Research Square

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Outcomes of a newly developed solid posterior offset tibiotalocalcaneal intramedullary nail in the treatment of traumatic, unstable fragility ankle fractures

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Abstract

PURPOSE: The primary aim of this study was to evaluate outcomes following tibiotalocalcaneal arthrodesis using a solid posterior offset hindfoot arthrodesis nail in the management of unstable fragility ankle fractures.

METHODS: Design: Retrospective case series.

Setting: A single academic tertiary referral centre in the west of Ireland.

Patient Selection Criteria: Patients over the age of 50 with an unstable fragility ankle fracture treated with a solid posterior offset hindfoot arthrodesis nail in our institution were included.

Outcome Measures and Comparisons: Clinical and radiological outcomes were examined preoperatively, and at three and six months postoperatively. Pre- and postoperative functional status was assessed with the Olerud and Molander (O&M) score. Patients were followed up at six months and two years postoperatively.

RESULTS: A total of six patients met inclusion criteria and were included. All patients achieved clinical and radiological union by the six-month follow-up. Three out of six of patients returned to baseline mobility, and four of six patients had no pain at the six-month follow-up. On average, O&M scores were 64 preoperatively, 48 at six-month follow-up, and 56 at two-year follow-up. One patient experienced superficial wound infection and was treated with antibiotics. No other significant complications occurred.

CONCLUSIONS: This small case series has demonstrated that tibiotalocalcaneal arthrodesis with a solid posterior offset hindfoot arthrodesis nail is a safe and effective procedure that can be used in the management of unstable fragility ankle fractures. It demonstrated a low complication rates and good functional outcomes in our cohort at two-year follow-up.

LEVEL OF EVIDENCE: Therapeutic Level IV

1. Introduction

Although open reduction and internal fixation (ORIF) is the operative cornerstone in treating ankle fractures, the growing incidence and severity of fragility ankle fractures presents a challenge. It is the third most common fracture in the elderly preceded by hip and distal radius fractures, with 184 cases per 100,000 people per year and is expected to increase substantially.[1, 2] Fragility ankle fractures are not only difficult to manage due to the presence of weakened, osteoporotic bone and poor soft tissue quality but also due to significant comorbidities that are commonly present in this cohort of patients such as diabetes, chronic obstructive pulmonary disease and peripheral vascular disease (PVD). These diseases compromise the regenerative capacity of bone and wound healing. Moreover, postoperative weight-bearing protocols in these patients are likely to be more conservative, further increasing the potential for adverse events, including those pertaining to immobility.[3, 4] As such, complication rates can reach as high as 40%.[5–7] It has been shown that conservative weightbearing protocols can have detrimental outcomes in elderly patients, and one of the theoretical advantages in using a load bearing device such as an ankle and hindfoot arthrodesis nail is to facilitate early weightbearing postoperatively.[8, 9]

Despite the ubiquitous use of ORIF and external fixation to treat fragility ankle fractures, utilisation of hindfoot and ankle arthrodesis is steadily increasing by way of anticipating postoperative complications such as metalware failure, post-traumatic arthritis, and persistent pain. Fusion can be achieved through plate and screws, external

fixation, and intramedullary (IM) nails.[8–10] IM nails are favourable constructs in hindfoot and ankle arthrodesis, especially in weakened bone, due to their superior biomechanical properties including their excellent rotational stability, load-sharing, and bending stiffness.[11–13] Newer generation IM nails have been developed over the past three decades and, when compared to their older generation counterparts, are associated with higher union rates.[14, 15] Similarly, IM nails can be placed through small incisions, making it ideal in candidates with diabetes and PVD who are prone to wound infections.[16] The primary aim of this case series was to present the clinical and radiological outcomes of TTC arthrodesis using a posterior offset hindfoot arthrodesis nail for the treatment of unstable fragility fractures of the ankle at six-month and two-year follow-up. We also aimed to assess the incidence of postoperative complications and investigate functional outcomes.

