Foot and Ankle Surgery 20 (2014) 215–220

Contents lists available at ScienceDirect

Foot and Ankle Surgery

journal homepage: www.elsevier.com/locate/fas

Pre-requisites for optimum centering of a tibiotalocalcaneal arthrodesis nail

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ARTICLE INFO

Article history:
Received 5 March 2014
Received in revised form 8 May 2014
Accepted 20 May 2014

Keywords:
Tibiotalocalcaneal arthrodesis
Arthritis
Hindfoot
Biomechanics
Outcome studies

ABSTRACT

Background: Purpose of study was to compare nail alignment, incidence of stress riser and fracture with straight and curved nails of different lengths.
Methods: We conducted a retrospective review of consecutive, initially 13 straight and subsequently 15 curved nails implanted in 17 men and 11 women. Angles of incidence and reflection subtended by nail tip with inner tibial cortex were measured. Cortical hypertrophy was assessed on follow-up radiographs.
Results: Angles of incidence and reflection were greater with short straight nails, less with long straight nails and stayed close to zero with long curved nails.

Stress fractures occurred in 2 patients with straight nails at the level of the proximalmost tibial screw. Cortical hypertrophy was present in 7 patients with straight nails and in only 1 patient with a curved nail ($p = 0.01$).
Conclusions: Both nail length and inbuilt valgus contribute to better central positioning within the tibia. However, cortical stress reactions occur less frequently with curved nails.

1. Introduction

Tibiotalocalcaneal (TTC) arthrodesis is commonly performed in the management of primary or post-traumatic two-level hindfoot osteoarthritis, avascular necrosis of the talus, diabetic neuropathic hindfoot, neuromuscular deformity or in the salvage of failed total ankle replacement. Armamentarium available for fixation of TTC includes lag screws, plates and intramedullary nails.

Ankle arthrodesis nails can be straight or curved. Rationale for utilizing a curved nail as opposed to a straight nail includes preservation of physiological hindfoot valgus and avoidance of hindfoot varus as can occur with use of straight nails [1]. Proponents of curved nails further argue that incorporation of slight valgus within the nail obviates the need for medialization of the talus and resection of the medial malleolus with its inherent risk of damage to the deltoid vascular supply to the talus, and helps achieve better centralization of the tip of the nail within the medullary canal of the tibia with less risk of cortical hypertrophy, stress riser and fracture [2–4]. Curved nails also permit a more lateral calcaneal entry point with decreased risk of injury to the lateral plantar nerve and vessels [5]. Nail curvature varies from a single distal lateral bend to designs with double distal posterior and lateral bends with a proximal recurvatum bow [6,7].

Complication rates following TTC arthrodesis range from 15 to 80% [8–10]. While most complications arising from prominent hardware can be addressed by simple measures, stress reactions and stress fractures pose more significant morbidity.

The aim of this study is to review our experience with both straight (Biomet Ankle Arthrodesis Nail, Warsaw, Indiana) and curved (T2 Ankle Arthrodesis Nail, Stryker, Kalamazoo, Michigan) ankle nails. The straight nail was available in lengths of 15 and 18 cm. The curved nail comes in lengths of 15, 20 and 30 cm, the distal 47 mm of which has a 5 degrees valgus bend. We report the incidence of complications, and in particular of stress reactions and fractures with either nail. Through detailed analysis of radiographs, we identify and discuss factors essential for proper centering of the nail within the medullary canal of the tibia.

2. Methods

2.1. Subjects

This retrospective study comprised 28 consecutive patients, 17 men and 11 women, who had undergone tibiotalocalcaneal

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http://dx.doi.org/10.1016/j.fas.2014.05.007
1268-7731/

arthrodesis by the senior author over an eight-year period. Patient's age ranged from 33 to 86 years (mean, 59 years).

2.2. Operative technique

All patients received antibiotic prophylaxis. After positioning in semi-lateral decubitus, standard skin preparation and draping to above knee level, a transfibular approach was made with resection of the distal end of the fibula, which was subsequently milled for use as bone graft. A supplemental anteromedial approach allowed preparation of the articular surfaces of the medial malleolus and adjoining talus. However, the medial malleolus was preserved and not transected so as to provide a medial buttress when translating the talus medially. Careful preparation of both ankle and subtalar joints was carried out manually using chisel and curette. Fenestration of the joint surfaces was performed using a 2.5 mm drill bit to create a bone slurry for enhancing bone healing.

Reduction was obtained with the ankle at 0–5 degrees of dorsiflexion, 5 degrees of hindfoot valgus and 5–10 degrees of external rotation. A guidewire was inserted via a plantar heel incision, maintaining the talus abutted medially against the medial malleolar remnant. Reaming was carried out in steps of 0.5 mm–1.0 mm above the desired nail diameter. The appropriate sized nail was introduced across the calcaneum and talus into the tibia.

After inserting lateral-to-medial proximal tibial locking screws across the straight nail, external compression was applied across the subtalar and ankle joints followed by lateral-to-medial talar, lateral-to-medial calcaneal and postero-anterior calcaneal distal locking screws.

