■ TRAUMA

Fragility fractures of the ankle in the frail elderly patient

TREATMENT WITH A LONG CALCANEOTALOTIBIAL NAIL

S. S. Al-Nammari,
S. Dawson-Bowling,
A. Amin,
D. Nielsen

From St George's Hospital, Tooting, London, United Kingdom

Conventional methods of treating ankle fractures in the elderly are associated with high rates of complication. We describe the results of treating these injuries in 48 frail elderly patients with a long calcaneotalotibial nail.

The mean age of the group was 82 years (61 to 96) and 41 (85%) were women. All were frail, with multiple medical comorbidities and their mean American Society of Anaesthesiologists score was 3 (3 to 4). None could walk independently before their operation. All the fractures were displaced and unstable; the majority (94%, 45 of 48) were low-energy injuries and 40% (19 of 48) were open.

The overall mortality at six months was 35%. Of the surviving patients, 90% returned to their pre-injury level of function. The mean pre- and post-operative Olerud and Molander questionnaire scores were 62 and 57 respectively. Complications included superficial infection (4%, two of 48); deep infection (2%, one of 48); a broken or loose distal locking screw (6%, three of 48); valgus malunion (4%, two of 48); and one below-knee amputation following an unsuccessful vascular operation. There were no cases of nonunion, nail breakage or peri-prosthetic fracture.

A calcaneotalotibial nail is an excellent device for treating an unstable fracture of the ankle in the frail elderly patient. It allows the patient to mobilise immediately and minimises the risk of bone or wound problems. A long nail which crosses the isthmus of the tibia avoids the risk of peri-prosthetic fracture associated with shorter devices.

Cite this article: *Bone Joint J* 2014; 96-B:817–22.

After the hip and wrist, the third most common site of fragility fracture in the elderly is at the ankle.[1] The number of fragility fractures are set to rise further as a result of the anticipated increase in life expectancy and the prevalence of osteoporosis.[1,2] Osteoporosis currently results in more than nine million fractures worldwide each year.[3] Ankle fractures have a bimodal age distribution, with peaks in young men and older women.[1] The elderly are at increased risk of ankle fracture, not just because of their poor bone quality, but also because of their increased tendency to fall.[4,5]

The management of an ankle fracture poses specific challenges in the frail elderly patient. Both operative and non-operative techniques are associated with a high rate of complications. Non-operative treatment has been associated with a nonunion rate of between 48%[6] and 73%,[7-9] and a malunion rate between 36%[7] and 61%[8], and the incidence of chronic pain at one year is up to 68%.[9] After open reduction and internal fixation, the rate of nonunion ranges between 0%[10] and 19%,[11] malunion between 5%[10] and 19%,[6,7] and the incidence of wound complications from 9%[10] to 23%.[11] Chronic pain is reported in up to 56% of patients and contributes to high levels (63%) of patient dissatisfaction.[9]

A number of factors are believed to contribute to the poor results seen after internal fixation in the elderly. The soft tissues are frequently in poor condition, even prior to injury. Comorbidities such as diabetes, peripheral vascular disease, and the prolonged use of corticosteroids are not uncommon and increase the risk of sepsis, nonunion, malunion and delayed wound healing.[10-12] The high prevalence of osteoporosis[1,4,12] renders commonly used methods of internal fixation technically demanding and prone to failure. These issues are further compounded by the patient's frequent inability to limit weight-bearing postoperatively. Any surgical technique that can circumvent these difficulties would therefore be welcomed.

Intramedullary stabilisation of fragility fractures of the ankle was first described in 1963 using a Steinmann pin.[13] Subsequently, other reports have described it used alone or in

■ S. S. Al-Nammari, MBChB, MSC(Oxon.), FRCS(Tr&Orth), Orthopaedic Registrar
■ S. Dawson-Bowling, MA, MSc, LLM, FRCS(Tr&Orth), Consultant Orthopaedic Surgeon
■ A. Amin, MBBS, FRCS(Tr&Orth), Consultant Orthopaedic Surgeon
■ D. Nielsen, MBBS, FRCS(Tr&Orth), Consultant Orthopaedic Surgeon
Department of Orthopaedics, St George's Hospital, Tooting, London, UK.