2. Methods

2.1 Data Source and Study Population

Data was collected retrospectively from our institution from 2020 to 2025. Six patients over the age of 50, who had undergone TTC arthrodesis with a solid posterior offset hindfoot arthrodesis nail for an unstable ankle fragility fracture were included. All patients had evidence of poor bone stock noted either radiologically with evidence of osteopenia on plain films or via a history of a pathological fracture resulting from a low-energy injury.[17, 18] The fracture pattern was deemed unstable if there was significant talar shift determined by: a medial clear space of over 2mm on anteroposterior (AP) x-ray, a tibiofibular clear space of greater than 6mm, any bi-malleolar or tri-malleolar fractures or any fracture dislocation of the ankle.[19, 20] Patients were excluded from the study if: an open fracture was present, the fracture resulted from high energy trauma, patients had received TTC nailing for indications other than ankle fractures or had revision procedures or a prior TTC nail. Ethical approval was granted by the Clinical Research and Ethics Committee of the clinical site, and all patients gave voluntary, written, informed consent.

2.2 Variables and outcomes

The primary independent variable in this study was postoperative complications. These included non-union, malunion, wound infection, amputation, metalware related complications and mortality. Secondary variables explored were radiological outcomes, specifically time to union of the subtalar and tibiotalar joints, and functional outcomes. Radiographic union was defined as clear evidence of bridging trabeculae in at least three of four cortices in multiple planes across the arthrodesis site on post- operative radiographs. This definition of union has been utilised in a number of similar studies. [21–26] Patients included in the study had a minimum follow-up of 6 months. All patients were scheduled for postoperative follow-up at 6 weeks, 3 months, 6 months, and 2 years. Assessment of plain films for bony union was independently performed by two of the authors, each of whom are orthopaedic surgeons with a minimum of three years postgraduate training (RM and JP). If consensus was lacking, a third party (a fellowship trained orthopaedic foot and ankle surgeon) reviewed the films for final consensus.

Functional outcomes postoperatively were measured by the presence of persistent pain and return to baseline mobility. The Olerud and Molander score was utilised as a metric to determine patients' functional status and symptoms both pre- and postoperatively.[27–29] Demographic characteristics such as age and gender were collected. Preoperative comorbidities were accounted for using the Charlson Comorbidity Index (CCI) as well as

the American Society of Anesthesiologists (ASA) grade. Important prognostic factors were specifically obtained such as Body Mass Index (BMI), presence of diabetes, and smoking status.

2.3 Operative technique

All procedures were performed by a single fellowship trained consultant orthopaedic foot and ankle surgeon (SK) using the TriWay TibioTaloCalcaneal Arthrodesis system™ (TriWay; In2Bones, Lyon, France). Spinal or general anaesthetic was given followed by prophylactic intravenous antibiotics. The patient was placed in a supine position and a thigh tourniquet applied. In four of the six patients, the joint surfaces were prepared arthroscopically to protect the soft tissues. In these patients, standard anteromedial and anterolateral portals were used, and a shaver, burr and curette were used to remove articular cartilage and debride down to healthy, bleeding bone. The subtalar joint was prepared using a mini-open technique with a small lateral incision over the sinus tarsi. Two of the six patients had an open technique. In these two cases, a lateral incision was made and fibulectomy performed. The joint surfaces were prepared using an osteotome, curette, and bone rongeurs. Once the joint surfaces were prepared, the same technique was used for nail insertion in all cases. First, the fracture was reduced, and a guide wire was inserted under fluoroscopic guidance through the center of the lateral column of the calcaneus, through the center of the talar dome and into the tibial canal. A cannulated drill and reamer were used to ream the calcaneus, talus, and tibial canal to 1mm above the desired nail diameter. The nail was assembled onto the targeting jig and inserted manually. The calcaneal screw and the 6.5mm subtalar joint compression screw were measured and inserted before manual compression of the ankle joint. Following placement of the distal screws and compression of the ankle joint, the tibial screws were inserted bicortically from medial to lateral. X-ray was used to confirm hardware placement, and the wound was closed in layers. Each patient was placed in a plaster of Paris backslab and instructed to remain non-weightbearing on the operated side. The authors have previously published a more detailed description of this surgical technique using the same device.[21]