With the curved nail, a talar screw was first placed from lateral to medial followed by medio-lateral proximal tibial screws. Next, internal compression of the tibio-talar joint was effected by virtue of a compression screw within the nail, followed by external compression across the subtalar joint. Distal lateral-to-medial and postero-anterior calcaneal locking screws were then inserted. End-caps were placed into each nail to prevent bone ingrowth.

Post-operatively, a below knee back slab was applied for 48–72 h. This was converted to a non weight-bearing plaster cast, which was subsequently changed to a light-weight cast at 2 weeks. At 6 weeks, repeat radiographs were obtained and protected weight bearing encouraged in an Aircast Walker boot for a further six weeks. Full weight-bearing was encouraged at 12 weeks.

2.3. Clinical and radiographic review

All patients were followed up until clinically and radiologically united. Electronic case records were reviewed to determine patient demographics, indications for surgery, comorbidities, union rate, post-operative complications and re-operation rate.

The senior author and two orthopaedic residents independently analyzed post-operative radiographs for radiological union, cortical hypertrophy and position of metalwork. Different angular measurements were obtained including the angle subtended by the shaft of the nail with the anatomical axis of the tibia. We chose the angles of incidence and reflection at where the bevelled edge of the nail abuts the inner tibial cortex because this is where stress fractures and cortical hypertrophy tend to occur. On anteroposterior projections, the angle of incidence is that subtended by the straight medial border of the nail with the inner cortex of the *near distal* tibia (Fig. 1A). The angle of reflection is the angle subtended by the straight medial border of the nail with the inner cortex of the *far proximal* tibia (Figs. 1C and 2A) (*near distal* refers to the tibial cortex running alongside nearby the nail and *far proximal* refers to the tibial cortex running off on the far side proximal to the nail). Similarly, angles of incidence and reflection were obtained on lateral radiographs (Figs. 1B, D and 2B).

3. Results

Primary osteoarthritis of both ankle and subtalar joints formed the commonest indication for tibiotalocalcaneal arthrodesis (Table 1). All 28 patients underwent unilateral procedures, 19 of which were tibio-talo-calcaneal, 1 tibio-calcaneal, 5 pantalar arthrodeses and 3 conversion procedures. Tibial antegrade nails were first removed in 2 of the conversion procedures – prior to pantalar arthrodesis in 1 and tibio-calcaneal arthrodesis in another patient who developed avascular necrosis of the talus following a Hawkins type IV fracture dislocation of the talar neck and an ipsilateral tibial diaphyseal fracture. The third patient underwent TTC after removal of a failed total ankle replacement. Curved ankle nails were utilized in 15 patients and straight nails in 13. Five patients suffered from diabetes mellitus and none were smokers around the time of surgery.

Overall complication rate was 53% (15 of 28 patients) (Table 2). Fisher's 2-tailed exact test demonstrated no statistical difference in the incidence of complications between curved and straight nails ($p = 0.258$). Neither did associated comorbidities of diabetes ($p = 0.645$) nor of rheumatoid arthritis ($p = 0.604$) affect the complication rate.

Superficial infection developed in 3 patients. Infection ensued following direct trauma at the site of the head of a proximal locking tibial screw at three months post surgery in a thin alcohol-dependent patient. It cleared up following removal of screw. Another patient had superficial dehiscence of the lateral wound with associated cellulitis, which settled with regular dressings and oral antibiotics. Chronic discharging sinus in the patient who underwent TTC for a failed total ankle replacement was due to residual debris within the soft tissues from wear of the poly and resolved with exploration and wound debridement at eleven months post nailing.

Partial wound dehiscence occurred in 3 patients, in all of whom healing by secondary intention occurred without need for surgical re-intervention. Of 6 patients who developed soft tissue related complications, 2 were diabetic, 1 had rheumatoid arthritis and 1 was alcohol dependent. The other 2 patients had no associated co-morbidities.

In 3 patients, one of the distal lateral-to-medial locking screws backed out and became prominent, necessitating removal under local anaesthesia. Another patient required removal of both proximal tibial locking screws and the postero-anterior calcaneal screw for ongoing pain at these sites, despite the screw heads not being palpable.

Except for 2 patients, all other cases went on to radiological union as defined by visible bridging callus on biplanar plain radiography at 38–98 days and were full weight bearing without pain at time of final discharge. CT scan was obtained in 2 patients

Table 1
Indications for tibiotalocalcaneal arthrodesis.

Pathology	Straight nail	Curved nail
Osteoarthritis	4	6
Rheumatoid arthritis	2	2
Psoriatic arthropathy	1	0
Failure of ankle fracture fixation	1	1
Primary nailing of ankle fracture in elderly	1	0
Malunion/nonunion of tibial plafond fracture	1	1
Idiopathic avascular necrosis of talus	1	1
Post-traumatic avascular necrosis of talus	1	0
Stage 4 tibialis posterior insufficiency	0	2
Neuromuscular disorder	1	1
Conversion of total ankle replacement to TTC	0	1
Total	13	15