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Results of Ankle & Hindfoot Fusion using Retrograde Tibiotalocalcaneal Nail: A Prospective Study of 24 Cases

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Abstract: ***Objective: To evaluate clinically and functionally the post-operative results of patients treated with tibiotalocalcaneal arthrodesis for the treatment of posttraumatic, inflammatory arthropathy and neuropathy of ankle and subtalar joint. Methods: Prospective study of 24 cases undergoing ankle & subtalar arthrodesis with intramedullary retrograde TTC nail. All patients were evaluated for time to fusion, AOFAS and VAS scores, satisfaction, and complications of surgery. The mean follow-up was 12 months (range 9–24 months). Results: The union rate was 87%, and the fusion occurred at mean 17 weeks (10–24 weeks). The post-operative AOFAS score improved in 82.45 and VAS score was 2.9 and 90% of patients were satisfied with the procedure performed. Complications occurred in 15 patients, including infection (8.3%), implant failure (8.3%) and nonunion (16.6%). Conclusion: Ankle & subtalar arthrodesis with retrograde intramedullary TTC nail proved to be a good option for saving the ankle joint, with improvement of clinical and functional scores.***

Keywords: Retrograde tibiotalocalcaneal nail,ankle and hindfoot fusion

1. Introduction

Hindfoot arthritis is a disabling condition which leads to severe pain, deformity, alteration of gait and as a result, associated pain in the knee, hip, or back often contributes to general health problems. Conservative management will not improve pain and function to an acceptable level in all patients, but patients are advised to try a few modalities before surgery. Bracing to limit motion of the arthritic joint is the mainstay of conservative treatment. Preservation of motion of ankle joint by total ankle replacement is expensive and requires surgical expertise, also instrumentation is not available readily in a resource-poor setup. In order to achieve a stable pain-free foot function & a plantigrade foot for ambulation, hindfoot fusion continues to be a mainstay of surgical management in ankle and subtalar arthritis. This includes arthrodesis of ankle and subtalar joint in single surgical sitting. Historically, Pantalar arthrodesis was performed which had its own disadvantages. Operative alternatives of hindfoot arthrodesis include open or arthroscopic debridement, realignment osteotomies, distraction arthroplasty, allograft replacement, and total ankle arthroplasty.

Arthrodesis, can obtain a stable, pain-free ankle and improvement in the quality of life in patients. Some biomechanical aspects of the ankle make it particularly suitable for arthrodesis. Hindfoot arthrodesis can be considered for patients who have limited motion of the ankle and subtalar joint, chronic pain in whom conservative measures have failed, and have one of the following diagnoses:

- Non reconstructable and neglected Posttraumatic arthritis,Osteoarthritis
- Arthritis from chronic instability of the ankle
- Rheumatoid or autoimmune inflammatory arthritis,Gout
- Postinfectious arthritis
- Charcot neuroarthropathy
- Osteonecrosis of the talus
- Failure of total ankle arthroplasty
- Instability of the ankle from neuromuscular disorders.

Compared with other types of fixation, intramedullary nails have been found to have higher bending stiffness, rotational stability, and dynamic compression while providing a durable, load-sharing construct.[4,15,16] . The use of a retrograde intramedullary straight nail was first described by Gerhard Küntscher[19] in 1967 and offered a stable construct with a load-sharing device and broad, intrinsically stable cortical contact. The use of straight nails is associated with the potential risk of injury to the lateral plantar artery and nerve, cortical hypertrophy or stress fractures at the tibia, and plantar breakout because of poor cortical anchorage in the medial part of the calcaneus.[16,22,28,36] . Newer TTC nails have improvements of a valgus distal bend to accommodate for normal tibiocalcaneal valgus & a dynamic screw to achieve compression at arthrodesis site. The aim of this study was to examine the clinical experience with a TTC nail as well as to document the functional and quality of life outcomes for patients treated with TTC nail for severe ankle and foot abnormalities.

2. Aims & Objectives

- To identify patients requiring arthrodesis of both the ankle & subtalar joint.
- Evaluate the outcome of results of Tibiotalocalcaneal nail (TTC) nail in different indications of ankle and subtalar arthrodesis using AOFAS-AHS, VAS score.
- To assess clinical satisfaction of patients including pain, function & gait.
- To study union clinically and radiologically.
- To study advantages and disadvantages of TTC nail.
- To assess complications rate and their management.