2.4 Postoperative protocol

Patients were advised to mobilise as soon as was safe after surgery, whilst remaining non-weight-bearing (NWB) on the affected limb with help of walking aids. Appropriate deep vein thrombosis (DVT) prophylaxis was given in the form of subcutaneous low molecular weight heparin (LMWH) and Thromboembolic Deterrent (TED) stockings. Radiographs were taken one day postoperatively. A wound review was performed at two weeks and the backslab changed to a moulded below knee cast. At 6 weeks postoperatively, patients were placed into an Aircast walking boot, radiographs were repeated, and patients were advised to progressively weight bear as tolerated. Patients were reviewed clinically and radiologically at 3-month and at 6-month follow-up, and clinically at two-year follow-up.

3. Results

Patient demographics are summarised in Table 1. Overall, 6 patients were included from January 2020 to May of 2023. The majority of patients were female (4/6, 67%) with a median age of 72.5 years (IQR, 51–87). At the time of surgery, the median BMI and CCI was 40 kg/m^2 and 5 (IQR, 2–8), respectively. Four (67%) of patients had diabetes. There were no intraoperative complications or cases of early postoperative mortality. Of note, 4 patients had surgery prior to TTC nailing; 3 patients treated with external fixation due to poor soft tissue quality and the other with ORIF with subsequent failure of metalwork. One of these patients was treated with prolonged external fixation followed by casting but talar shift was noted in cast and the decision was made to proceed with TTC

arthrodesis. The other patients were treated with external fixation as a temporising measure until TTC nailing could be performed.

Most patients had an unremarkable intra- and postoperative course. Complications consisted of a superficial wound infection in 1 patient, treated successfully with a short course of oral antibiotics. One patient, when returning to weight-bearing, sustained an inversion injury to the ipsilateral ankle. A CT was performed showing periosteal thickening at the superior end of the nail with no fracture of bone or metalware. They were placed back in an Aircast boot for an additional 6 weeks and advised to NWB for this time. No other complications occurred. Three patients returned to baseline mobility, with one patient returning to near-baseline mobility (independent to requiring a crutch). The remaining 2 patients had a significant change in baseline mobility. One patient was able to mobilise with a frame preoperatively, but subsequently was unable to mobilise independently and required hoist transfers from bed to chair routinely. The final patient was mobilising independently at baseline, to requiring a Zimmer frame postoperatively. The average length of acute hospital stay was 40 days (range, 9-115 days). Medical, non-orthopaedic related complications occurred in 2 patients prolonging hospital stay, with 4/6 patients being discharged to a step-down facility.

Table 1
Demographics and clinical characteristics of patients who underwent TTC arthrodesis.

Patient	Follow-up (months)	Age	Gender	CCI	BMI (Kg/m^2)	Smoking status	Diabetic	Post-Operative Complications	Acute hospital LOS (days)
1	42	87	M	8	39	Yes	Yes	SWI	48*
2	31	58	M	2	52	No	No	Nil	40
3	10	51	F	6	29	No	Yes	Nil	18
4	7	75	F	6	54	Yes	Yes	Nil	115*
5	4	70	F	3	38	No	No	Nil	11
6	4	75	F	5	41	Yes	Yes	Nil	9

* Prolonged LOS due to medical complications and comorbidities

CCI = Charlson comorbidity index; BMI = Body mass index; LOS = Length of stay; SWI = Superficial wound infection

An example of successful TTC arthrodesis from our cohort is displayed in Fig. 1.

Preoperative radiograph (A) and at six-month follow-up (B and C) demonstrating successful union across the ankle and subtalar joints.

