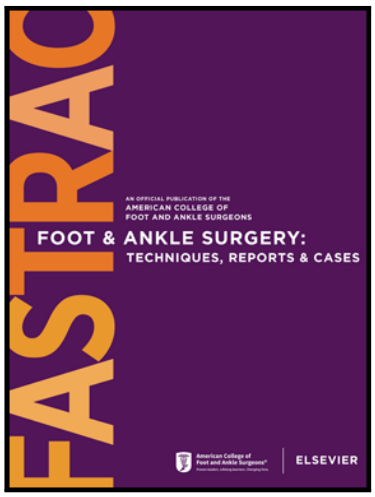

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Tibiotalocalcaneal Arthrodesis for the Treatment of Midfoot Charcot Neuroarthropathy

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Abstract:

Charcot neuroarthropathy of the foot and ankle is a destructive disorder resulting in severe and debilitating deformity. The goal of surgical reconstruction in Charcot neuroarthropathy is to create a stable, plantigrade foot that is amenable to bracing and offloading. Many reconstruction methods have been described in the literature including ostectomy of osseous prominences, realignment ostoeotmies, intramedullary midfoot beaming, plate fixation and external fixation. In this study we describe the use of tibiotalocalcaneal arthrodesis with intramedullary nail fixation for the treatment of midfoot Charcot neuroarthropathy in 12 consecutive patients. The mean age of our patient population was 61.33 years, mean BMI was 37.03 kg/m^2, 9 patients were type II diabetics, 2 patients were type I diabetics and 1 patient had a diagnosis of idiopathic neuropathy without underlying diabetes mellitus (DM). The mean duration of DM diagnosis was 24.73 years. 9 patients within the study population had suffered from chronic or recurrent ulcerations secondary to osseous deformity that had failed conservative treatment and 3 patients had residual ulceration at the time of surgery. Fusion was observed in 10 of 12 patients within the study. All patients had a functional, plantigrade foot post-operatively. Overall, 5 patients are ambulating in custom diabetic shoes without assistive devices while the remaining patients are ambulating with assistive devices. The results of this study indicate that tibiotalocalcaneal arthrodesis with retrograde intramedullary nail fixation for midfoot Charcot neuroarthropathy is a reliable treatment option to provide a stable, plantigrade, braceable foot.

Level of Evidence: IV- Case Series

Keywords: charcot neuroarthropathy, tibiotalocalcaneal arthrodesis, limb salvage, diabetes

Introduction:

Charcot neuroarthropathy (CN) of the foot and ankle is a destructive disorder resulting in severe and debilitating deformity secondary to pathological fracture and dislocation (1-7). This is generally a manifestation of pathological loss of neurological function leading to secondary vascular compromise. This coupled with repetitive, insensate micro trauma can lead to pathologic fracture and eventual collapse of the pedal arch (8-9). These deformities can result in ulceration due to elevated pressures from underlying osseous prominences or dislocations (10). The inherent instability of the charcot foot can make conservative treatment such as bracing exceptionally difficult leading to wound complications (1-5).

Diabetes is the most common cause of peripherial neuropathy in the developed world (11). While CN is generally characterized as a complication of chronic diabetes, this pathology can also be caused by other pathologies which induce peripheral neuropathy. These include chronic alcoholism, trauma, meningomyelocele, spinda bifida, syringomyelia, leprosy, syphyillis, and

idiopathic peripheral neuropathy (8). The incidence on CN in neuropathic non-diabetic patients is 1% and is 0.1-13% for neuropathic diabetic patients (11).

Traditionally, the initial treatment of CN in the foot and ankle has been non-operative, using offloading devices such are short leg casts or Charcot restraint orthotic walker devices with the goal being to maintain a plantar grade pedal structure following the coalescence phase of the pathology. In those cases where there is prominent or significant angular deformity, surgical intervention is often times indicated. Due to such difficulties with conservative treatment, surgical reconstruction and stabilization of these deformities may be necessary when appropriate (2-5).

The goal of surgical reconstruction in CN is to create a stable, plantigrade foot that is amenable to bracing and offloading. Many reconstruction methods have been described in the literature including ostectomy of osseous prominences, realignment ostoeotmies, intramedullary midfoot beaming, plate fixation and external fixation (12). To our knowledge no previous studies have described the efficacy of tibiotalocalcaneal (TTC) arthrodesis for the treatment of midfoot CN. The purpose of this study is to retrospectively review our patient population that has undergone midfoot Charcot neuroarthropathy salvage with TTC arthrodesis with intramedullary nail fixation. We propose that creating a rigid construct of the hindfoot and ankle allows for stabilization of the midfoot to prevent progression of the Charcot deformity and ultimately allow for a plantigrade, braceable foot.

