

Retrograde Intramedullary Nail–Assisted Tibiototalcalcaneal Arthrodesis: Evaluation of Fusion Rates, Functional Recovery, and ComplicationsVachan S.¹, Vaibhav B. K.², Sahukar B. M.³¹Department of Orthopedics, Hosmat Hospital McGrath Road, Bangalore, Karnataka, India²MS Orthopaedic, Senior Resident, Department Of Paediatric Orthopedics, King George Medical University, Lucknow, UP, India³Department of Orthopedics, Sanjay Gandhi Institute of Trauma and Orthopedics, Bangalore, Karnataka, India

Received: 01-05-2026 / Revised: 15-06-2026 / Accepted: 21-07-2026

Corresponding author: Dr. Sahukar B M

Conflict of interest: Nil

Abstract**Background:** Tibiototalcalcaneal (TTC) arthrodesis is a well-established salvage procedure for end-stage ankle and hindfoot arthritis. Retrograde intramedullary nailing offers stable fixation with favorable fusion and functional outcomes.**Materials and Methods:** This prospective study included 31 patients who underwent TTC arthrodesis between 2020 and 2022. Functional outcome was assessed using the American Orthopaedic Foot and Ankle Society (AOFAS) Ankle-Hindfoot Score, while radiological union was evaluated on serial radiographs.**Results:** The mean age of the patients was 38.58 ± 14.61 years, and 80.6% were males. Radiological union was achieved in 29 patients (93.5%), with a mean fusion time of 14.48 ± 3.36 weeks. The mean AOFAS score improved significantly from 24.87 ± 4.75 preoperatively to 79.00 ± 12.91 at 12 months ($p < 0.001$). Overall, 71.0% of patients achieved good-to-excellent functional outcomes. Postoperative complications were minimal, with superficial infection in 9.7% and nonunion in 3.2% of patients.**Conclusion:** Retrograde intramedullary nailing for TTC arthrodesis provides a high fusion rate, significant functional improvement, and a low complication rate, making it an effective limb-salvage procedure for patients with end-stage ankle and hindfoot arthritis.**Keywords:** Tibiototalcalcaneal arthrodesis; retrograde intramedullary nail; ankle fusion; AOFAS score; radiological union.**DOI:** 10.25258/ijcpr.18.8.5This is an Open Access article that uses a funding model which does not charge readers or their institutions for access and distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0>) and the Budapest Open Access Initiative (<http://www.budapestopenaccessinitiative.org/read>), which permit unrestricted use, distribution, and reproduction in any medium, provided original work is properly credited.**Introduction**

End-stage ankle and hindfoot arthritis is a debilitating condition characterized by chronic pain, deformity, instability, and functional limitation, leading to significant impairment in mobility and quality of life[1]. Common causes include post-traumatic arthritis, inflammatory arthropathy, Charcot neuroarthropathy, avascular necrosis of the talus, and failed previous ankle surgery. When conservative treatment fails, surgical intervention is required to restore a stable, painless, and plantigrade foot.[2] Ankle arthrodesis remains the gold standard for the management of advanced ankle arthritis and accounts for more than 85% of surgical procedures performed for end-stage ankle disease.[3,4] The procedure aims to relieve pain, correct deformity, and restore functional alignment. Although ankle motion is eliminated, compensatory movement at adjacent joints helps preserve gait and overall function after fusion.[5] Various fixation techniques

have been described for ankle arthrodesis, including crossed screws, plates, external fixation, and intramedullary nailing.[4,6,7] Among these, retrograde intramedullary nailing has become increasingly popular, particularly for patients with combined ankle and subtalar arthritis, severe deformity, Charcot arthropathy, talar osteonecrosis, osteoporosis, and failed previous fusion. The technique provides a stable load-sharing construct with excellent axial and rotational stability while allowing simultaneous fusion of the tibiotalar and subtalar joints.[8,9] Tibiototalcalcaneal (TTC) arthrodesis is an established limb-salvage procedure for complex ankle and hindfoot disorders. Modern retrograde intramedullary nails have improved biomechanical stability, enhanced fusion rates, and facilitated earlier rehabilitation. However, complications such as delayed union, nonunion, infection, and implant failure continue to occur, and

the reported functional and radiological outcomes remain variable across studies. [8,10] Although retrograde intramedullary nailing has demonstrated promising results, prospective data evaluating both functional and radiological outcomes, particularly in the Indian population, remain limited. Therefore, the present prospective study was undertaken to evaluate the functional and radiological outcomes of tibiototalcaneal arthrodesis using a retrograde intramedullary nail and to assess its effectiveness as a limb-salvage procedure in patients with complex ankle and hindfoot pathology.