There were no cases of non-union or malunion. Radiological outcomes are presented in Table 2. At the three-month of follow-up, there was radiographic evidence of union at the tibiotalar joint in 5/6 (83%) patients, with complete union in the final patient occurring at 6-month follow-up. At the subtalar joint, 3/6 (50%) patients had evidence of complete bony union at three-month follow-up, while the remaining 3 patients achieved completed union at 6-month follow-up. Similarly, functional outcomes evaluated by pre- and postoperative Olerud and Molander (O&M) scores, presence of pain and return to baseline mobility were favourable (Table 2). The mean O&M scores were 64 preoperatively, 48 and six-month follow-up, and 56 at two-year follow-up. Four out of six

(67%) patients had no pain at their 6-month follow-up, with one patient only having mild persistent pain in the ankle, and the other experiencing moderate amounts of pain while weight bearing. Five out of six (83%) patients attended two-year follow-up. Unfortunately, one patient (17%) had passed away prior to two-year follow-up from a condition unrelated to the device or surgery. None of the five patients (100%) followed up at two years had pain around the ankle.

Table 2
Radiological and functional outcomes of patients who underwent TTC arthrodesis.

Patient	Pre-operative mobility status	Post-operative mobility status (6 months)	O&M score pre-operatively	O&M score (6 months)	O&M score (2 years)	Time to union of subtalar joint (months)	Time to union of tibiotalar joint (months)
1	Frame	Frame	60	50	RIP	3	6
2	Independent	Independent	70	60	65	3	6
3	Independent	Independent	90	80	60	3	3
4	Frame	Hoist	60	25	65	6	6
5	Independent	Crutch x1	55	40	50	3	3
6	Independent	Frame	50	35	40	3	3

O&M = Olerud and Molander score

4. Discussion

The current study is the first to describe the outcomes of TTC arthrodesis using a solid posterior offset hindfoot arthrodesis nail in traumatic, unstable, fragility ankle fractures, and was a continuation of our previously published work.[25] The demographics and characteristics of this cohort were similar to those described in similar reports of fragility ankle fractures undergoing TTC nailing.[2, 30] The majority of patients were female and frail as determined by the presence of osteopenia, high CCI scores in the cohort as well as low energy mechanisms of injury resulting in unstable fracture patterns. Moreover, the current study reports no occurrence of intraoperative complications, and a single minor postoperative complication of superficial wound infection. No cases of non-union or malunion were reported, and no revision surgery or amputations were required. The literature suggests favourable outcomes after TTC nailing in these patient cohorts when compared to other forms of fixation, such as ORIF or fusion via plate and screws. Radiological outcomes are consistently favourable, however postoperative complications rates vary between studies.[6, 31] A significant factor that differs between these studies is the use of different IM nail constructs. Despite this, there is a paucity of data that currently exists comparing complication rates with different nail implants.

The retrograde intramedullary tibiotalocalcaneal nail used in this study has a number of defining features. It is a load-sharing construct that has increased compression potentials as the nail incorporates a 6.5mm subtalar joint compression screw. It is a solid nail construct which increases the torsional and bending rigidity compared to some other nail systems which utilise cannulated nails.[32] It has a seven-degree posterior offset which facilitates implant placement and increases purchase in the calcaneus as measured by the distance from the nail

to the calcaneo-cuboid joint.[21] The system uses Cotter screws in the calcaneal, tibial and talar bone which promote union through rigid fixation. Cotter screws increase the overall stability of the nail by acting like bolts, reducing the risk of screw disengagement. Loosening of these screws can present an issue. Corin et al. conducted a study of seventy elderly patients with distal tibial fractures treated with a hindfoot nail.[33] Ten of the participants underwent removal of metal due to loosening of the nails locking bolts. As this feature secures the construct and promotes union of the arthrodesis, it is paramount that it remains stable.