Correspondence should be sent to Mr S. S. Al-Nammari; e-mail: shafic2@hotmail.com

doi:10.1302/0301-620X.96B6.32721 $2.00

Bone Joint J 2014;96-B:817–22.
Received 29 June 2013; Accepted after revision 4 March 2014

Table I. Medical comorbidities

Comorbidity	Complete cohort (n, (%))	Under 80 (n, (%))	80 and over (n, (%))
Ischaemic heart disease	20 (*42*)	3 (*27*)	17 (*46*)
Cardiac failure	12 (*25*)	2 (*18*)	10 (*27*)
Chronic Obstructive Pulmonary Disease (COPD)	15 (*31*)	2 (*18*)	13 (*35*)
Cerebrovascular accident/transient ischaemic attack (CVA/TIA)	16 (*33*)	1 (*9*)	15 (*41*)
Malignancy	7 (*15*)	2 (*18*)	5 (*14*)
Alcohol dependence	8 (*17*)	5 (*46*)	3 (*8*)
Chronic glucocorticoid usage	13 (*27*)	2 (*18*)	11 (*30*)
Chronic warfarin usage	12 (*25*)	3 (*27*)	9 (*24*)
Diabetes mellitus	15 (*31*)	3 (*27*)	12 (*32*)
Renal disease/dialysis	6 (*13*)	1 (*9*)	5 (*14*)
Dementia & Wernickes encephalopathy	16 (*33*)	2 (*18*)	14 (*38*)
Liver disease	15 (*31*)	8 (*73*)	7 (*19*)
Previous osteoporotic fracture	20 (*42*)	5 (*46*)	15 (*41*)
Inflammatory arthropathy	4 (*8*)	1 (*9*)	3 (*8*)
Mean American Society of Anaesthesiologists (ASA) score (range)	3 (3 to 4)	3 (3 to 4)	3 (3 to 4)
Mean number of comorbidities (range)	3.3 (3 to 4)	3.2 (3 to 4)	3.4 (3 to 4)

Table II. Pre- and post-operative functional demand/independence. Post-operative status: was recorded at the last point of patient contact. This was the time of discharge in the non-survivors and the final outpatient follow-up in survivors

Housing and mobility	Complete cohort (n, (%))	Under 80 (n, (%))	80 and over (n, (%))
Own home pre-injury	11 (*23*)	3 (*28*)	8 (*22*)
Return to own home after injury	9 (*82*)	2 (*67*)	7 (*88*)
Sheltered housing before injury	20 (*42*)	5 (*45*)	15 (*41*)
Return to sheltered housing after injury	17 (*85*)	4 (*80*)	13 (*87*)
Nursing home resident before injury	17 (*35*)	3 (*27*)	14 (*38*)
Return to nursing home after injury	17 (*100*)	3 (*100*)	14 (*100*)
Return to same accommodation after injury	43 (*90*)	2 (*18*)	3 (*8*)
Independent community ambulator before injury	0 (*0*)	0 (*0*)	0 (*0*)
Independent community ambulator after injury	0 (*0*)	0 (*0*)	0 (*0*)
Supported community ambulator (< 200 m with frame) before injury	15 (*31*)	4 (*37*)	11 (*30*)
Return to supported community ambulator (< 200 m with frame) after injury	13 (*87*)	3 (*75*)	10 (*91*)
Supported housebound ambulator before injury (sticks/crutches/frame)	33 (*69*)	7 (*64*)	26 (*70*)
Return to supported housebound ambulator after injury (sticks/crutches/frame)	32 (*97*)	7 (*100*)	25 (*96*)

association with other types of internal fixation.[14,15] However, these methods do not allow immediate unrestricted weight-bearing and have also been shown to be associated with high complication rates.[13-15]

Over the last decade, there have been three reports on the se of retrograde calcaneotalotibial nails to treat these injuries.[16-18] These reports argue that this group of patients are physiologically comparable to those presenting with a fractured neck of the femur, in terms of having both multiple medical comorbidities and a high medium-term mortality of between 17%[16] and 46%.[17] These three small case series report no nonunion and a low rate of malunion (0% to 8%),[16-18] and that immediate partial[17] or unrestricted[16,18] weight-bearing was possible.

