Tibiotalocalcaneal Arthrodesis Utilizing a Titanium Intramedullary Nail with an Internal Pseudoelastic Nitinol Compression Element

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Category: Ankle,Ankle Arthritis,Hindfoot,Trauma

Keywords: Tibiotalocalcaneal Arthrodesis Arthritis Nitinol Intramedullary Nail Dynamic Compression Union Charcot

Introduction/Purpose: Fusion construct stability and compression across arthrodesis sites must be optimized in tibiotalocalcaneal (TTC) arthrodesis using a retrograde locking intramedullary nail. Compression generated with modern TTC nails may dissipate with time, theoretically caused by settling of the arthrodesis surfaces and bone resorption during the early phase of bone healing. One millimeter of bone resorption has been shown to dramatically decrease compressive forces across an arthrodesis site. An arthrodesis nail with an internal pseudoelastic nickel titanium alloy (nitinol) compression element has the potential to create sustained compression across tibiotalar and subtalar arthrodesis surfaces. The purpose of this study is to evaluate the effectiveness of this nail in creating and sustaining compression across the tibiotalar and subtalar joints and to report rates of both union and complications.

Methods: In this retrospective case series, we hypothesize that union rates will be higher than those reported in the literature. Secondly, we aim to define a more precise CT-based fusion rate for tibiotalocalcaneal arthrodesis. Finally, we aim to provide in vivo evidence of dynamic compression via the internal pseudoelastic nitinol element.
A query of the OrthoCarolina administrative database was performed based on the CPT codes for tibiotalar and subtalar arthrodesis from January 2013 to June 2016. CT scans were reviewed on a cut-by-cut basis using sagittal reformats to calculate a percentage of joint surface bony union; at least 50% joint surface bone bridging was used to define union. Intra-operative and post-operative radiographs were calibrated and reviewed in order to measure subsidence (thus continual compression postoperatively) of the nitinol element relative to the intramedullary nail, using the PA screw as a reference.

Results: 20 patients were identified and included in analysis. Three patients were excluded. A median of 93% and 84% of the tibiotalar and subtalar joint surfaces united, respectively. Union rate of arthrodesis surfaces among patients without Charcot was 94%. Three patients had Charcot osteoarthopathy and five had talar avascular necrosis; a history of Charcot was a risk factor for nonunion ($p=0.04$). 87% of all arthrodesis surfaces united. 79% of patients went on to both tibiotalar and subtalar union. The PA screw was found to travel an average of 3.5 mm from intra-operative to initial 2-3 week post-operative radiographs ($p<0.0001$), providing additional compression postoperatively. 4 revision surgeries were required at a median 9 months post-operative, 2 for deep infection but 0 for delayed or nonunion.

Conclusion: Regarding the primary outcome measure, arthrodesis union based on CT scans using a conservative 50% joint surface bone bridging cut-off to define union, the rate of union was high even in the face of challenging clinical scenarios. The percentage of arthrodesis surfaces that fused was higher than anticipated. Unloading of the pseudoelastic nitinol element occurred over the first 2-3 post-operative weeks and represents in vivo evidence that the dynamic compression generated by this nail works.

Foot & Ankle Orthopaedics, 2(3)
DOI: 10.1177/2473011417S000171