



The Impact of Postoperative CT Parameters on Functional Outcomes in Joint Depression-Type Calcaneal Fractures Fixed with Sinus Tarsi Locking Plate: A Retrospective Analysis

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Purpose: To examine the correlation between postoperative computed tomography (CT) parameters and functional outcomes in patients treated with sinus tarsi locking plates for joint depression-type calcaneal fractures.

Methods: This study retrospectively analyzed patients who underwent sinus tarsi locking plate fixation for joint depression-type calcaneal fractures at a tertiary hospital between 2019 and 2021. The patients were followed up for an average of 16 months. Collected data included demographic information and postoperative CT parameters, including Böhler's angle and posterior facet congruity. Functional outcomes were evaluated using the Foot and Ankle Ability Measure (FAAM) score.

Results: Postoperative CT scans were used to evaluate the quality of fracture reduction in 55 patients with calcaneal fractures treated with sinus tarsi locking plates. The mean FAAM score was 79.4 (range: 42–100). Among the patients, 45 (82%) achieved good functional outcomes, while 10 (18%) had poor outcomes, with no significant demographic differences between groups. Anatomical, near-anatomical, and poor reduction of the posterior facet were observed in 49%, 31%, and 20% of cases, respectively. Böhler's angle was $>20^\circ$ and $<20^\circ$ in 76% and 24% of cases, respectively. Anatomical reduction of the posterior facet showed a significant correlation ($P=0.025$) with favorable outcomes, whereas Böhler's angle showed no significant association ($P=0.685$).

Conclusions: Sinus tarsi locking plate fixation is effective in achieving satisfactory posterior facet reduction and functional outcomes for joint depression-type calcaneal fractures. Postoperative CT scans can help predict functional recovery by evaluating posterior facet reduction. Achieving posterior facet anatomical reduction is essential for favorable functional recovery.

Keywords: Calcaneus fracture, Postoperative CT, Sinus tarsi locking plate

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Calcaneal fractures are relatively common injuries, with their complex anatomy making effective treatment challenging^(1,2). Joint depression-type calcaneal fractures, in particular, pose significant management difficulties when using percutaneous techniques⁽³⁾, often necessitating open reduction. Although the lateral extensile approach typically achieves better fracture reduction, the sinus tarsi

approach has shown promise in terms of functional outcomes and lower complication rates⁽⁴⁻⁶⁾.

Sinus tarsi locking plate fixation has been demonstrated to offer reliable stability, low complication rates, and favorable functional outcomes in treating calcaneal fractures⁽⁷⁻¹⁰⁾. Additionally, postoperative computed tomography (CT) has emerged as a valuable tool for assessing the quality of reduction, particularly in examining posterior facet congruity, which can be challenging to evaluate with plain radiographs⁽¹¹⁻¹³⁾.

This study aims to examine the correlation between postoperative CT parameters and functional outcomes in patients with joint depression-type calcaneal fractures treated with sinus tarsi locking plates. By analyzing the postoperative CT images and patient-reported functional outcomes, we aim to identify significant correlations between these parameters.

MATERIALS AND METHODS

This retrospective study analyzed data from 55 patients who underwent sinus tarsi locking plate fixation for joint depression-type calcaneal fractures (Fig. 1) at a tertiary hospital between 2019 and 2021. The study was approved by the institutional review board, and informed consent was obtained from all patients.

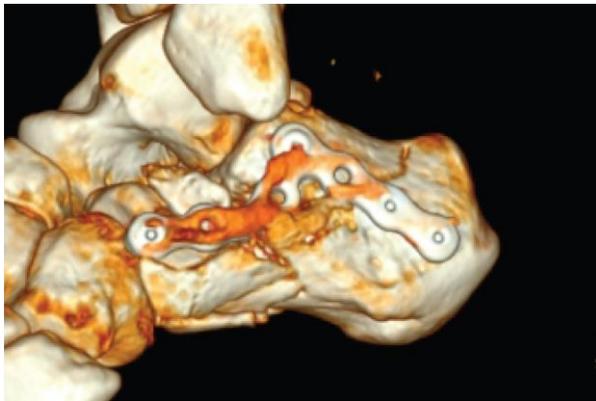


Fig. 1 Postoperative computed tomography scan of Sinus tarsi locking plate fixation.