However, these studies all used 'short' nails that did not cross the isthmus of the tibia. The use of a short nail to treat a fracture of the proximal femur has been shown to increase the risk of fracture at the tip of the nail.[19] In elective surgery, peri-prosthetic stress fractures of the tibia have been described when 'short' nails are used to augment tibiotalo-calcaneal fusion, the reported rates being between 6%[20] and 14%.[21] The rate of peri-prosthetic fracture when using a 'short' calcaneotalotibial nail for trauma is up to 10%.[18]

In this study, we describe our indications, operative technique and results using a long, locked calcaneotalotibial nail for the fixation of a fragility fracture of the ankle in a frail, elderly group of patients.

Patients and Methods

Between 1 January 2010 and 1 January 2013, 48 patients presented to our hospital with a fracture of the ankle and were treated using a calcaneotalo-tibial nail (T2 retrograde femoral nailing system (Stryker, Mahwah, New Jersey)). For the purposes of this study, these patients were identified retrospectively from the theatre logbooks, implant charts

Fig. 1

Anteroposterior radiograph of an unstable bimalleolar ankle fracture in an 87-year-old female patient.

and clinic letters. Individual patient data were obtained by reviewing the case notes, electronic charts and imaging.

A total of 41 patients (85%) were women. The mean age of the whole group was 82 years (61 to 96), and 34 patients (71%) were aged > 80. Their mean American Society of Anaesthesiologists (ASA) score[22] was 3 (3 to 4). All had multiple medical comorbidities (Table I) and had low functional demands (Table II). None were community ambulators pre-operatively, either with or without support.

The injury was low energy in 45 (94%) patients. Despite this, 19 (40%) had open fractures and ten (21%) required a formal soft-tissue coverage procedure. Each fracture was displaced and unstable. The fracture was bimalleolar in 30 cases (63%) and in 18 (37%) it also included the posterior margin of the distal tibia. According to the Lauge–Hansen classification[23] 35 (73%) were supination–external rotation, nine (19%) pronation–external rotation and four (8%) pronation–abduction injuries.

The decision to treat these cases with a nail was made in each case by the orthopaedic consultant on call at the time of admission. Indications were patients considered physically and/or mentally too frail to manage restricted weight-bearing post-operatively, and those with severely restricted mobility immediately prior to their injury. Those who could walk independently for more than 200 m were excluded, regardless of their age. Patients able to walk short distances (less than 200 m) outdoors, but requiring use of a frame, and those mobile only at home with or without support, were included. Patients with poor bone stock, as shown by a past history of fragility fracture, radiological evidence of severe osteopenia or a low-energy ankle fracture, were included. The procedure was carried out by a consultant in 33 (69%) cases and by a registrar in 15 (31%). The mean operating time was 55 minutes (25 to 90), and there were no intra-operative complications.

Operative technique and post-operative care. The procedures were undertaken under image intensifier guidance with the patient supine and a sandbag under the ipsilateral hip. A tourniquet was used in only four patients (8%) at the discretion of the operating surgeon. A single dose of intravenous antibiotic was given on induction of anaesthesia. The surgical technique was the same in each case, using the T2 retrograde femoral nailing system (Stryker).

The fracture was reduced by manual traction under image intensifier guidance. A radio-opaque ruler and marker pen were used to mark out the axes of the desired entry point for nail passage in both anteroposterior (AP) and lateral planes. A guide wire was inserted percutaneously before making a 2 cm longitudinal skin incision in the heel around the guide wire and using blunt dissection down to the plantar surface of the calcaneus.

The guide wire was then inserted into the calcaneus and across the subtalar joint, aiming for the centre of the dome of the talus on both AP and lateral views. Once the wire reached the subchondral surface of the dome of the talus, the fracture was reduced. The ankle was brought into neutral flexion and the guide wire passed across the tibiotalar joint into the shaft of the tibia. Initial reaming into the tibial metaphysis was performed, after which the initial guide wire was exchanged for a ball-tipped guide wire: this was passed proximally until the tip was level with the tibial tuberosity proximally and its length was then measured.

