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An overview of conservative treatment options for diabetic Charcot foot neuroarthropathy

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Conservative management of Charcot foot neuroarthropathy remains efficacious for certain clinical scenarios. Treatment of the patient should take into account the stage of the Charcot neuroarthopathy, site(s) of involvement, presence or absence of ulceration, presence or absence of infection, overall medical status, and level of compliance. The authors present an overview of evidence-based non-operative treatment for diabetic Charcot neuroarthropathy with an emphasis on the most recent developments in therapy.

Keywords: *diabetic foot*; *osteomyelitis*; *Charcot neuroarthropathy*; *ulcer*; *bone stimulation*

The association between Charcot neuroarthropathy (CN) and diabetes mellitus was first described by Jordan in 1936 (1). Since that time numerous treatment protocols have been proposed for this potentially devastating condition. Early diagnosis and swift care are the keys to reducing amputation risk in this patient population. Conservative management remains efficacious for certain clinical scenarios. Treatment of the patient should take into account the stage of CN, site(s) of involvement, presence or absence of ulceration, presence or absence of infection, overall medical status, and level of compliance. The most commonly used classification is the three-staged system described by Eichenholtz: Stage I is the developmental or acute phase, Stage II is the coalescent or quiescent phase, and Stage III is the consolidation or reconstruction and reconstitution phase (2). Involvement of the midfoot is most common in the diabetic population and this site tends to be more amenable to conservative options versus hindfoot or ankle CN. Generally, conservative care for the CN foot and ankle has been recommended for the following scenarios: joints in the acute phase, deformities that are clinically stable and that do not compromise the soft tissue envelope, stable deformities without soft tissue or bone infection, patients who do not have adequate arterial perfusion to support surgical reconstruction, and those patients who are extremely high risk for anesthesia and surgical intervention due to the presence of multiple severe comorbid conditions. The authors present an overview of evidence-based non-operative treatment for CN with an emphasis on the most recent developments in therapy.

Immobilization and mechanical protection

The initial stage of CN is typically characterized by clinical erythema, warmth and swelling of the extremity, along with radiographic findings of bone fragmentation and debris with joint disruption and dislocation. Immobilization at this point is crucial to the prevention of further collapse and permanent deformity. Prolonged non-weight-bearing cast immobilization is typically advocated for at least 3 months to allow for resolution of acute inflammation and radiographic consolidation of fragmented bone. The total contact cast (TCC) has established an important role in the treatment of Stage I CN. In 2000, a survey of US orthopedic surgeons revealed that 80% of respondents used the TCC as their first-line therapy (3). This study pointed out, however, that there is some controversy regarding the necessity for complete non-weight bearing. The traditional TCC can be modified with a rigid rocker sole or a cast shoe to facilitate pressure reduction during ambulation. Many practitioners allow weight bearing in the TCC since most insensate patients will inevitably bear some weight on the affected limb during treatment. Proponents of the weight bearing TCC also cite the increased load stress on the

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contralateral limb that may have unfavorable consequences. A prospective study on 10 patients by Pinzur et al. (4) demonstrated successful treatment of Stage I CN using the weight bearing TCC with an average return to depth inlay shoes and custom orthoses in 9.2 weeks. Sinacore (5) showed longer healing times with the TCC when the site of CN involvement was at the ankle, hindfoot, or midfoot compared to that of the forefoot. Numerous fabrications of the TCC have been developed to help decrease cost of materials and length of time for application.