Patients were followed up for a mean of 16 months, during which demographic data and postoperative CT parameters, including Böhler's angle

and posterior facet congruity (Fig.2), were analyzed to assess the quality of reduction. Böhler's angle and posterior facet congruity were evaluated using postoperative CT reference points based on previously published studies⁽¹²⁾. The quality of reduction was classified as anatomical reduction (stepping <1 mm), near-anatomical reduction (stepping 1–3mm), and poor reduction (stepping >3mm)⁽¹⁴⁾. The Foot and Ankle Ability Measure (FAAM) score was used to evaluate clinical outcomes^(15,16), with functional outcomes stratified as poor (score <90) or good (score ≥90)⁽¹⁷⁾.

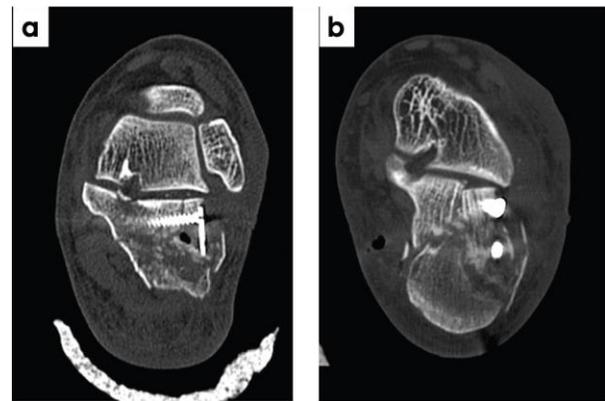


Fig. 2 Postoperative computed tomography scan of posterior facet reduction. **a.** anatomical reduction of posterior facet, **b.** poor reduction of the posterior facet.

Appropriate statistical methods, including multivariable logistic regression analysis, were used to analyze all data and examine the correlation between postoperative CT parameters and functional outcomes in patients with joint depression-type calcaneal fractures treated with sinus tarsi locking plates.

RESULTS

Postoperative CT scans were utilized to assess the quality of reduction achieved in 55 patients with joint depression-type calcaneal fractures treated with sinus tarsi locking plate fixation. Clinical outcomes were evaluated using the FAAM score, which revealed a mean value of 79.4 (range: 42–100) across all patients. Among these patients, 45 (82%) achieved good functional

outcomes, while 10 (18%) exhibited poor functional outcomes. No statistically significant differences in patient demographics were observed between the good and poor outcome groups (Table 1).

The results indicated that anatomical reduction with posterior facet congruity was achieved in 27 (49%) cases, near-anatomical reduction in 17 (31%) cases, and poor reduction in 11

(20%) cases. Multivariate analysis revealed a significant correlation between anatomical reduction and favorable functional outcomes ($P=0.025$). Additionally, Böhler's angle was restored to greater than 20° in 42 (76%) patients but remained less than 20° in 13 (24%) patients. However, no significant correlation was identified between Böhler's angle and the FAAM score ($P=0.685$) (Table 2).

Table 1 Patient demographics.

	Good	Poor	P-value
Age (years)	46.6 (± 11.27)	49.3 (± 12.55)	0.505
Sex			
Male	32 (71.1%)	9 (90%)	0.423
Female	13 (28.9%)	1 (10%)	
Mechanism of injury			
Fall from height	40 (88.9%)	9 (90.0%)	1.000
Traffic accident	5 (11.1%)	1 (10.0%)	
Initial Böhler's angle ($^\circ$)	-0.62 (± 10.28)	-1.5 (± 7.63)	0.800
Smoking	17 (37.8%)	3 (30%)	0.731
Body mass index (kg/m^2)	23.60 (± 3.46)	21.88 (± 3.49)	0.161
Time to surgery (h)	157.56 (± 132.90)	209.5 (± 130.32)	0.267

Table 2 Correlation between postoperative computed tomography parameters and functional outcome (Multivariate analysis).