We reamed sequentially to between 1 mm and 1.5 mm more than the chosen diameter of the nail with the aim of passing the tibial isthmus with the nail in every case. The quality of the tibial bone was frequently so poor that it was unnecessary to ream the tibia. Distal locking was undertaken using a proprietary jig: the specific design of the T2 retrograde femoral nail generally meant that screws were sited in both the talus and the calcaneus. Proximal locking screws were inserted freehand (Figs. 1 to 3).

Skin closure was undertaken with interrupted 3/0 nylon in 43 cases (90%) and clips in the rest. A bulky dressing was applied and all patients were encouraged to mobilise fully weight-bearing as soon as possible.

Patients were followed up at two and six weeks, three and six months. There was no intention to remove the nail unless it was required to deal with a complication.

Results

Post-operative surgical complications included two superficial surgical site infections (4%) and two graft-/flap-related infections (4%). Asymptomatic valgus malunion occurred in two patients (4%). In three others (6%) one of the distal locking screws either became loose or broke, requiring removal in two patients, both of whom recovered uneventfully. One patient developed a deep infection and required removal of the nail at another hospital four months after the primary procedure, by which time the fracture was said to have united. The most serious complication was the need for a below-knee amputation four days after the initial surgery in a patient with multiple comorbidities (ASA 3) who had sustained a Grade IIIc open fracture.

Fig. 2a

Fig. 2b

Twelve-week post-operative radiographs of the same 87-year-old female patient showing satisfactory union in a) anteroposterior and b) lateral view.

Fig. 3a

Fig. 3b

Twelve-week post-operative radiographs of an unstable ankle fracture in a 79-year-old female patient showing satisfactory union in a) anteroposterior and b) lateral view.

Table III. Six-month mortality: cause and timescale

Mortality	Number and cause
Month 1	2 myocardial infarction, 1 bronchopneumonia
Month 2	1 cerebrovascular accident
Month 3	1 cerebrovascular accident, 1 bronchopneumonia
Month 4	3 urinary sepsis, 1 cerebrovascular accident, 1 bronchopneumonia
Month 5	2 bronchopneumonia, 1 Upper gastrointestinal bleed, 1 myocardial infarction
Month 6	3 bronchopneumonia, 1 cerebrovascular accident, 1 gastric carcinoma

Despite successful initial revascularisation, there was further delayed vascular compromise. Post-operative medical complications included nine cases of pneumonia (19%) and five cases of myocardial infarction (MI) (10%). Support from the intensive care unit (ICU) was needed for six patients (13%).

The mean time before a patient was able to mobilise was 15 days (0 to 52). However, all of those who failed to mobilise within 72 hours of surgery suffered an acute post-operative medical complication. Of the 12 patients who were both lucid and medically stable after surgery, all were able to mobilise within 48 hours.

Fracture union (diagnosed on a combination of clinical and radiological grounds) occurred after a mean of nine weeks (6 to 14). There were no cases of nonunion, nail breakage or peri-prosthetic fracture.

The six-month mortality rate for the entire group was 35% (17 of 48). One death occurred within two weeks of surgery, after an MI on the fifth post-operative day; this was felt to be potentially related to the surgical intervention (Table III).

Of the 31 patients who survived for six months after their surgery, 28 (90%) had returned to their pre-operative level of function. Of the 14 patients who both survived six months and were intellectually capable of taking the Olerud and Molander questionnaire,[24] the mean pre-operative score was 62 (40 to 80) and the mean post-operative score after six months was 57 (35 to 70).

Discussion

The characteristics of our cohort were similar to that described in other reports on fragility fractures in the elderly in showing a significant preponderance of women with a low-energy injury.[2,16,25] Although our patients were substantially older and had lower functional demands than those in other published series who had undergone internal fixation,[6-8] they were comparable to those in other reported groups treated with a calcaneotalotibial nail.[16-18] This reflected our selection criteria, as the procedure was only considered for patients who were physiologically frail and had a low functional demand. It is interesting to note that although 45 (94%) of our patients had low-energy injuries, the incidence of open fractures in our series was high (40%, 19 of 48) compared with other published series. We think that this is due to a combination of factors, including our status as a major trauma centre, the high rate of steroid usage in our cohort and the poor-quality soft tissues frequently seen in this group of patients.