Materials and Methods

This prospective observational study was conducted in the Department of Orthopaedics and Traumatology at tertiary care centre.

Study Population: A total of 31 consecutive patients with end-stage ankle and/or hindfoot arthritis who fulfilled the eligibility criteria were prospectively included in the study. The study cohort comprised 25 males and 6 females. All patients underwent tibiototalcaneal arthrodesis using a retrograde intramedullary nail.

Inclusion Criteria

- Post-traumatic ankle arthritis
- Avascular necrosis (AVN) of the talus
- Post-infective sequelae involving the ankle joint
- Rheumatoid arthritis affecting the ankle joint
- Charcot neuroarthropathy

Exclusion Criteria

- Peripheral vascular disease
- Uncontrolled diabetes mellitus
- Skeletally immature patients (children)

Preoperative Evaluation: All patients underwent detailed history taking and comprehensive clinical examination. Routine preoperative laboratory investigations were performed, including complete blood count, renal function tests, blood glucose, and other investigations as indicated. Standard weight-bearing anteroposterior (AP) and lateral radiographs of the ankle were obtained to evaluate the severity of arthritic changes, deformity, and plan surgical management.

Surgical Technique: All procedures were performed under appropriate anaesthesia using a standardized posterolateral approach. Articular cartilage from the tibiotalar and subtalar joints was thoroughly debrided, and the joint surfaces were prepared until healthy bleeding cancellous bone was exposed. Deformity correction was achieved, and the ankle was positioned in neutral alignment. Tibiototalcaneal arthrodesis was performed using a retrograde intramedullary nail according to standard surgical principles. Intraoperative fluoroscopy was used to confirm satisfactory

alignment and implant positioning before wound closure.

Postoperative Evaluation and Follow-up: Patients were followed up at regular intervals according to the institutional protocol. Clinical assessment and radiographic evaluation were performed during each follow-up visit. Standard AP and lateral radiographs of the ankle were obtained to assess implant position, progression of fusion, and radiological union.

Outcome Measures: The primary outcome was functional outcome, assessed using the American Orthopaedic Foot and Ankle Society (AOFAS) Ankle-Hindfoot Score. Radiological outcome was evaluated based on serial radiographs assessing evidence of fusion, implant stability, and maintenance of alignment. Functional and radiological outcomes at the final follow-up were analyzed to determine the effectiveness of retrograde intramedullary nailing for tibiototalcaneal arthrodesis.

Statistical Analysis: Data were entered into Microsoft Excel and analyzed using IBM SPSS Statistics software (version 25.0). Continuous variables were expressed as mean $\pm$ standard deviation (SD) or median (interquartile range), depending on data distribution, while categorical variables were presented as frequencies and percentages. Preoperative and postoperative AOFAS scores were compared using the paired t-test or Wilcoxon signed-rank test, as appropriate. A p value <0.05 was considered statistically significant.

Results

A total of 31 patients with end-stage ankle and hindfoot arthritis underwent tibiototalcaneal arthrodesis using a retrograde intramedullary nail and were included in the final analysis. The mean age of the study population was 38.58 ± 14.61 years. The largest proportion of patients belonged to the 31–45 years age group (45.2%), followed by 15–30 years (32.3%), 46–60 years (12.9%), and >60 years (9.7%). There was a marked male predominance, with 25 (80.6%) males and 6 (19.4%) females. The left side was affected in 17 patients (54.8%), while the right side was involved in 14 patients (45.2%) (Table 1). The most common indication for surgery was right-sided tibiotalar arthritis, observed in 8 patients (25.8%), followed by chronic left ankle arthritis and left-sided tibiotalar arthritis, each accounting for 6 patients (19.4%). Chronic right ankle arthritis and left ankle arthritis were present in 4 patients (12.9%) each, whereas right ankle arthritis and Charcot ankle were identified in 2 (6.5%) and 1 (3.2%) patients, respectively.

The mean tourniquet time was 74.35 ± 7.46 minutes, with a range of 65–95 minutes (Table 2).

Radiological fusion was successfully achieved in 29 of 31 patients, resulting in an overall union rate of 93.5%, whereas nonunion occurred in 2 patients (6.5%). The mean time to radiological fusion was 14.48 ± 3.36 weeks. Fusion was achieved by 12 weeks in 12 patients (38.7%), by 14 weeks in 7 patients (22.6%), by 16 weeks in 8 patients (25.8%), and between 24 and 26 weeks in 2 patients (6.4%) (Table 3).