Fragility ankle fractures in the elderly are difficult to treat as significant comorbidities are often present, including osteoporosis, PVD, diabetes, and obesity. Each of these are risk factors for non-union, wound infections and metalware failure, increasing the likelihood for the need of revision surgery. It has been established that in such patients, conservative treatment and ORIF are both associated with inconsistent outcomes. For instance, Buckingham et al. examined outcomes in elderly patients with ankle fractures treated conservatively compared with ORIF.[34] Non-union rates were as high as 56% in patients treated conservatively and 20% in those treated with ORIF, with approximately 30% of patients experiencing persistent pain. Similarly, Makwana et al. found that functional outcomes improved in a similar cohort of patients when treated surgically, at the expense of higher complications, reaching up to 50%.[35] However, there is growing evidence to suggest that fusion via intramedullary nailing results in more favorable outcomes than ORIF and conservative management. Amirfeyz et al. conducted a study on thirteen elderly patients with fragility fractures of the ankle treated with TTC nailing. No patients suffered from non-union and the overwhelming majority had a good functional outcome returning to painless, baseline mobility.[19] Likewise, Al-Nammari et al. in a separate study with a similar population of 48 patients had no cases of non-union and minimal postoperative complications.[36]

The current study has several limitations. It is a case series, and all data were collected retrospectively. As such there is a lack of a control group to compare these results to other forms of treatment. In addition, the sample size was small resulting in a low power of the study. Also, due to a limited period of follow-up for a portion of the patients, late complications of the procedure, if they were to occur, would not be included. Moreover, union is better determined via CT scanning to determine the degree of callus formation. This study took place in a healthcare setting where CT scanning for research purposes is not accessible due to both ethical and monetary considerations. As such, serial X-rays were utilised to determine union via the defined criteria described above. This is consistent with several other studies in the literature who have published without using CT to determine union. [21–26, 37]

5. Conclusion

We report satisfactory clinical outcomes and a high union rate using a solid posterior offset hindfoot arthrodesis nail for the treatment of traumatic unstable fragility fractures of the ankle. The nail has unique features that may provide superior stabilisation than some other new generation TTC nails. In addition, the posterior offset of the nail allows for easy insertion and increased purchase in the calcaneus. The sample size of this case-series is small, and so the authors advise caution when extrapolating these results. The authors also recommend that further studies with larger sample sizes and long-term follow-up should be conducted to confirm these results.

Declarations

Competing Interests

Rayyan S. Mirdad has no competing interests to declare that are relevant to the content of this article.Jacques Pretorius has no competing interests to declare that are relevant to the content of this article..Kaylem M. Feeney has no competing interests to declare that are relevant to the content of this article.Evelyn P. Murphy no competing interests to declare that are relevant to the content of this article.Abdulaziz Mirdad no competing interests to declare that are relevant to the content of this article.John Mahon has no competing interests to declare that are relevant to the content of this article.Lily Nolan has no competing interests to declare that are relevant to the content of this article.Kieran O'Sullivan has no competing interests to declare that are relevant to the content of this article.Stephen R. Kearns was involved in the development of the TriWay Tibiotalocalcaneal Arthrodesis System. As a result of his contribution to its development, he receives royalties related to the sale of this product.

Author Contribution

All authors have made substantial contribution to the conception or design of the work; or the acquisition, analysis, or interpretation of data for the work. All authors have substantially contributed to drafting the work or revising it critically for important intellectual content. All authors have given final approval of the version to be published.Rayyan Mirdad – Conception, acquisition, analysis, drafting. Jacques Pretorius – Conception, acquisition, analysis, drafting. Kaylem Feeney – Analysis, interpretation, drafting, revising. Evelyn Murphy – Conception, acquisition, analysis, revising.Abdulaziz Mirdad – Acquisition, analysis, drafting. John Mahon – Acquisition, analysis, drafting.Lily Nolan – Acquisition, analysis, drafting. Kieran O'Sullivan – Acquisition, analysis, draftingStephen Kearns – Conception, design, interpretation, revising.

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Figures



Figure 1

An Example of a Successful TTC Arthrodesis

Preoperative radiograph (A) and at six-month follow-up (B and C) demonstrating successful union across the ankle and subtalar joints.