We believe the surgical procedure to be fairly straightforward. Although most operations were carried out by consultants, most of these were not foot and ankle specialists. The mean operating time was fairly short, and there were no intra-operative complications noted. The choice of the T2 retrograde femoral nailing system was largely determined by the fact that most intramedullary nails designed for use around the foot and ankle are not long enough to pass the isthmus of the tibia. Although we accept that this

system is not ideally suited for use as a calcaneotalotibial nail, we contend that most of the other systems currently available are not either. With the T2 system, the distal locking trajectory is not ideal and can only be performed in the lateral/medial plane. In the calcaneus it is known that AP locking screws are mechanically superior. However, even in severely osteoporotic individuals, the bone stock within the talus remains adequate.

We also experienced problems with screw migration in the distal locking holes, and it may be that the next generation of nails with threaded locking holes, locking end caps, or locking bolts may help to avoid this. Nevertheless, surgeons in our unit are familiar with the use of the T2 system to treat femoral fractures and we believe that this series demonstrates acceptable results for its use in this context.

Our rate of superficial infection of 4% is within the published range of between 0%[16,18] and 7%,[17] despite our much higher rate of open injuries. Although we had one deep infection which required exchange of the nail, this compares very favourably with conventional methods of internal fixation, which have rates of infection and wound problems of between 9% and 23%.[10,11] We had no cases of nonunion and a low rate of malunion, which mirrored pre-existing published series on calcaneotalotibial nails and compared favourably with other modes of internal fixation. Unlike other series[16,17,18] we do not remove nails routinely. None of our patients sustained periprosthetic fractures or nail breakage, which is likely to be due to the low functional demands of this patient cohort. The high morbidity and mortality rates are unsurprising, given the advanced age and multiple medical comorbidities in this cohort. However, we do not feel that the physiological insult associated with this procedure is excessive, and our peri-operative mortality rate of 2% (1 of 48) is similar to the 3% quoted for other methods of internal fixation in this group of patients.[10]

Eliminating both subtalar and tibiotalar joint movement, does not appear to impair the overall function of these patients. After six months, most patients had regained their pre-operative functional levels, and as in previous reports[16-18] the Olerud and Molander scores did not fall substantially. This is perhaps a reflection of the fact that patients were selected for the procedure based on their low functional demand. Interestingly, in one of the previous studies over half the patients declined elective removal of the nail, as they perceived their ankle to be more stable than it had been before their injury.

Our study has a number of limitations. All data were collected retrospectively, with all of the attendant weaknesses implicit in this type of study design. There was no control group to allow comparison with other established forms of treatment. The decision to undertake intramedullary nail fixation was essentially subjective, as there were no established criteria for inclusion in this treatment group. The population represented here is heterogonous in terms of age, fracture pattern and pre-injury level of function. Finally, the six-month follow-up is relatively short, although we suggest that longer follow-up is difficult to achieve in such a patient population.

Nevertheless, in keeping with our initial objectives in using a longer nail, we have avoided peri-prosthetic fractures and have furthermore found it to be necessary to remove the nail in only one instance, thereby minimising the need for further surgery in this high-risk patient group.

Surgical intervention should minimise the risk of complications to delicate soft tissues and bone, while being robust enough to permit immediate mobilisation and rehabilitation. We believe that a long, locked calcaneotalotibial nail is currently the best way of achieving mobilisation and rehabilitation in this particular group of patients and that it has encouraging clinical results.

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

This article was primary edited by A. Ross and first proof edited by D. Rowley.

