Outcomes and Management of Infected Intramedullary Nails used for Tibiotalocalcaneal Arthrodesis in Limb Salvage: A Retrospective Case Series

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STATEMENT OF PURPOSE

The purpose of the current study is to report on the outcomes of patients undergoing revision of infected tibiotalocalcaneal arthrodesis (TTCA) for limb salvage in a high-risk patient population. In addition, we aim to describe our staged management protocol for infected intramedullary nails utilizing antibiotic rods, implanted antibiotic coated nails or antibiotic impregnated block spacers.

INTRODUCTION

Complex hindfoot and ankle deformities due to pes planovalgus, cavovarus, trauma, or neurological disorders such as Charcot neuroarthropathy (CN) present a unique challenge to the foot and ankle surgeon. Several constructs including plates, screws, intramedullary nails, and external fixation have been utilized to create a stable, plantigrade foot for ambulation. Arthrodesis of the ankle and subtalar joint with intramedullary nail fixation for control of hindfoot and ankle deformities has become increasingly popular because of its load sharing characteristics and increased stiffness of the construct. [1-10]

Tibiotalocalcaneal arthrodesis (TTCA) results in severe stiffness and limitation in global foot function and is generally reserved for salvage procedures. The use of TTCA via retrograde intramedullary nail (IMN) fixation to achieve a rectus alignment of the hindfoot and ankle is a well-described technique for significant deformity correction and limb salvage.[2-10] Although successful limb salvage rates have been reported, TTCA via IMN has several reported major complications including persistent pain, osteomyelitis, tibial stress fracture, nonunion, malunion, hardware failure, and limb loss. Reported complication rates vary quite significantly in the literature with nonunion rates ranging from 0 – 71%,[2,3,5,8-10] and an average overall complication rate as 55.7%. [1]

Infected intramedullary nails require revision surgery with debridement and antibiotic management to adequately treat and establish an infection free and functional limb. Infection rates are noted to be higher in patients undergoing TTCA secondary to the possible presence of complicated diabetes and are potentially limb threatening because of anatomic location.[2,11,15] Local management of infected IMN via antibiotic coated wire or IMN fixation has been reported for both tibial and femoral fractures with good success.[21,22] Revision of infected TTCA with IMN fixation also show moderate to good success, but reports are limited to small case series and case reports.[11,13]

METHODS

A comprehensive search of the surgical database of the senior author (PRB) was performed to find for patients who had undergone hindfoot or ankle arthrodesis from January 1st, 2006 to December 31st, 2016. The patients were then narrowed to those with primary arthrodesis via intramedullary nail fixation. Review of the patient database revealed 119 procedures with IMN fixation performed over the study period. Included patients had to have primary TTCA performed by the senior author (PRB), were > 18 years of age, had a minimum follow-up of 1 year, and had confirmed infection via soft tissue or bone culture. In addition, only those who underwent removal of IMN with revision via staged protocol were investigated. Only 19 patients met our inclusion criteria., Charts and radiographs were reviewed to determine demographics, co-morbidities, and outcomes. Outcomes measures included mortality, proximal amputation, persistence of antibiotic rod, and utilization of bracing.

Indication	n (%)
Charcot neuroarthropathy	10 (52.6)
Post-traumatic arthritis	2 (10.5)
Osteoarthritis	2 (10.5)
Equinovarus deformity	7 (36.8)
Avascular necrosis of talus	2 (10.5)
Failed total ankle replacement	1 (5.3)
Revision arthrodesis/nonunion	1 (5.3)

Table 1. Indications for index procedure (n=19 patients)