Case report

The authors have successfully used the TCC for patients in which surgical reconstruction was not indicated. One such patient was a 46-year-old female who had presented to our outpatient clinic with new onset swelling and redness of her left foot. She reported sustaining a twisting injury about 2 weeks prior but felt no pain at the time. She had noticed progressive difficulty in bearing weight to the affected foot. Her medical history was positive for poorly controlled diabetes mellitus, hypertension, and hyperlipidemia. She denied previous foot or ankle injuries or ulcerations, but admitted to numbness in both feet for the past few years. On physical examination, her vital signs were stable. Her left foot demonstrated strongly palpable pulses and non-pitting edema circumferentially about the midfoot and forefoot with erythema that dissipated upon elevation of the limb. She had no open wounds or tenting of the skin; however, there was notably increased temperature of the left foot compared to the contralateral side. Both feet revealed absent protective sensation when tested by Semmes-Weinstein 5.0 g monofilament. Radiographs of the left foot and ankle showed marked soft tissue swelling and subtle diastasis between the first and second metatarsal bases and between the medial and intermediate cuneiforms. Based on medical history, traumatic incident in the presence of peripheral neuropathy, as well as clinical and radiographic evidence, we diagnosed the patient with acute phase CN of the midfoot. She was immobilized in a non-weight-bearing TCC for 12 weeks with cast changes, clinical evaluation, and serial radiographs at 2-week intervals. Once we noticed resolution of edema, erythema, and warmth to the foot, along with radiographic evidence of coalescence at the midfoot, she was gradually transitioned to custom molded extra depth shoes with multidensity insoles and a double-upright ankle-foot-orthotic brace. Thereafter, she was able to regain full ambulatory status with a stable, plantigrade foot without preulcerative lesions or infection without complications (Figs 1 and 2).

In contrast to the TCC, the use of the patellar tendon-bearing brace (PTB) can help off-set the increased load on the contralateral limb. This brace has also been used in the treatment of diabetic foot ulcers. Saltzman et al. (6) established that the PTB reduced load transmission to the hindfoot but not at the midfoot or forefoot, therefore cautioned the importance of using it accordingly. The PTB has also been recommended for prophylactic protection of the contralateral limb during immobilization of the involved foot and/or ankle. Clohisy and Thompson (7) found evidence of CN on the contralateral limb after an average of 4.5 months in such cases. The Charcot Restraint Orthotic Walker (CROW) is a long-term custom device that essentially serves as a removable TCC (8). The device is a custom molded, full-foot enclosure consisting of a polypropylene outer shell, rocker sole, and plastizote padded inner lining (Fig. 3). The CROW was initially developed for use in Stage I CN; however, more recently it is also proving useful in Stage 3 to maintain foot and ankle alignment. Koller et al. (9) advocate the CROW for patients following surgical reconstruction, specifically after external fixation procedures. It is important to note that design and efficacy of the removable walker device relies heavily on patient compliance.

Once the CN has progressed to Stage 3, commercially available orthopedic footwear is recommended. Forefoot and midfoot deformities can be accommodated by full-length multidensity inserts and extra depth shoes. Severe midfoot deformities require the fabrication of custom shoes to accommodate the misshapen foot. Mild rearfoot deformities may tolerate a high-top custom-molded shoe with a full-length orthotic device. Moderately unstable ankle deformities may benefit from a solid ankle foot orthoses and a therapeutic shoe. Severely unstable rearfoot deformities require a PTB brace in a custom shoe. Similar recommendations exist for use of custom footwear and/or bracing following surgical reconstructions of CN. Further studies are needed with regard to these modalities as there are currently no randomized controlled trials available for the application of TCC, CROW, PTB, or orthopedic bracing and footwear in CN patients.

Bone growth stimulation

First developed in the 1950s and commonly used in fracture care, electrical bone stimulation has become popular in the treatment of CN due to its ability to stimulate osteogenesis in the early stages of the disease (10). Fitzsimmons and Baylink (11) performed cell culture studies showing that low-energy electromagnetic fields stimulate insulin-like growth factor II, which increases calcium flux and is associated with increased rate of bone cell proliferation. Hanft et al. (12) used combined magnetic field bone stimulation on patients with Stage I CN for 30 min daily in addition to off-loading and demonstrated a statistically significant reduction in time to consolidation when compared to control subjects (11 weeks vs. 23.8 control). Additionally, Strauss and Gonya (13) showed accelerated bone healing