Based on the final AOFAS Ankle-Hindfoot Score grading, excellent functional outcomes were achieved in 8 patients (25.8%), good outcomes in 14 patients (45.2%), fair outcomes in 5 patients (16.1%), and poor or failed outcomes in 4 patients (12.9%). Overall, 22 patients (71.0%) achieved good-to-excellent functional outcomes (Table 4, Figure 1).

Full weight bearing was achieved by 2.5 months in 8 patients (25.8%), by 3 months in 16 patients (51.6%), and at or beyond 4 months in 7 patients (22.6%), indicating that the majority of patients attained unrestricted weight bearing within 3 months after surgery (Table 4). The mean preoperative AOFAS score was 24.87 ± 4.75 . A significant improvement in functional outcome was observed throughout the follow-up period, with the mean score increasing to 49.03 ± 7.49 at 3 months ($p =$

0.004), 63.13 ± 11.06 at 6 months ($p < 0.001$), and 79.00 ± 12.91 at 12 months ($p < 0.001$).

The improvement was progressive and statistically significant at each postoperative assessment compared with the preoperative baseline (Table 5, Figure 2). Postoperative complications were infrequent. Twenty-seven patients (87.1%) experienced no complications following surgery. Superficial surgical site infection developed in 3 patients (9.7%) and was successfully managed with appropriate treatment.

Nonunion occurred in 1 patient (3.2%), while the overall radiological assessment identified two cases of nonunion (Table 6, Figure 3). Among female patients, 4 (66.7%) achieved good or excellent functional outcomes, whereas 2 (33.3%) had fair, poor, or failed outcomes. Among male patients, good or excellent outcomes were observed in 18 (72.0%), while 7 (28.0%) had fair, poor, or failed outcomes.

The difference in functional outcome between males and females was not statistically significant (χ^2 test, $p = 0.742$). Similarly, postoperative complications occurred in 1 female (16.7%) and 3 males (12.0%), with no significant association between gender and complication rate (χ^2 test, $p = 0.731$) (Table 6, Figure 3).

Table 1: Baseline Demographic and Clinical Characteristics of the Study Population (n = 31)

Variable	n (%) / Mean $\pm$ SD
Age (years), Mean $\pm$ SD	38.58 ± 14.61
Age group 15–30 years	10 (32.3)
Age group 31–45 years	14 (45.2)
Age group 46–60 years	4 (12.9)
Age group >60 years	3 (9.7)
Male	25 (80.6)
Female	6 (19.4)
Left side	17 (54.8)
Right side	14 (45.2)

Table 2: Primary Diagnosis and Operative Characteristics (n = 31)

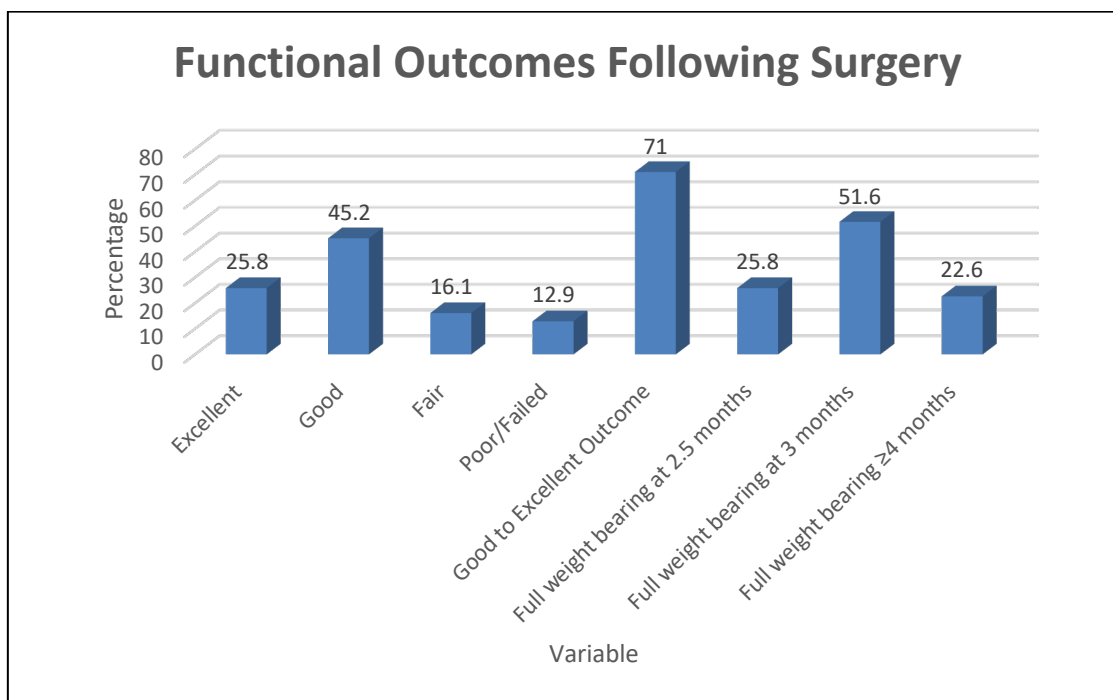
Variable	n (%)
Tibiotalar arthritis (Right)	8 (25.8)
Tibiotalar arthritis (Left)	6 (19.4)
Chronic left ankle arthritis	6 (19.4)
Chronic right ankle arthritis	4 (12.9)
Left ankle arthritis	4 (12.9)
Right ankle arthritis	2 (6.5)
Charcot ankle	1 (3.2)
Tourniquet time (minutes), Mean $\pm$ SD	74.35 ± 7.46
Range	65–95