RESULTS

Antibiotic impregnated PMMA coated wires and block spacers were used for revision of infected TTCA in 19 patients. Seven female and 14 male patients (age range, 22 - 76 years) were included in the study. The average body mass index (BMI) at preoperative appointment was 36.4 ± 12.7 kg/m^2 (range, 18.7 - 60.9 kg/m^2). Diabetes Mellitus, peripheral neuropathy, history of ulceration, and current or former smoker were common variables among the study population (Table 1). One half of the diabetic patients (n=12) were insulin dependent (n=6). Glycemic control was reported with hemoglobin A1c (HbA1c) values within 3 months of the initial surgery. Data was available for 13/19 patients and 10/12 diabetic patients. The average HbA1c was 5.87% ± 0.32% in the non-diabetic population and 7.87% ± 1.59% in the diabetic population. Less common preoperative variables included autoimmune disorders and peripheral arterial disease. Patients most commonly underwent the initial TTCA for Charcot neuroarthropathy and for acquired equinovarus deformities (Table 2). While most patients had one indication for surgery, 6/19 patients had two indications for their procedure (i.e. equinovarus deformity with osteoarthritis or avascular necrosis of the talus with failed total ankle replacement).

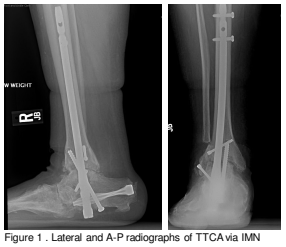

Figure 1 . Lateral and A-P radiographs of TTCA via IMN

Variable	
Age (y), mean ± SD	49.5 ± 12.9
Female, n (%)	7 (36.8)
Left side, n (%)	11 (57.9)
BMI (kg/m^2), mean ± SD	36.4 ± 12.7
Diabetes Mellitus, n (%)	12 (36.2)
Insulin use, n (%)	6 (33.3)
HbA1c (%)	
Non-diabetic	5.87 ± 0.32
Diabetic	7.87 ± 1.59
Tobacco use (current or former), n (%)	10 (52.6)
History of ulceration, n (%)	13 (68.4)
Peripheral neuropathy, n (%)	16 (84.2)
Peripheral arterial disease, n (%)	4 (21.1)
Autoimmune disorder, n (%)	1 (5.3)

Table 2. Patient demographics (n=19)

The mean time to revision following the primary TTCA procedure was 56.6 ± 61.4 weeks. The average follow-up duration was 115.9 ± 92.9 weeks following the first revision procedure performed. An overall successful limb salvage was obtained in 14/19 (73.7%) patients and limb loss was observed in 5/19 (26.3%). Three of 19 (15.8%) patients were deceased within the follow-up period. Two of the deceased had undergone below knee amputation while one had a salvaged limb at time of death. Among those with below knee amputation, the average time to first revision was 23.0 ± 11.9 weeks compared with 68.5 ± 67.8 weeks in those who did not have amputation (p = 0.0878). Odds of below knee amputation were higher among our non-smoking and insulin patient cohorts. Odds were 0 among the smoking group and 1.25 among the non-smoking group (p = 0.0108) while odds were 2 in the insulin group compared with 0.09 in the non-insulin group (OR = 22, p = 0.0217). None of the remaining preoperative variables or indications for surgery showed any statistically significant relationship with amputation outcomes

RESULTS (CONT)

For the patients that were deceased within the follow-up period, only one pre-operative variable had any statistically significant relationship. The body mass index was significantly higher in the deceased cohort (50.5 ± 16.56 kg/m^2) compared with 33.7 ± 10.1 kg/m^2 in the living group. Eleven (57.9%) of the patients were utilizing some form of external bracing and 7 (36.8%) of patients had retained antibiotic coated rod or wire at final follow-up. It was found that the average time to revision was significantly longer in those who had bracing (82.8 ± 71.0 weeks) compared with those who did not (20.3 ± 10.0 weeks) have bracing at final follow-up (p = 0.0043). None of the preoperative variables or indications for initial procedure showed any statistically significant relationships with presence of retained antibiotic coated rod or wire.