Patients & Methods:

Following approval of the study through the institutional review board, we retrospectively analyzed all patients with a diagnosis of Charcot neuroarthropathy undergoing reconstruction between July 2017 and March 2020. Patients were identified for inclusion through current procedural terminology (CPT) code 27870 and 28725. Inclusion criteria were diagnosis of midfoot Charcot neuroarthropathy (Brodsky Type 1), TTC arthrodesis, completed operative note, pre-operative and post-operative radiographs and 12 month follow up post-operatively. Exclusion criteria included workers compensation and cancer diagnosis. Operative notes were utilized to determine procedures performed. Postoperative notes were utilized to identify the use of assistive devices postoperatively, postoperative complications, as well as, return to activities. Postoperative radiographs were independently reviewed by 4 co-investigators. Postoperative radiographs were utilized to determine osseous union at the TTC arthrodesis site, as well as, maintenance of correction of the midfoot deformity and hardware failure.

All patients were treated surgically with TTC arthrodesis. Midfoot osteotomies were performed in all patients to remove osseous prominences and to allow for a plantigrade foot. Achilles tendon lengthening or tenotomy was performed in all patients to reduce the plantar pressures about the forefoot following arthrodesis. No fixation was applied to the midfoot in any patient within the study population. The ankle and subtalar joints were prepped in standard fashion with curettage, rotary burr and subchondral drilling. All surgeries were performed by the senior author (RM).

Results:

We identified 12 consecutive patients (9 males and 3 females) with a diagnosis of midfoot Charcot neuroarthropathy who underwent TTC arthrodesis via retrograde intramedullary nail fixation between July 2017 and March 2020. Their mean age was 61.33 years (43 to 79 years). The mean BMI of the patient population was 37.03 kg/m^2 (30.3 to 55.8). Three patients were morbidly obese with a BMI greater than 40 kg/m^2. In all, 9 patients were type II diabetics, 2 patients were type I diabetics and 1 patient had a diagnosis of idiopathic neuropathy without underlying diabetes mellitus (DM). The mean duration of DM diagnosis was 24.73 years (8 to 69 years). Overall, glycemic control was poorly controlled in our study population with a mean HbA1c of 7.9% (6.4 to 11.7%). A total of 8 patients had a diagnosis of chronic kidney disease while 2 patients had a diagnosis of diabetic retinopathy. In total 9 patients within the study population had suffered from chronic or recurrent ulcerations secondary to osseous deformity that had failed conservative treatment. Of these, 3 patients had residual ulceration at the time of surgery. Patient demographics can be found in Table 1.

Fusion was observed in 10 of 12 patients within the study at an average of 14.2 weeks (12 to 18 weeks). Both non-unions were asymptomatic. All patients had a functional, plantigrade foot post-operatively. At 1 year post-op no patient had developed recurrent ulcerations. Overall, 3 patients were ambulating in CROW boots while 4 patients were ambulating in custom diabetic shoes with double upright ankle foot orthoses and the remaining 5 patients were ambulating in custom diabetic shoes without assistive devices.

We did not identify any signs of hardware failure during the study period. No patient required reoperation on the ipsilateral limb during the study period. No patients within the study

population went on to proximal amputation during the study period. Pre and post-operative radiographs are seen in Figures 1 and 2 demonstrating stable midfoot CN without progression and plantigrade foot architecture following TTC arthrodesis.

Discussion:

In addition to restoring lower extremity stability and function with arthrodesis of the hindfoot and ankle, Shibata and colleagues demonstrated relative protection of the midfoot joints in patients who underwent tibiotalar and tibiocalcaneal arthrodesis. Of the 15 patients in their series who achieved solid fusion, they reported no remarkable degenerative changes to the midfoot joints at final follow-up at an average of greater than nine years postoperatively. Additionally, Shibata and coworkers reported resolution of all clinical symptomatology, with exception of minor ulceration, in all patients who achieved successful arthrodesis (6). Several subsequent studies support these findings, including a recent study from Siebachmeyer and colleagues, who demonstrated a 100 percent limb salvage rate and 80 percent resolution of ulceration in their 20-patient cohort following correction of multiplanar deformities of the ankle and hindfoot via arthrodesis with intramedullary (IM) nailing (7). While intramedullary nail fixation is common current practice standard for hindfoot and ankle charcot neuroarthropathy to our knowledge there are no previous studies that demonstrate the effectiveness of tibiotalocalcaneal (TTC) arthrodesis with intramedullary nail fixation for midfoot CN.

Overall, this study demonstrated good results in patients with Charcot neuroarthropathy that underwent TTC fusion with intramedullary nailing. Our study population had a 100% limb

salvage rate and 0% re-ulceration rate during the study period. We achieved an 83.33% fusion rate within our study population with the patient's developing non-union being asymptomatic with restoration of ambulatory status. The results of the study indicates that creating a rigid construct of the hindfoot and ankle allows for stabilization of the midfoot and prevents progression of midfoot Charcot. This allows the creation of a plantigrade foot which is braceable allowing for ambulation.

