis, persistent pain, or disability. Two of the most common surgical techniques for these fractures are the STA and the extensile lateral approach (ELA).

The aim of this study is to analyze and compare the radiological, clinical, and functional outcomes along with early and late post-operative complications of CFs managed by STA and ELA.

Methods

Study/Research Design: This was a prospective comparative study aimed at evaluating the effectiveness of two surgical approaches, ELA and STA, in treating displaced intra-articular CFs. The study was performed in the Orthopedics and Emergency Department at Shri Guru Ram Rai Institute of Medical & Health Sciences (SGRRIM&HS), Dehradun, India, with ethical clearance granted by the Institutional Ethics Committee prior to commencement.

The study included 120 patients and was conducted over a period of 30 months from February 2022 to August 2024.

Sample Selection Inclusion Criteria

1. Patients with diagnosed CFs on X-ray,
2. Patients aged between 18 and 65 years with Sanders type 2 and 3 fractures,
3. Ambulatory patients before injury having no contraindications to anesthesia.

Exclusion Criteria

1. Compound fractures of calcaneum or patients with Sanders type 1 or 4 CFs,
2. Pathological fractures of calcaneum or patients with neurovascular deficit of limb,
3. Comorbid patients unfit for surgery.

Preoperative Protocol: Preoperatively, a comprehensive patient history was obtained, detailing the mechanism of trauma and any pre-existing medical conditions that might affect surgical outcomes, such as diabetes, hypertension (HTN), or previous fractures. Initial assessment included foot X-ray in anteroposterior (AP), lateral, and axial views, which allowed for proper visualization of the fracture pattern and alignment. Additionally, a computed tomography (CT) scan of the calcaneum with three-dimensional (3D) reconstruction was performed for better preoperative planning and to determine the severity and specific characteristics of the fracture, especially in terms of articular involvement.

Before surgery, baseline blood investigations were conducted to assess the fitness for surgery. After being informed about the objectives of study, the risks and benefits of participation, and the details of the surgical procedure, written informed consent was obtained from each patient.

Randomization: After fulfilling the inclusion criteria and providing informed consent, patients were randomly assigned to one of the two treatment groups. The randomization process ensured that Group 1 would undergo treatment using ELA, while Group 2 would receive treatment using STA.

Surgical Management: The patients, once randomized, underwent surgery by one of the two surgical approaches, either STA or ELA, for the management of their displaced intra-articular CFs.

Figure 1. Sinus tarsi approach (STA) to calcaneus

The incision, exposure, reduction, fixation, and closure were done as per the assigned group of the patient and protocol for that particular group (Figures 1, 2).

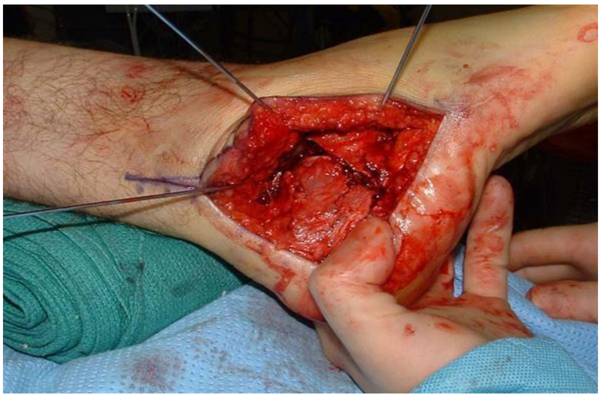

Figure 2. Extensile lateral approach (ELA) to calcaneus

Drain was placed in both of the patient cohorts at the end of surgery (Figure 3).

Figure 3. Postoperative drain placed in situ

Postoperatively, the patients were kept nil per os (NPO) for 4 to 6 hours. Intravenous (IV) fluids, analgesics, and antibiotics were administered as per the postoperative treatment protocol.

Compression bandaging along with below knee Plaster of Paris (PoP) slab was given and the patient was kept non-weight bearing.