Table 3: Radiological Outcomes Following TTC Arthrodesis

Variable	Value
Mean time to fusion (weeks), Mean $\pm$ SD	14.48 $\pm$ 3.36
Fusion achieved	29 (93.5)
Nonunion	2 (6.5)
Fusion at 12 weeks	12 (38.7)
Fusion at 14 weeks	7 (22.6)
Fusion at 16 weeks	8 (25.8)
Fusion at 24–26 weeks	2 (6.4)

Table 4: Functional Outcomes Following Surgery

Variable	n (%)
Excellent	8 (25.8)
Good	14 (45.2)
Fair	5 (16.1)
Poor/Failed	4 (12.9)
Good to Excellent Outcome	22 (71.0)
Full weight bearing at 2.5 months	8 (25.8)
Full weight bearing at 3 months	16 (51.6)
Full weight bearing $\geq$ 4 months	7 (22.6)

**Figure 1: Functional Outcomes Following Surgery****Table 5: Comparison of AOFAS Scores During Follow-up**

Follow-up	Mean $\pm$ SD	P value*
Preoperative	24.87 $\pm$ 4.75	—
3 months	49.03 $\pm$ 7.49	0.004
6 months	63.13 $\pm$ 11.06	<0.001
12 months	79.00 $\pm$ 12.91	<0.001
Paired t-test		

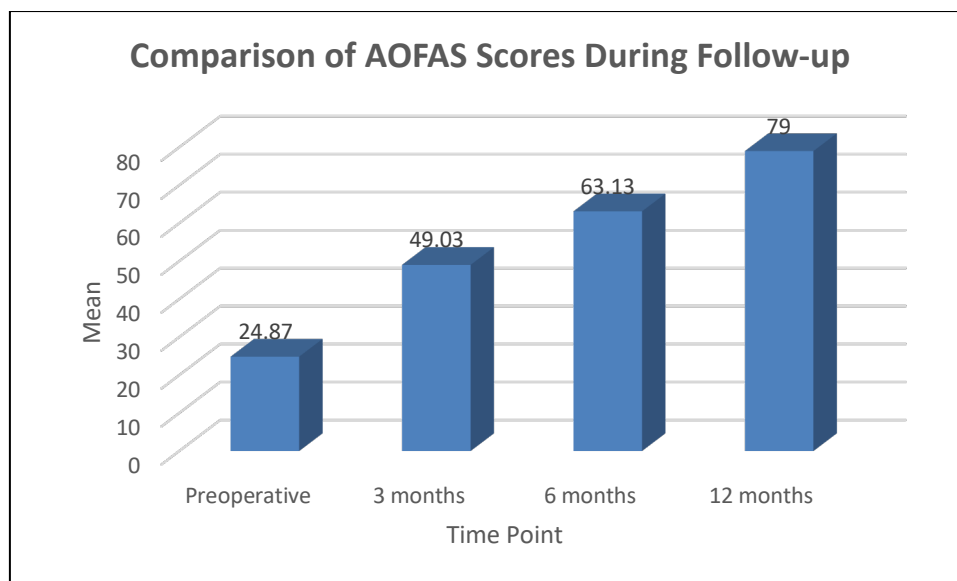


Figure 2: Comparison of AOFAS Scores during Follow-up

Table 6: Postoperative Complications and Gender-wise Outcomes

Variable	Female (n=6)	Male (n=25)	P value
Good/Excellent outcome	4 (66.7%)	18 (72.0%)	0.742
Fair/Poor/Failed	2 (33.3%)	7 (28.0%)	
Any complication	1 (16.7%)	3 (12.0%)	0.731
No complication	5 (83.3%)	22 (88.0%)	