With the CN patient population the ability to remain ambulatory or regain ambulatory status is critical for long-term health and reduced morbidity and mortality. We believe that one of the critical findings within this study is that during the 1 year follow-up there was no recurrence of ulcerations or development of new ulcerations. This is especially important when we consider the 9 patient's that had chronic or recurrent ulcerations and the majority of study participants had poorly controlled diabetes. This can go a long way in preventing further complications and potentially additional surgical intervention, amputation, or possible loss of limb. There is a heavy burden on the patient, the healthcare system, and an overall large financial burden for continued care of chronic wounds.

Additionally, we found that there were no failures in hardware whether that be breakage or loosening of fixation or position of fixation. The maintenance of hardware throughout the study period is an important finding to support the stability of this construct in the setting of CN. Much like the study by Shibata and colleagues demonstrated that hindfoot and ankle arthrodesis stabilized the midfoot in their study. We believe that the results of this study support those findings. No patient within our study population had progression of their CN

pathology with all patients having a stable, plantigrade foot at 1 year follow up and all patients being ambulatory.

There are limitations of the study with the retrospective nature of the study, low patient population, lack of advanced imaging to determine osseous union and relatively short follow up. However, we believe that the results of this study indicate the need for further evaluation of the use of TTC arthrodesis for the treatment of midfoot CN. CN is a difficult pathology faced by foot and ankle surgeons. With the diabetic population growing CN is likely to become even more prevalent and it is imperative that we as foot and ankle surgeons develop appropriate treatment options. Further, multi-center, prospective studies evaluating the efficacy of TTC arthrodesis for the treatment of midfoot CN will help us better understand the efficacy of this treatment option.

In conclusion, we believe that the use of intramedullary nailing of the rearfoot to achieve TTC arthrodesis for midfoot CN may provide a successful means to help manage this debilitating disease and restore functionality of this patient population.

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Figure 1: Pre-operative radiographs showing midfoot CN with collapse of the pedal arch.

Figure 2: Post-operative radiographs following TTC arthrodesis for midfoot CN showing stable, plantigrade foot without progression of CN.

Table 1:

Patient	Age	Gender	BMI	DM Type	Duration of DM	HbA1c	CKD	Retinopathy	Tobacco Status
1	69	Male	44.9	Type I	69	7.7	No	No	Never
2	46	Male	31.2	Type II	14	8.2	Yes	No	Never
3	79	Female	41.3	None	N/A		No	No	Former
4	77	Female	37.3	Type II	20	6.5	Yes	No	Former
5	61	Male	31.6	Type II	25	7.1	Yes	No	Never
6	53	Male	39.5	Type II	23	8.5	Yes	No	Current
7	43	Male	32.3	Type II	8	6.7	No	No	Never
8	52	Male	55.8	Type II	12	11.7	Yes	Yes	Never
9	59	Male	30.3	Type II	16	8.1	Yes	No	Never
10	77	Female	37.3	Type II	15	9.8	Yes	Yes	Former
11	59	Male	32.3	Type I	59	6.5	No	No	Never
12	61	Male	30.6	Type II	11	6.4	Yes	No	Never

DM = Diabetes Mellitus; CKD = Chronic Kidney Disease

Table 2: Location of Charcot Neuroarthropathy and Ulcer History

Patient	Charcot Location	Ulcer History	Ulcer at time of Surgery
1	Chopart	Yes	No
2	Lis Franc	Yes	No
3	Chopart	Yes	No
4	Chopart	Yes	No
5	Lis Franc	Yes	No
6	Chopart	Yes	Yes
7	Chopart	Yes	No
8	Chopart	Yes	Yes
9	Lis Franc	Yes	No
10	Chopart	Yes	Yes
11	Chopart	Yes	No
12	Lis Franc	Yes	No

Table 3: Surgical and Clinical Outcomes

Patient	Fusion	Fusion Wks	Reulceration	Recurrent Deformity	Functional	Gait Assistance	Re-operation	Amputation
1	Yes	18	No	No	Yes	DM Shoes, Double Upright AFO	No	No
2	Yes	14	No	No	Yes	DM Shoes	No	No
3	Yes	15	No	No	Yes	DM Shoes, Double Upright AFO	No	No
4	Yes	12	No	No	Yes	DM Shoes, Double Upright AFO	No	No
5	Yes	14	No	No	Yes	DM Shoes	No	No
6	No	N/A	No	No	Yes	CROW	No	No
7	Yes	14	No	No	Yes	DM Shoes	No	No
8	No	N/A	No	No	Yes	CROW	No	No
9	Yes	12	No	No	Yes	DM Shoes	No	No
10	Yes	13	No	No	Yes	CROW	No	No
11	Yes	14	No	No	Yes	DM Shoes, Double Upright AFO	No	No
12	Yes	16	No	No	Yes	DM Shoes	No	No

Figure 1a

Figure 1b

Figure 2a

Figure 2b