3. Material and Methods

Study Design
Study duration: 3.5 years

Between January 2016 and June 2019, a prospective study of 24 TTC nails in 21 consecutive eligible patients were performed in patients having arthritis of both ankle and subtalar joints in a tertiary care institute. Patients' demographic data and the indication for surgery was recorded in a predesigned proforma (Annexure 1).Essential investigations of all the patients were done. Patients were followed up at intervals of 1, 3 and 6 months and at follow up patients were evaluated clinically and radiologically. Clinical and radiological union as well as joint function were used to assess the outcome of the surgery. Post operative complications, if any were recorded at each follow up.

Implants:
We have used the Tibiotalocalcaneal (TTC) nail - Ankle arthrodesis nail

Table 1

Nail	Details
LENGTH	**25 cm**
OUTER DIAMETER	**8/9/10 mm**
INNER DIAMETER	**4 mm**
PROXIMAL LOCKING 3.9 mm screw -8 mm nail 4.9 mm screw -9/10 mm nail	**TIBIAL SCREW*** **1 STATIC** **1 DYNAMIC**
DISTAL LOCKING- 4.9 mm screws	**1 TALAR SCREW - DYNAMIC** **2 CALCANEAL SCREWS- BOTH STATIC** **(mediolateral & posteromedial to anterolateral)**
VALGUS BEND	**3 ^{0}**

Figure 9 (a): TTC NAIL, END CAP, 4.9 mm SCREW

Figure 9 (b): JIG, Connection Bolt

Figure 9 (c): Left to Right

Connection Bolt, Outer Sleeve, Inner Sleeve, Trocar, Drill Bit 4.5 mm, Reamer, Screw Driver, Guide Pins

4. Surgical Technique

Spinal/General anaesthesia is required.The patient is positioned in the lateral decubitus position on a radiolucent operating table with the affected extremity facing the ceiling. Tourniquet hemostasis at the thigh was used in all operations. A posterolateral approach was used to facilitate access to the ankle and subtalar joints. Distal fibular resection is performed at the level of the syndesmosis with an oscillating saw. The articular surfaces of the ankle and subtalar joints were thoroughly resected to ensure contact between viable bleeding bones. Autologous bone graft obtained from the resected distal fibula was performed to fill bony defects. A 3-4 cm longitudinal incision was made in the heel pad lateral to the midline and a hemostat used to bluntly dissect down to the calcaneus. The ideal entry point for the calcaneus is at the junction of the lateral one-third and medial two-thirds, which corresponds to the mid-point of the medullary canal of the tibia.A ball-tipped guide wire is inserted transcalcaneal through the talus into the tibial medullary canal using image intensification. Progressive reaming is performed with successively larger reamers in 0.5 mm increments. It is recommended to ream to 1-2 mm larger than the anticipated nail's outside diameter. When reaming is complete, remove the ball-tipped guide wire or exchange it

for a plain tip nail driving guide. In this procedure, the main concerns are to avoid anterior and posterior subluxation, which can be achieved by placing the talus correctly in the ankle joint. External rotation was adjusted to match that of the contralateral foot (ranging from 5° to 10°). The nail was inserted under fluoroscopic guidance. The goal of alignment is a plantigrade foot without pronation or supination of the forefoot. First, one transverse locking screw was placed in the talus, after which two proximal locking screws were inserted into the tibia under fluoroscopic guidance and positioned at the superior end of the nail from medial to lateral with the target device. A shaft screw was then inserted into the oblong hole at the distal end of the nail for compression. When the compression screw is inserted axially into the distal end of the nail, it pushes against the shaft screw to generate compression between the resected bone surfaces. The distal screw of the calcaneus was placed from lateral to medial with the target device after completion of the compression procedure. Finally, the posterior-to-anterior calcaneal screw was inserted from posteromedial to anterolateral. Wound closure was performed in a standard manner.

Immobilization was achieved with a below-knee orthotic for a minimum of 6 weeks (non-weight-bearing for 6 weeks, partial weight-bearing for another 6 weeks. Findings on X-ray films and medical co-morbidities were recorded at each follow-up visit: at 6 weeks, 3 months, 6 months, and 1 year after surgery.

Ankle and hindfoot radiographs, including weight-bearing lateral and antero-posterior ankle views as well as calcaneal axis view, were performed preoperatively and postoperatively. Clinical union was defined as pain-free passive and active movement at the subtalar and ankle joints. Radiographic union was defined as bone trabeculae crossing the joint with joint line obliteration and consolidation. Delayed union was defined as absence of radiographic evidence of bony consolidation at the 3-month follow-up visit.