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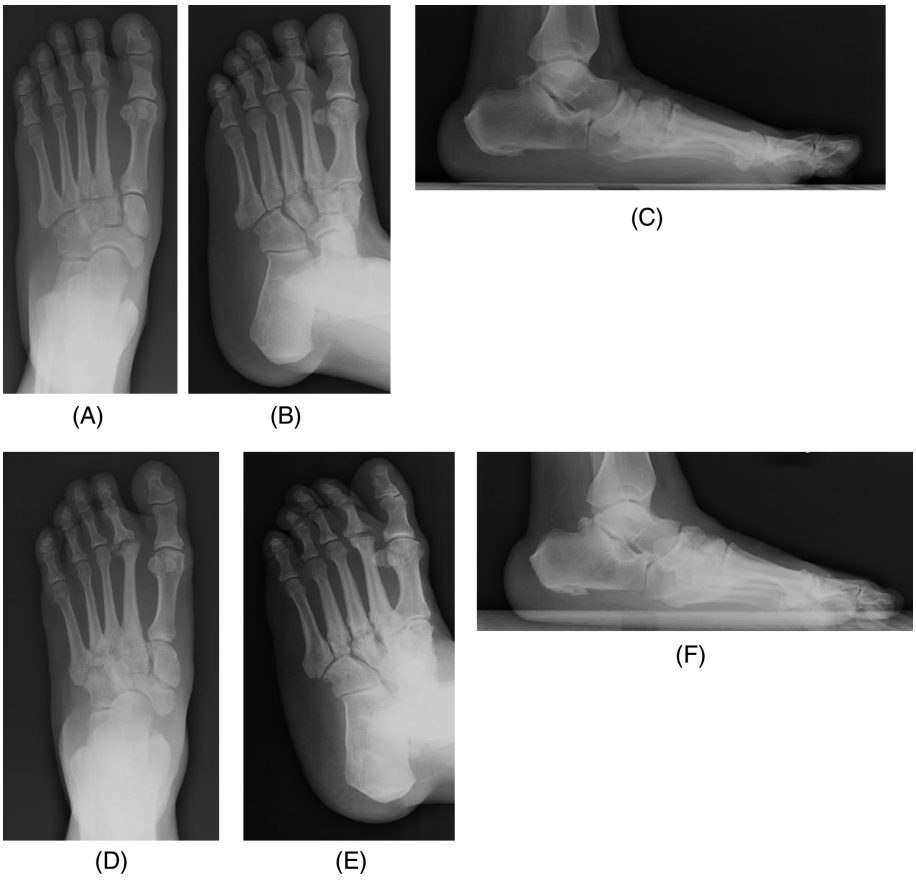

Fig. 1. Initial clinical presentation of an acute Charcot foot neuroarthropathy at the midfoot level with radiographic bony fragmentation and minimal collapse (A–C). Patient had no history of any open wounds or osteomyelitis and was eventually treated with strict immobilization, total contact casting, and progression into diabetic custom molded shoe gear and bracing. Final radiographic views at 1-year follow-up showing bony consolidation and no further progression of the deformity (D–F).

with the use of low intensity ultrasound for a Charcot subtalar and ankle joint arthrodesis. Both implantable and external devices are available. Surgeons have used bone stimulators in conjunction with other reconstructive procedures, however, the magnitude of their benefit is yet unknown (14).

Drug therapy

Due to bone mineral density alterations in CN patients manifested by localized osteopenic changes, bisphosphonates have been tested for their benefit with off-loading in Stage I. Bisphosphonates are pyrophosphate analogs that inhibit osteoclastic bone resorption and are commonly used in treatment of conditions characterized by abnormal bone turnover. Pamidronate is the most commonly used and acts by attaching onto hydroxyapatite crystals in newly synthesized bone matrix, blocking access of osteoclast precursors to this matrix. Jude et al. (15) performed a randomized double-blind placebo-controlled 39 patients with active Charcot in which a single 90 mg pamidronate infusion was administered and standard off-loading provided while foot temperatures, symptoms, and bone turnover markers were measured over 1-year. There was a statistically significant reduction in bone turnover, symptoms, and disease activity. Similarly, Pitocco et al. (16) showed significant reduction in bone resorption markers with the use of another bisphosphonate alendronate and noted clinical improvements in the CN foot at 6 months.