Postoperative CT parameters	Odd ratio	95% CI	P-value
Böhler's angle ($^\circ$)			
0–20	1		
>20	1.41	0.09–14.16	0.687
Posterior articular facet reduction			
Poor	1		
Near	6.55	0.90–47.56	0.063
Anatomical	7.52	1.23–43.95	0.025*

DISCUSSION

The optimal surgical approach for displaced intra-articular fractures is influenced by multiple factors, including the surgeon's experience with different methods, patients' comorbidities, and characteristics of the fracture and soft tissues. Over the past few decades, novel surgical approaches and techniques have been developed to minimize soft tissue complications and achieve a more precise restoration of the posterior facet⁽¹⁾. The sinus tarsi approach involves making an

incision from the tip of the lateral malleolus towards the base of the fourth metatarsal bone, providing excellent visualization of the subtalar joint. A comprehensive meta-analysis has supported this approach, highlighting its multiple advantages over the extensile lateral approach. The study demonstrated statistically significant reductions in operative time, complication rates, re-operations, and postoperative articular displacement^(18,19).

Fixation options for the sinus tarsi approach include screw fixation, plate fixation, and anatomic plate fixation. Although no significant differences have been observed in wound complications and functional outcomes, both biomechanical and clinical studies have consistently shown that plate fixation offers superior performance in terms of stability, preservation of Böhler's angle, and the rate of implant removal compared to screw fixation^(7,9,10,20). In this study, all the patients were treated using an anatomical locking plate for the sinus tarsi approach, with no reported wound complications or hardware removal.

The posterior facet of the calcaneus is essential for weight-bearing and the biomechanics of subtalar motion. Cadaveric studies have demonstrated that articular incongruity leads to a major shift in load. Incongruent reduction of this joint can also impair foot and ankle function and may lead to osteoarthritis over time. Posterior facet congruity has been linked to better functional outcomes. The postoperative CT evaluation in this study revealed that 80% of cases achieved anatomical or near-anatomical alignment, which was associated with favorable functional outcomes.

The normal range for Böhler's angle is 20–40°. A reduction in this angle indicates a collapse of the posterior facet of the calcaneus, resulting in increased pressure on the subtalar joint. Several studies have reported a correlation between Böhler's angle and functional outcomes. However, in this study, no significant association was found between the angle and functional outcomes. Notably, the majority of patients who underwent sinus tarsi locking plate fixation achieved a restoration of Böhler's angle to greater than 20°.

CONCLUSIONS

In conclusion, sinus tarsi locking plate fixation for joint depression-type calcaneal fractures offers effective posterior facet reduction and favorable functional outcomes. Postoperative CT assessments can help predict functional outcomes by evaluating the posterior facet alignment. Anatomical reduction of the posterior facet is essential for achieving optimal functional recovery.

REFERENCES

1. Allegra PR, Rivera S, Desai SS, et al. Intra-articular calcaneus fractures: current concepts review. *Foot Ankle Orthop* 2020;5: 2473011420927334.
2. Razik A, Harris M, Trompeter A. Calcaneal fractures: Where are we now?. *Strategies Trauma Limb Reconstr* 2018;13:1-11.
3. de Vroome SW, van der Linden FM. Cohort study on the percutaneous treatment of displaced intra-articular fractures of the calcaneus. *Foot Ankle Int* 2014;35:156-62.
4. Schepers T. The sinus tarsi approach in displaced intra-articular calcaneal fractures: a systematic review. *Int Orthop* 2011;35:697-703.
5. Busel G, Mir HR, Merimee S, et al. Quality of reduction of displaced intra-articular calcaneal fractures using a sinus tarsi versus extensile lateral approach. *J Orthop Trauma* 2021;35: 285-8.
6. Li L hua, Guo Y zhi, Wang H, et al. Less wound complications of a sinus tarsi approach compared to an extended lateral approach for the treatment of displaced intraarticular calcaneal fracture: A randomized clinical trial in 64 patients. *Medicine (Baltimore)* 2016;95: e4628.
7. Wang Z, Wang XH, Li SL, et al. Minimally invasive (sinus tarsi) approach for calcaneal fractures. *J Orthop Surg Res* 2016;11:164.
8. Zhang G, Ding S, Ruan Z. Minimally invasive treatment of calcaneal fracture. *J Int Med Res* 2019;47:3946-54.
9. Sato K, Yorimitsu M, Uehara T, et al. Comparison of screw versus locking plate fixation via sinus tarsi approach for displaced intra-articular calcaneal fractures. *Foot Ankle Surg* 2023;29:97-102.
10. Kir MC, Ayanoglu S, Cabuk H, et al. Mini-plate fixation via sinus tarsi approach is superior to cannulated screw in intra-articular calcaneal fractures: A prospective randomized