References

1. **Court-Brown CM, McBirnie J, Wilson G.** Adult ankle fractures--an increasing problem? *Acta Orthop Scand* 1998;69:43–47.
2. **Kannus P, Palvanen M, Niemi S, Parkkari J, Järvinen M.** Increasing number and incidence of low-trauma ankle fractures in elderly people: Finnish statistics during 1970-2000 and projections for the future. *Bone* 2002;31:430–433.
3. **Johnell O, Kanis JA.** An estimate of the worldwide prevalence and disability associated with osteoporotic fractures. *Osteoporos Int* 2006;17:1726–1733.
4. **Seeley DG, Kelsey J, Jergas M, Nevitt MC.** Predictors of ankle and foot fractures in older women. The Study of Osteoporotic Fractures Research Group. *J Bone Miner Res* 1996;11:1347–1355.
5. **Hasselman CT, Vogt MT, Stone KL, Cauley JA, Conti SF.** Foot and ankle fractures in elderly white women. Incidence and risk factors. *J Bone Joint Surg [Am]* 2003;85-A:820–824.
6. **Litchfield JC.** The treatment of unstable fractures of the ankle in the elderly. *Injury* 1987;18:128–132.
7. **Ali MS, McLaren CA, Rouholamin E, O'Connor BT.** Ankle fractures in the elderly: nonoperative or operative treatment. *J Orthop Trauma* 1987;1:275–280.
8. **Anand N, Klenerman L.** Ankle fractures in the elderly: MUA versus ORIF. *Injury* 1993;24:116–120.
9. **Buckingham RA, Hepple S, Winson IG.** Outcome of ankle fractures in the elderly. *Foot Ankle Surg* 2000;6:175–178.
10. **Srinivasan CM, Moran CG.** Internal fixation of ankle fractures in the very elderly. *Injury* 2001;32:559–563.
11. **Beauchamp CG, Clay NR, Thexton PW.** Displaced ankle fractures in patients over 50 years of age. *J Bone Joint Surg [Br]* 1983;65-B:329–332.
12. **Salai M, Dudkiewicz I, Novikov I, Amit Y, Chechick A.** The epidemic of ankle fractures in the elderly--is surgical treatment warranted? *Arch Orthop Trauma Surg* 2000;120:511–513.
13. **Duke RF.** Severe fracture-dislocation of ankle treated by transarticular steinmann pin. *Lancet* 1963;2:1251–1253.
14. **Childress HM.** Vertical transarticular pin fixation for unstable ankle fractures: impressions after 16 years of experience. *Clin Orthop Relat Res* 1976;120:164–171.
15. **Scioscia TN, Ziran BH.** Use of a vertical transarticular pin for stabilization of severe ankle fractures. *Am J Orthop (Belle Mead NJ)* 2003;32:46–48.
16. **Lemon M, Somayaji HS, Khaleel A, Elliott DS.** Fragility fractures of the ankle: stabilisation with an expandable calcaneotalotibial nail. *J Bone Joint Surg [Br]* 2005;87-B:809–813.
17. **Amirfeyz R, Bacon A, Ling J, et al.** Fixation of ankle fragility fractures by tibiotalocalcaneal nail. *Arch Orthop Trauma Surg* 2008;128:423–428.
18. **Jonas SC, Young AF, Curwen CH, McCann PA.** Functional outcome following tibio-talar-calcaneal nailing for unstable osteoporotic ankle fractures. *Injury* 2013;44:994–997.
19. **Norris R, Bhattacharjee D, Parker MJ.** Occurrence of secondary fracture around intramedullary nails used for trochanteric hip fractures: a systematic review of 13,568 patients. *Injury* 2012;43:706–711.

20. Hammett R, Hepple S, Forster B, Winson I. Tibiotalocalcaneal (hindfoot) arthrodesis by retrograde intramedullary nailing using a curved locking nail. The results of 52 procedures. *Foot Ankle Int* 2005;26:810–815.

21. Thordarson DB, Chang D. Stress fractures and tibial cortical hypertrophy after tibiotalocalcaneal arthrodesis with an intramedullary nail. *Foot Ankle Int* 1999;20:497–500.

22. Saklad M. Grading of patients for surgical procedures. *Anesthesiology* 1941;2:281–284.

23. Lauge-Hansen N. Fractures of the ankle. II. Combined experimental-surgical and experimental-roentgenologic investigations. *Arch Surg* 1950;60:957–985.

24. Olerud C, Molander H. A scoring scale for symptom evaluation after ankle fracture. *Arch Orthop Trauma Surg* 1984;103:190–194.

25. Sporer SM, Weinstein JN, Koval KJ. The geographic incidence and treatment variation of common fractures of elderly patients. *J Am Acad Orthop Surg* 2006;14:246–255.