Table 1. Post-operative Böhler angle and Gissane angle

Group	Böhler angle (°) (mean ± SD)	Gissane angle (°) (mean ± SD)	P-value
STA	27.8 ± 3.1	128.5 ± 3.6	0.001
ELA	28.5 ± 3.2	130.2 ± 3.8	

STA: Sinus tarsi approach; ELA: Extensile lateral approach; SD: Standard deviation

A check X-ray was performed to ensure the proper alignment of the fracture fragments and the improvement in Böhler's and Gissane's angles after fixation (Tables 1, 2).

Table 2. Functional outcome [American Orthopedic Foot and Ankle Society (AOFAS) score] at 6 weeks, 12 weeks, and 24 weeks

Group	6 weeks AOFAS score (mean ± SD)	12 weeks AOFAS score (mean ± SD)	24 weeks AOFAS score (mean ± SD)	P-value
STA	84.0 ± 5.2	87.0 ± 5.1	91.0 ± 4.9	0.001
ELA	83.0 ± 6.0	86.0 ± 5.8	90.0 ± 5.5	

AOFAS: American Orthopedic Foot and Ankle Society; STA: Sinus tarsi approach; ELA: Extensile lateral approach; SD: Standard deviation

The suture line was inspected on the 2nd and 4th postoperative days to check for signs of infection or delayed healing (Table 3).

Table 3. Functional outcome [Maryland Foot Score (MFS)] at 6 weeks, 12 weeks, and 24 weeks

Group	6 weeks MFS (mean ± SD)	12 weeks MFS (mean ± SD)	24 weeks MFS (mean ± SD)	P-value
STA	85.0 ± 4.5	88.0 ± 4.2	90.0 ± 4.3	0.001
ELA	86.0 ± 5.3	86.0 ± 5.5	89.0 ± 5.2	

MFS: Maryland Foot Score; STA: Sinus tarsi approach; ELA: Extensile lateral approach; SD: Standard deviation

Drain was removed on 2nd post-operative day if the dressing was healthy and sutures were removed on the 10th postoperative day. Patients were discharged after suture removal. Follow-up was conducted at 3 weeks, 6 weeks, 12 weeks, and 24 weeks.

At each follow-up, assessment was performed by the Visual Analogue Scale (VAS) score, the American Orthopedic Foot and Ankle Society (AOFAS) score, and

Maryland Foot Score (MFS). The follow-up visits helped in assessing the clinical, radiological, and functional outcomes and also in identifying any complications. Radiographic imaging was performed at each follow-up by getting AP, axial, and lateral views of the foot to monitor the healing process. Signs of union or any complications like non-union/malunion were noted.

Results

A total of 120 patients with displaced intra-articular CFs were included in the study and were managed either by the STA or the ELA approach.

Demographic Characteristics: The majority of patients belonged to the 31-45 years age group (41.7%), followed by those aged 18-30 years (33.3%), with the remaining patients falling in the 46-65 years group (Table 4).

Table 4. Distribution of patients according to age (n = 120)

Parameters	Category	n (%)	P-value
Age (year)	18-30	40 (33.30)	0.002
	31-45	50 (41.70)	
	46-65	30 (25.00)	

Sanders classification revealed that type II fractures were more common, accounting for 58.3% of cases, while type III fractures constituted 41.7% of the study population (Table 5).

Table 5. Distribution of fracture types (Sanders classification) (n = 120)

Fracture type	n (%)	P-value
Sanders type II	70 (58.3)	0.001
Sanders type III	50 (41.7)	

Timing of Surgery: The mean interval between injury and surgery was significantly shorter in the STA group compared to the ELA group. Patients treated with STA underwent surgery at a mean of 4 days, whereas those treated with ELA had surgery at a mean of 6 days. This difference was statistically significant (P = 0.01).

Radiological Outcomes: Post-operative assessment of the Böhler angle showed significant improvement in both groups. The mean post-operative Böhler angle was slightly higher in the ELA group (28.5° ± 3.2°) compared to the STA group (27.8° ± 3.1°), and this difference was statistically significant (Tables 1, 6).