- study. *J Orthop Surg (Hong Kong)* 2018;26:2309499018792742.
11. de Muinck Keizer RJO, Beerekamp MSH, Ubbink DT, et al. Systematic CT evaluation of reduction and hardware positioning of surgically treated calcaneal fractures: a reliability analysis. *Arch Orthop Trauma Surg* 2017;137:1261-7.
 12. Qiang M, Chen Y, Zhang K, et al. Measurement of three-dimensional morphological characteristics of the calcaneus using CT image post-processing. *J Foot Ankle Res* 2014;7:19.
 13. Roll C, Schirmbeck J, Müller F, et al. Value of 3D reconstructions of CT scans for calcaneal fracture assessment. *Foot Ankle Int* 2016;37:1211-7.
 14. Sanders R, Vaupel ZM, Erdogan M, et al. Operative treatment of displaced intraarticular calcaneal fractures: long-term (10-20 Years) results in 108 fractures using a prognostic CT classification. *J Orthop Trauma* 2014;28:551-63.
 15. Arunakul M, Arunakul P, Suesiritumrong C, et al. Validity and reliability of Thai version of the Foot and Ankle Ability Measure (FAAM) subjective form. *J Med Assoc Thai* 2015;98:561-7.
 16. Carcia CR, Martin RL, Drouin JM. Validity of the Foot and Ankle Ability Measure in athletes with chronic ankle instability. *J Athl Train* 2008;43:179-83.
 17. Li Y, Tsang RCC, Liu D, et al. Applicability of cutoff scores of Chinese Cumberland Ankle Instability Tool and Foot and Ankle Ability Measure as inclusion criteria for study of chronic ankle instability in Chinese individuals. *Phys Ther Sport* 2021;48:116-20.
 18. Meng Q, Wang Q, Wu X, et al. Clinical application of the sinus tarsi approach in the treatment of intra-articular calcaneal fracture. *Medicine (Baltimore)* 2018;97:e0175.
 19. Mehta CR, An VVG, Phan K, et al. Extensile lateral versus sinus tarsi approach for displaced, intra-articular calcaneal fractures: a meta-analysis. *J Orthop Surg Res* 2018;13:243.
 20. Eelsing R, Aronius LB, Halm JA, et al. Implant choice and outcomes of the sinus tarsi approach for displaced intra-articular calcaneal fractures. *Foot Ankle Int* 2023;44:738-44
 21. Mulcahy DM, McCormack DM, Stephens MM. Intra-articular calcaneal fractures: effect of open reduction and internal fixation on the contact characteristics of the subtalar joint. *Foot Ankle Int* 1998;19:842-8.
 22. Sangeorzan BJ, Ananthakrishnan D, Tencer AF. Contact characteristics of the subtalar joint after a simulated calcaneus fracture. *J Orthop Trauma* 1995;9:251-8.
 23. van Hove S, de Vos J, Verbruggen JPAM, et al. Gait analysis and functional outcome after calcaneal fracture. *J Bone Joint Surg Am* 2015; 97:1879-88.
 24. Sayyed-Hosseini SH, Shirazinia M, Arabi H, et al. Does the postoperative quality of reduction, regardless of the surgical method used in treating a calcaneal fracture, influence patients' functional outcomes?. *BMC Musculoskelet Disord* 2023;24:562.