Patients were evaluated on the basis of gait analysis, AOFAS-AHS , VAS score. The final results were classified into four categories: Excellent, Good, Fair and Poor according to following final scores. According to the AOFAS criteria, the patient can be classified with a poor (0–69), fair (70–80), good (80–90) or excellent (90–100) function. The VAS criterion classifies pain as absent (0), mild (1–3), moderate (4–6), high intensity (7–9) and intolerable (10). Patients classified as AOFAS' poor function (less than 69) and severe VAS (between eight and 10) were selected preoperatively for the arthrodesis procedure. After surgery and after six months of evaluation, the same patients answered again to the questionnaires (AOFAS and VAS), patient satisfaction and post-operative complications.

5. Results

The average age of the cohort was 62.2 years (range, 46−79 years), with a male: female ratio of 10:12. The mean follow-up time was 22.3 months (range, 6.8−38 months).

The indications for TTCA using a curved nail were arthritis affecting the ankle and subtalar joint, severe talar avascular necrosis, failed ankle arthroplasty and arthrodesis associated with secondary subtalar joint arthritis, and hindfoot deformities that were refractory to other treatments (Table 2). This is a prospective study of 21 patients operated on 24 feet for Hindfoot fusion using TTC nail. Of these 3 patients were operated on both feet. Following results were found on observation. In present study, mean age was **42** year.(22-68 years).

Clinical case

Figure 4(a): Pre-operative clinical and radiological photographs of 44 year old male

Figure 4 (b): Post operative clinical and radiological photographs

Table 2: Indications

Indications	Number (out of 24)	Percentage
Severe Primary Arthritis	2	8.3%
Post-Traumatic Arthrosis	8	33.4%
Charcot's Arthropathy	4	16.7%
Deformity Secondary to Neuromuscular Diseases	4	16.7%
Failed Ankle Arthrodesis Using Other Methods	6	25%

The mean operation time was 128 minutes (range, 72 to 214 minutes).

Union

In the present study, out of 21 patients (24 feet) 22 had union both clinically & radiologically (91.7 %); 2 patients (8.3%) final outcome was nonunion. Clinical union precedes radiological union. Thus, 16 (66.7%) patients had clinical union at 16 weeks follow up whereas 14 (58%) patients had radiological union at the same follow up. Owing to cancellous bone, usually union is not a problem but nonunion is still a complication .On an average, clinical and radiological union was seen at 16 weeks.

Table 3: Post-Operative Complications

	Number	Percentage
Infection	2	8.3%
Non-union	4	16.6%
Delayed union	1	4.2%
Malunion	1	4.2%
Implant failure	2	8.3%
Stress fracture	0	-
Distal Screw impingement	4	16.6%
Distal Screw loosening	1	4.2%
Amputation	0	-

In present study,6 patients had Major postoperative complications affecting outcome (25%). 2 patients had infection (8.3%) & 4 patients had nonunion (16.7 %). 6 patients had distal screw related problems. out of them 2 had broken screws ,4 had screw impingement & 1 had loosening.

In This Study, Pre-Op Average Score Was **53.4** Which Means All 24 Patients Were Have Poor AOFAS-AHS Score (0-69)

Table 4: Comparison between AOFAS criteria in pre & postoperative period

AOFAS	Preoperative	Postoperative	Percentage	Result %
Poor	24	2	8.3%	36.7%
Fair	0	6	25.3%	
Good	0	14	58%	64.3%
Excellent	0	2	8.33%	

In present study; Average Post Op Score Is 82.45, which means Majority Of patients have a good outcome, 16 patients (64.3%) patients had either excellent or good results; 2 (8.3%) patients operated by TTC nail show poor result as per AOFAS- AHS score.

6. Discussion

The aim of this study was to evaluate the effects of the TTCA using a curved, retrograde intramedullary nail. In this single surgeon series, 91.7% bony fusion rate with a 8.3% overall complications rate was achieved in 24 cases who had undergone TTC arthrodesis using a curved, retrograde intramedullary nail.