Table 6. Pre-operative Böhler angle and Gissane angle

Group	Böhler angle (°) (mean ± SD)	Gissane angle (°) (mean ± SD)	P-value
STA	8.2 ± 2.3	153.7 ± 4.3	0.07
ELA	7.5 ± 2.1	154.2 ± 4.5	

STA: Sinus tarsi approach; ELA: Extensile lateral approach; SD: Standard deviation

Similarly, restoration of the Gissane angle was achieved in both groups. The STA group demonstrated a mean post-operative Gissane angle of 128.5° ± 3.6°, while the ELA group showed a mean of 130.2° ± 3.8°. The difference between the two groups was statistically significant (P = 0.001) (Tables 1, 6).

Operative Time: The mean operative time was significantly shorter in the STA group (65.5 ± 10.2 minutes) compared to the ELA group (85.3 ± 12.4 minutes). This difference was statistically significant (P = 0.001).

Post-Operative Complications: Post-operative complications were infrequent in both groups. In the STA group, one case of implant impingement was noted. In the ELA group, two cases (3.3%) of tarsal tunnel syndrome (TTS) and five cases (8.4%) of implant impingement were observed.

There were no cases of implant failure or subtalar arthritis in either group. The differences in complication rates between the two approaches were not statistically significant (Tables 7, 8).

Table 7. Early post-operative complications

Complication	STA (n = 61) [n (%)]	ELA (n = 59) [n (%)]	P-value
Wound dehiscence	0 (0)	5 (8.3)	0.05
Infection	2 (3.2)	4 (6.7)	> 0.99
Delayed wound healing	1 (1.6)	4 (6.7)	0.49

STA: Sinus tarsi approach; ELA: Extensile lateral approach

Functional Outcomes: Functional outcomes were assessed using the AOFAS score at 6, 12, and 24 weeks post-operatively. Both groups showed progressive improvement over time. At 24 weeks, the STA group achieved a higher mean AOFAS score (91.0 ± 4.9) compared to the ELA group (90.0 ± 5.5), with the difference being statistically significant (P = 0.001) (Table 2).

Table 8. Late post-operative complications

Complication	STA (n = 61) [n (%)]	ELA (n = 59) [n (%)]	P-value
TTS	0 (0)	2 (3.3)	0.22
Implant impingement	1 (1.6)	5 (8.4)	0.44
Implant failure	0 (0)	0 (0)	-
Subtalar arthritis	0 (0)	0 (0)	-

STA: Sinus tarsi approach; ELA: Extensile lateral approach; TTS: Tarsal tunnel syndrome

MFS also demonstrated improvement in both groups across follow-up intervals. At 24 weeks, the STA group showed a higher mean score (90.0 ± 4.3) compared to the ELA group (89.0 ± 5.2). This difference was statistically significant (P = 0.001), indicating superior functional recovery in the STA group at the final follow-up (Table 3).

Discussion

The findings from the study reveal interesting demographic and clinical patterns related to CFs. The age distribution within the sample of 120 participants shows that the majority fall into the 31-45 years age group, accounting for 41.7%, followed by the 18-30 years group (33.3%), and the remaining in 46-65 years group (Table 4). This is consistent with previous studies, such as those by Attenasio et al., which reported a higher frequency of fractures in the working-age group (7).

In terms of fracture types, the study shows that Sanders type II fractures account for 58.3% of cases, while type III fractures make up 41.7% (Table 5). This is consistent with findings from studies like that of Fadle et al. where type II fractures were more common, likely due to the nature of the trauma mechanisms involved (8).

The significantly shorter interval to surgery observed with the STA in our series –mean 4 days versus 6 days for ELA (P = 0.01)–echoes findings from recent prospective and meta-analytic studies. Attenasio et al. reported that patients managed via the STA underwent definitive fixation at a mean of 5.2 ± 1.1 days compared to 7.8 ± 1.3 days for the ELA group (P < 0.05) (7). Similarly, Fadle et al. found a mean time to surgery of 5.1 ± 1.3 days in their randomized cohort treated with the STA versus 7.2 ± 1.5 days for the ELA cohort (P = 0.02) (8).

Beyond these congruent findings, our series achieved an even shorter mean interval of 4 days for the STA group, suggesting a particularly efficient perioperative workflow and early soft-tissue readiness. This earlier timing may confer clinical advantages by limiting the window of soft-tissue swelling and facilitating more straightforward reduction. In contrast, Syros et al. noted a mean delay of 6.5 ± 1.8 days in high-risk patients treated with STA, largely attributable to requisite swelling resolution in their comorbid cohort (9). This divergence underscores the importance of patient selection and soft-tissue management protocols in determining surgical timing.