Briefly, activation of osteoclasts involved in osteolysis is accomplished by the nuclear transcription factor NF-κB. The expression of NF-κB is induced by the cytokine RANK-L, which is accompanied by increased production of osteoprotegerin (OPG). The RANK-L/OPG system's theoretical role in osteopenia associated with diabetic neuropathy led to the development and use of intranasal salmon calcitonin for treatment of acute CN. A randomized controlled trial by Bem et al. (17) was performed on 32 acute CN patients administered 200 IU daily, showing reduction in markers of bone turnover as well as a decreased time to healing. This therapy has shown fewer complications compared to bisphosphonate use. Potential therapeutic agents that also have a direct effect on the RANK-L/OPG system in addition to

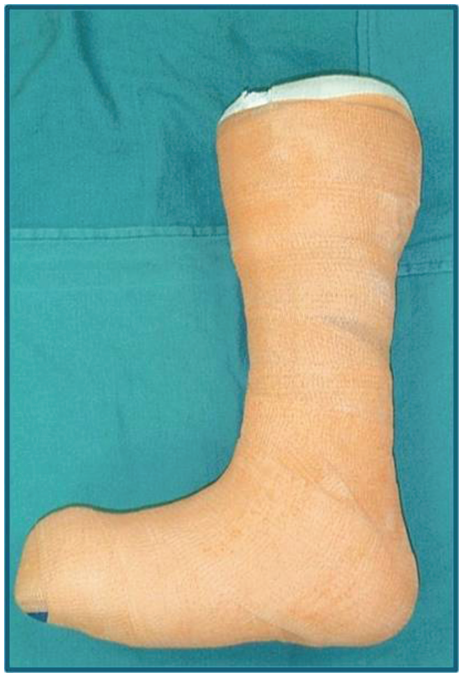

Fig. 2. Clinical picture of a total contact cast (TCC) typically used at our institution.

calcitonin are inhibitors of tumor necrosis factor-α (TNF-α), glucocorticoids and non-steroidal anti-inflammatories. Jeffcoate (18) has also mentioned other future options including synthetic OPG and RANK-L antagonists and other inhibitors of NF-κB and TNF-α.

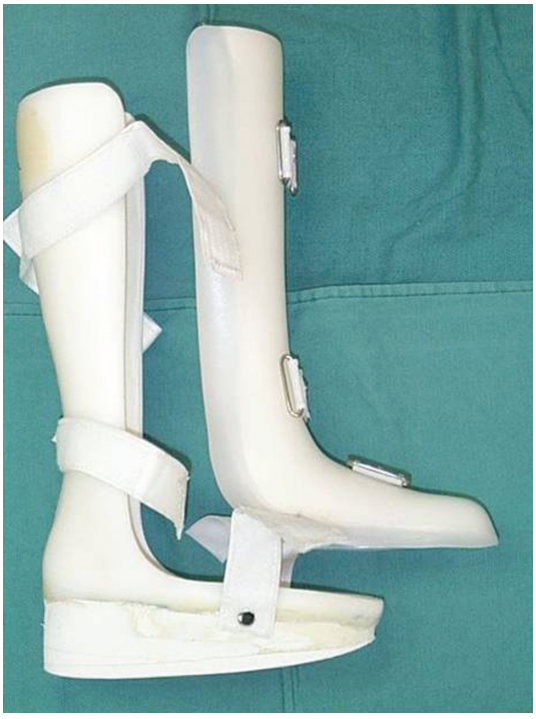

Fig. 3. Clinical photo of the Charcot Restraint Orthotic Walker (CROW) used at our institution.

Conclusion

Conservative options continue to evolve in their indications for the treatment of the CN foot and ankle. The modalities discussed within this article provide a wide variety of options; yet, a further higher level of evidence studies is warranted. There is no doubt that there are specific indications for conservative management versus surgical. Regardless of the chosen treatment pathway, all protocols should be specific to the patient based on their lower extremity pathology, overall medical status, and ability to comply with the given therapy.

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