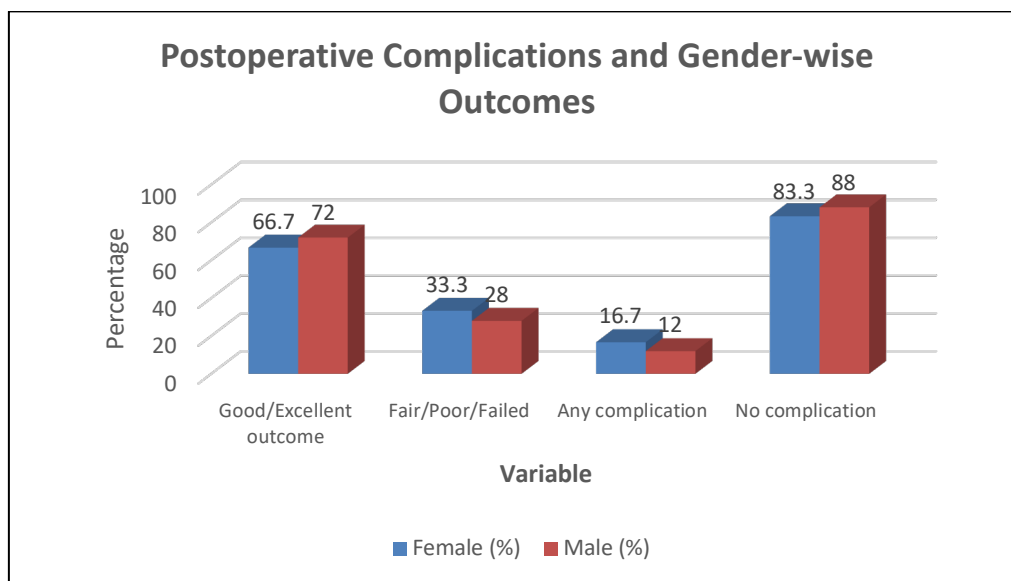


Figure 3: Postoperative Complications and Gender-wise Outcomes

Discussion

The present study included 31 patients with a mean age of 38.58 ± 14.61 years, which was lower than that reported by Chou et al. [11], who observed a mean age of 53 years in patients undergoing tibiotalocalcaneal (TTC) arthrodesis. The younger age in our series may be attributed to the predominance of post-traumatic arthritis among younger, active individuals. A marked male predominance was observed in our study, with 25 (80.6%) males and 6 (19.4%) females (male:female

ratio 4.2:1). Similarly, Chou et al. [11] reported that most patients undergoing TTC arthrodesis were males, reflecting the higher incidence of traumatic ankle injuries in this population. Post-traumatic arthritis was the most common indication for surgery in the present study.

This finding is consistent with Chou et al. [11], Mendicino et al. [12], Smith et al. [13], and Budnar and Hepple [14], who identified post-traumatic arthritis as the leading indication for TTC arthrodesis using retrograde intramedullary nailing.

These authors concluded that retrograde intramedullary nailing provides reliable fixation for complex ankle and hindfoot pathology. Radiological union was achieved in 29 of 31 patients (93.5%), with a mean fusion time of 14.48 ± 3.36 weeks. Chou et al. [11] reported fusion in 48 of 56 ankles (85.7%) with a mean union time of 19 weeks.

Likewise, the systematic review by Jehan et al. [15], which included 641 joints, reported an overall union rate of 86.7% with an average union time of 4.5 months. Compared with these studies, our study demonstrated a slightly higher union rate and shorter time to fusion, suggesting that retrograde intramedullary nailing provides stable fixation and reliable arthrodesis.

Functional outcomes improved significantly in our study. The mean AOFAS score increased from 24.87 ± 4.75 preoperatively to 79.00 ± 12.91 at 12 months ($p < 0.001$), and 71.0% of patients achieved good-to-excellent outcomes. Chou et al. [11] reported a mean postoperative AOFAS score of 66, while the systematic review by Lexer et al. (2015) [16] reported improvement in postoperative AOFAS scores to approximately 72 following retrograde intramedullary nailing. These findings indicate that our functional outcomes are comparable to, and slightly better than, those reported in previous literature.