The post-operative Böhler angle results indicate a statistically significant difference between STA and ELA (Figures 4, 5) with the latter showing a slightly higher mean of 28.5° ± 3.2°, compared to STA's 27.8° ± 3.1°. Both approaches, however, show substantial improvement in the alignment of the calcaneus post-operatively, reflecting successful restoration of anatomical positioning (Tables 1, 6). This finding aligns with previous studies, such as that of Attenasio et al., which demonstrated similar improvements in the Böhler angle with both approaches (7). The marginally better post-operative Böhler angle with ELA may indicate that it offers a slight advantage in achieving more precise anatomical restoration.

Figure 4. Improvement in pre- and post-operative Böhler and Gissane angles in patients managed by sinus tarsi approach (STA)

However, Weber et al. suggested that while ELA provided broader exposure and a greater ability to manipulate the fracture site, it did not significantly outperform STA in terms of functional outcomes, thus emphasizing that both approaches could be effective in achieving similar clinical results despite differences in alignment (10).

The post-operative Gissane angle measurements reveal that STA (Figures 4, 5) achieved a mean Gissane angle of 128.5° ± 3.6°, while ELA had a slightly higher mean of 130.2° ± 3.8°. The P-value of 0.001 indicates that this difference is statistically significant, suggesting that ELA may offer slightly better post-operative alignment in terms of the Gissane angle (Tables 1, 6). This aligns with studies such as Syros et al., which found that ELA, due to its wider exposure, might provide a better capacity to restore the Gissane angle to optimal alignment, particularly in more complex fractures (9). However, despite the higher post-operative Gissane angle, both approaches achieved clinically significant improvements, and the difference may not translate into major clinical outcomes such as functional recovery or long-term stability, as noted by Weber et al. (10). This subtle variation in the Gissane angle between the two surgical approaches highlights the importance of surgical technique and precision in restoring the calcaneus alignment and function.

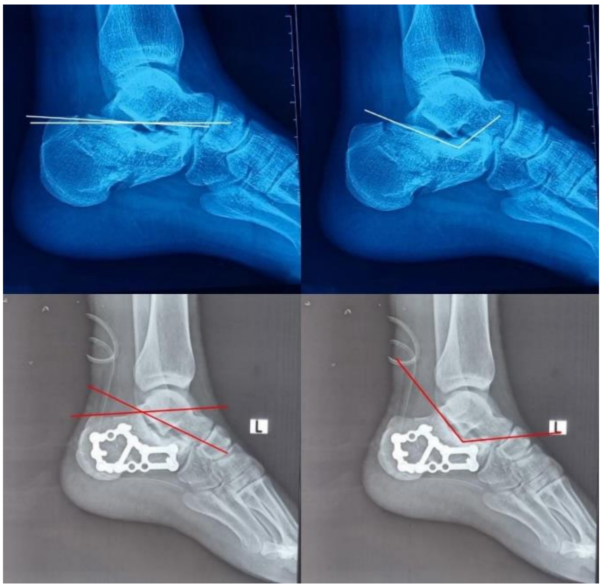

Figure 5. Improvement in pre- and post-operative Böhler and Gissane angles in patients managed by extensile lateral approach (ELA)

The comparison of the operative times for STA and ELA shows a statistically significant difference. The mean operative time for STA was 65.5 ± 10.2 minutes, compared to ELA, which had a mean of 85.3 ± 12.4 minutes. The P-value of 0.001 confirms this difference is statistically significant, highlighting the efficiency of STA. This finding aligns with studies like that of Attenasio et al., where STA demonstrated a reduced operative time due to its less invasive nature, resulting in less soft tissue dissection and quicker fracture fixation (7). The shorter surgical time is beneficial as it reduces the risks associated with prolonged anesthesia, including blood loss and soft tissue damage, which are critical factors in the recovery process. However, ELA, although taking longer, provides more extensive exposure, which can be essential for complex fractures requiring precise manipulation and fixation. Studies, such as that of Syros et al., have pointed out that while ELA requires a longer operative time, it allows for better visualization and access to more complicated fracture sites, ensuring accurate anatomical restoration (9).