The ideal position for the hindfoot after TTCA is a neutral position for dorsal/plantar flexion, 5° valgus and 5° to 10° external rotation. In the current study, satisfactory postoperative hindfoot alignment with physiological valgus was achieved despite significant preoperative varus and valgus deformity. The overall complication rate of using a nail in TTCA was 25%. Complications include complications of wound healing, superficial and deep infection, pseudoarthrosis, neurovascular damage, malalignment, stress fracture and persistent pain. Table 2

Published reports concerning TTCA (more than 20 patients) using retrograde nails including curved and straight nails

Table 5: Comparison of Results among Studies in the Literature

Study	Patient Number	Age	Follow Up in Months	Union Time In Weeks	Union Rate	AOFAS	VAS	Satisfaction
Chou et. al[17]	37	53(19-79)	26 (12-168)	19	86%	66	-	87%
Hammett et al.[13]	47	57.1 (25-81)	34(8-37)	17	87%	63 (13-84)	-	82%
Boer et. al.[2]	50	57.6 (22-82)	51(12-84)	20.4	96%	72 (32-86)	-	92%
Niinimaki et. al.[15]	34	57(25-77)	24(6-43)	16	76%	-	1.9	90%
Smith et al.[16]	10	60.6 (48-78)	14.7(12-18)	-	80%	69 (14-51)	2(0-7)	-
Quill et. al. [43]	40	47.6 (14-82)	30(18-60)	14	90%	-	-	90%
Goebel et al. [25]	29	53(26-71)	25(12-38)	17	90%	71 (49-83)	2.7	91%
This study	24	42(22-68)	12(6-30)	16	87%	82.45	2.87	90%

Infection is a common problem with intramedullary nails in TTCA[10], [20], [21]. In the current study, one patient had superficial delayed wound healing without infection. However, published reports indicate that intramedullary nails have risks of infection, especially in patients with a history of previous infection[2], [14], [21].

As to the fusion rate in patients treated with TTCA using a nail, Budnar *et al*. documented a fusion rate of 89% (40/45) using a short, anatomically curved intramedullary nail[1]. Mückley *et al*.[10] and Boer *et al*.[2] reported a union rate of 96% in a broad spectrum of patients similar to the pattern of our cohort. Mader *et al*. documented achieving a 100% union rate after TTCA using a retrograde nail in 10 patients with failed ankle arthrodesis, which is consistent with our results[22]. The fusion rate depends on many factors, including the underlying condition of the patient, debridement of the joint facets and the biomechanical characters of implants[7], [8], [10], [14], [19]. Firstly, the union rate is dependent on the following patient factors: whether the patient is a habitual smoker, the presence of avascular bone at the arthrodesis site and the patient's compliance with the postoperative non-weight-bearing protocol[10]. Secondly, other factors such as whether the surgeon performs debridement correctly, the degree of compression provided by the fixation and bone graft between the arthrodesis joint, also play important roles[7]. The main techniques for preparing the articular surfaces in TTCA are described in published reports; they include

thorough resection of the articular cartilage of both joints and preservation of the anatomical contours of the joints to minimize postoperative leg length discrepancy[10], [23]. However, Boer *et al*. recommended TTCA with a nail without formal debridement of the subtalar joint and a choice between open or percutaneous debridement of the ankle; they achieved a 100% fusion rate of the ankle joint and 96% fusion rate of the subtalar joint using this procedure[2]. In the current study, we performed thorough debridement and achieved a 100% fusion rate of both ankle and subtalar joints. Thirdly, intramedullary nails provide greater stability than crossed screws and results of a biomechanical study suggested a more favorable fusion rate with the former[24]. Additionally, Chou *et al*. reported that use of a posterior-anterior (PA) locking plane may make a decisive difference in contributing to greater angle stability[5]. Thus, PA locking and the reaming process may contribute significantly to achieving high union rates[25].

7. Limitations

A short-term follow-up,and a relatively smaller sample size is one of the chief limitations of this study. One disadvantage of TTCA is the rigidity of the hindfoot, which may predispose to secondary degenerative arthritis in the adjacent naviculocuneiform and tarsometatarsal joints. These complications had not yet occurred by the latest follow-up in our study. Secondly, the present study lacked a comparison group, such as patients managed with different implants. We only compared our results with those of relevant published studies. Thirdly, we did not lacks evaluate functional scores preoperatively in the current study and therefore could not objectively compare preoperative and postoperative function; however, the patients were subjectively satisfied with their outcomes. We could not exclude dysfunction of the peroneal tendon. Furthermore, we did not identify any long-term forefoot deformities after we had resected the fibula in the procedure of TTCA. However, we emphasize that comparison of radiological findings indicated that improved hindfoot alignment had been achieved. Finally, we had too few cases to establish a direct relationship between functional outcomes and radiographic findings.

The results of the present study suggest that TTCA using a short, retrograde, curved intramedullary nail is an acceptable technique for achieving solid fusion with minimal complications. However, long-term follow-up is necessary to provide definitive information about topics such as adjacent degenerative arthritis.

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