In the present study, 51.6% of patients achieved full weight bearing by 3 months, while 25.8% achieved full weight bearing by 2.5 months. Mendicino et al. [12] and Budnar and Hepple [14] emphasized that the biomechanical stability of retrograde intramedullary nails allows earlier progression to weight bearing while maintaining satisfactory fusion rates. Our findings support these observations. The complication rate in our study was low. Twenty-seven patients (87.1%) had no complications, whereas 3 patients (9.7%) developed superficial infection and 1 patient (3.2%) developed nonunion.

In comparison, Chou et al. [11] reported 8 nonunions (14.3%) and 6 wound infections among 56 ankles. Similarly, Jehan et al. [15] reported an overall complication rate of 55.7%, although the union rate remained satisfactory at 86.7%. The lower complication rate observed in our study may be attributed to careful patient selection, meticulous surgical technique, and standardized postoperative care.

Conclusion

Tibiototalcaneal arthrodesis using a retrograde intramedullary nail is a safe and effective treatment for end-stage ankle and hindfoot arthritis, providing a high fusion rate and significant improvement in functional outcomes.

The procedure achieved reliable pain relief, restoration of a stable plantigrade foot, and a low complication rate. These findings support retrograde intramedullary nailing as a dependable limb-salvage option in appropriately selected patients.

Limitations

The study was limited by its relatively small sample size and single-center design, which may affect the generalizability of the findings. Additionally, the absence of a comparison group and the short-term follow-up precluded assessment of long-term functional outcomes and adjacent joint degeneration.

References

1. Coester LM, Saltzman CL, Leupold J, Pontarelli W. Long-term results following ankle arthrodesis for post-traumatic arthritis. *J Bone Joint Surg Am.* 2001;83(2):219-28.
2. Tornetta P III, Ricci WM, Ostrum RF, McQueen MM, McKee MD, Court-Brown CM, et al. *Rockwood and Green's fractures in adults.* 8th ed. Philadelphia: Wolters Kluwer Health; 2015. p. 2542-46.
3. American Orthopaedic Foot and Ankle Society. Orthopaedic foot and ankle outreach and education. Rosemont (IL): American Orthopaedic Foot and Ankle Society.
4. DeHeer PA, Catoire SM, Taulman J, Borer B. Ankle arthrodesis: a literature review.
5. Wu WL, Su FC, Cheng YM, Huang PJ, Chou YL, Chou CK. Gait analysis after ankle arthrodesis. *Gait Posture.* 2000;11(1):54-61.
6. Clifford C, Berg S, McCann K, Hutchinson B. A biomechanical comparison of internal fixation techniques for ankle arthrodesis. *J Foot Ankle Surg.* 2014;53(1):1-4.
7. Gharehdaghi M, Rahimi H, Mousavian A. Anterior ankle arthrodesis with molded plate technique and outcomes. *Arch Bone Jt Surg.*
8. Bluman EM, Chiodo CP. Tibiotalar arthrodesis. *Foot Ankle Clin.*
9. Coughlin MJ, Nery C, Baumfeld D, Jastifer J. Tibiotarsal compression arthrodesis using a lateral locking plate.
10. Parker L, Singh D. The principles of foot and ankle arthrodesis.
11. Chou LB, Mann RA, Yaszay B. Tibiototalcaneal arthrodesis. *Foot Ankle Int.* 2000;21(10):804-808.
12. Mendicino RW, Catanzariti AR, Saltrick KR. Tibiototalcaneal arthrodesis with retrograde intramedullary nail fixation. *Clin Podiatr Med Surg.* 2004;21(4):611-619.
13. Smith WB, Hyer CF, Berlet GC. Tibiototalcaneal arthrodesis using retrograde intramedullary nail fixation. *J Foot Ankle Surg.* 2010;49(2):123-128.

14. Budnar VM, Hepple S. Tibiototalcalcaneal arthrodesis with intramedullary nail. Foot Ankle Clin. 2011;16(1):61-74.
15. Jehan S, Shakeel M, Bing AJ, Hill SO. The success of tibiototalcalcaneal arthrodesis with intramedullary nailing. Acta Orthop Belg. 2011;77(5):644-651.
16. Lexer E. The use of boiled cadaveric bone as intramedullary support in bone reconstruction. Arch Klin Chir. 1908;86:939-954.