The post-operative complications between STA and ELA showed a relatively low incidence of major issues in both groups (Tables 7, 8; Figure 6).

Figure 6. Early post-complication in form of superficial blackening at the suture line in the sinus tarsi approach (STA)

STA reported only one case of implant impingement (Figure 7), while ELA had two cases of TTS (3.3%) and five cases of implant impingement (8.4%).

Figure 7. Late postoperative complication – implant impingement

The P-values for both TTS (0.22) and implant impingement (0.44) indicate that these differences are not statistically significant, suggesting that both surgical approaches have similar rates of these complications. This aligns with findings from previous studies such as that of Ersin et al., where no significant difference in the complication rates was observed between the two approaches (11). Despite the higher incidence of implant impingement in ELA group, both approaches had similar results in terms of other complications like implant failure and subtalar arthritis, which were absent in both groups. These findings highlight the overall safety and comparable complication rates between the two surgical techniques, with ELA showing a slightly higher incidence of implant impingement, though not statistically significant.

When comparing functional outcomes, both surgical approaches showed consistent improvement over time as measured by AOFAS score (Table 2). STA started with an average score of 84.0 ± 5.2 at 6 weeks, which improved to 87.0 ± 5.1 at 12 weeks and 91.0 ± 4.9 at 24 weeks. Similarly, ELA showed a progressive improvement, with an AOFAS score of 83.0 ± 6.0 at 6 weeks, increasing to 86.0 ± 5.8 at 12 weeks, and reaching 90.0 ± 5.5 at 24 weeks. The P-value of 0.001 indicates a statistically significant difference between the two groups at 24 weeks, with STA demonstrating superior functional recovery at the longer follow-up period. This finding is consistent with previous studies, such as the study by Syros et al., where both approaches showed improvements, but STA was found to provide a more favorable long-term recovery (9). This suggests that STA may offer better functional outcomes in the long-term post-operative period, making it a potentially more effective option for patients in terms of functional recovery.

The MFS also demonstrated significant differences in functional outcomes at different follow-up intervals (Table 3). STA showed consistent improvement in scores over time, with a mean score of 85.0 ± 4.5 at 6 weeks, increasing to 88.0 ± 4.2 at 12 weeks and 90.0 ± 4.3 at 24 weeks. In contrast, ELA had a mean score of 86.0 ± 5.3 at 6 weeks, which remained stable at 86.0 ± 5.5 at 12 weeks, and increased to 89.0 ± 5.2 at 24 weeks. The P-value of 0.001 indicates that STA had significantly better MFS, particularly at the 24-week follow-up, highlighting superior functional recovery. This finding is supported by studies such as Batar et al., which suggested that STA resulted in better long-term functional outcomes, particularly in terms of foot and ankle function (12). The differences in the MFS underscore the clinical significance of choosing the most appropriate surgical approach for optimal functional recovery.

Conclusion

The present study aimed to compare the clinical, radiological, and functional outcomes of CFs managed by STA and ELA. By assessing various parameters such as operative time, pain management, wound healing, and post-operative complications, the study provides valuable insights into the efficiency and effectiveness of both approaches. The findings underscore that both approaches result in favorable outcomes, but STA offers several advantages, particularly in terms of reduced pain levels, quicker recovery, and fewer complications. These results align with the initial hypothesis of the study, suggesting that while both techniques are effective, STA is particularly beneficial for certain patients, especially those who prioritize faster recovery and lower complication risks.

Through detailed analysis, the study also revealed that despite STA offering a faster recovery and superior post-operative pain management, ELA remained a suitable option for more complex fractures, where greater exposure and manipulation were required. The significant differences in functional outcomes at 24 weeks further emphasize the clinical relevance of choosing the most appropriate surgical technique based on fracture severity, patient comorbidities, and expected recovery time. Ultimately, this study contributes valuable evidence to guide clinicians in their decision-making process, promoting tailored approaches for individual patients to optimize both short-term and long-term outcomes.

Conflict of Interest

The authors declare no conflict of interest in this study.

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