Variable	
Time to revision (wk), mean ± SD	56.6 ± 61.4
Follow-up time (wk), mean ± SD	115.9 ± 92.9
Total number of procedures, mean ± SD	6.16 ± 2.63
Below knee amputation, n (%)	5 (26.3)
Deceased, n (%)	3 (15.8)
Retained antibiotic rod, n (%)	7 (36.8)
Bracing, n (%)	11 (57.9)

Table 3. Outcomes. Data presented as mean standard ± deviation or n (%).

DISCUSSION

Our surgical approach is similar to a previous case report published out of our institution (Woods) and is in line with current orthopedic literature. First, infection control is obtained by removal of all infected hardware and with culture guided local and systemic antibiosis. Vancomycin and/or aminoglycoside antibiotics are delivered at high concentrations locally by elution from PMMA bone cement and systemic antibiotics are utilized for 6 weeks. The patient is monitored closely for clinical and laboratory evidence of resolution of infection, and if warranted, may require subsequent irrigation and debridement procedures with exchange of the antibiotic coated rod. In cases of severe bone loss or instability antibiotic spacers and external fixation may be required for stability. Once the patient is thought to have resolution of infection from a clinical and radiographic standpoint, intraoperative frozen sections and/or cultures are utilized for confirmation prior to definitive hardware placement. Appropriate management of intramedullary infection secondary to TTCA is critical to minimize risk of limb loss. Proximal amputations have a dramatic effect on patients' quality and duration of life. (Lerner) This critical understanding of the management of infected intramedullary nails has been recognized and well documented in the orthopedic literature. (Qiang, Reilly, Paley, Thonse, Sancineto)

Figure 2: (A)Clinical picture of infected extremity. (B-C) A-P and lateral radiographs with antibiotic coated wire. (D) Permanent antibiotic rod.

DISCUSSION (CONT)

Only a few small studies address infection with TTCA. One study by Bibbo et al in 2003 prospectively evaluated 5 patients with infected TTCA with retrograde IMN fixation[12]. At the conclusion of their study, all patients were clinically free of infection (average 20.2 months). Two of their patients achieved stable pseudoarthrosis, one had fusion with second IMN, one still had an antibiotic nail, and one had an elective amputation for chronic pain despite negative cultures following therapy. A second study by Pawar et al. in 2013 reports on 5 patients with infected neuropathic ankles treated with antibiotic impregnated polymethylmethacrylate (PMMA) coated IMN[11]. The average time to radiographic union was reported as 4.1 months and there was no reported recurrence or hardware failure within the follow up period, which averaged 18 months (12-24). A case report by Woods et al. supports the idea of permanent fixation by Thonse et al. and suggests that permanent antibiotic impregnated nail may provide adequate long-term results[14,15]. Monaco et al present another approach in a case report, which suggests use of fibular strut graft following eradication of infection with temporary antibiotic coated rod[13].

Retrograde intramedullary nail fixation for TTCA has been shown to be a successful means of limb salvage in complicated patient cohorts with overall limb salvage rates of 76%-100%[1,8,10,16,17]. Overall complication rates range from 17% - 70%[3,8,10]. Jehan et al performed a systematic review of 613 patients and report an overall average of 55.7% complications, 8.4% infection and 1.5% amputation rate[1]. Wukich et al demonstrated similar findings in their review of 342 diabetic patients with CN with an average infection rate of 22% compared with 13% infection for the 979 total patients included in their review[16]. Their dataset mirrored this with a 29.5% aggregate infection rate in their diabetic patient cohort compared with 21.4% in their non-diabetic group. Although our study does not look at overall complication rates observed in our entire TTCA patient cohort, it does demonstrate 19/119 (16.0 %) patients undergoing revision for deep infection, which is very similar to the 16.4% and 17.9% rates of deep infection for diabetic and non-diabetic patient cohorts respectively reported by Wukich et al.. Management of infected TTCA via retrograde IMN with our staged protocol has shown good limb salvage rates in a complicated cohort of patients. The overall limb salvage rate of 14/19 (73.7%) within our study period seems to be a reasonable outcome considering the nature of a revision procedure for infected TTCA, which is already considered a last resort in attempting limb salvage.

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