

# Charcot Foot: An Overview of the Pathophysiology and Conservative Treatments

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*NOTE: As with any case study, the results and outcomes should not be interpreted as a guarantee or warranty of similar results. Individual results may vary depending on the patient's circumstances and condition.*

## OVERVIEW

Charcot neuropathic osteo-arthropathy (CN), commonly known as Charcot foot, is an uncommon syndrome that typically manifests in the diabetic patient. In spite of distinct pathognomonic features, this deformity is commonly misdiagnosed. Common pathologies mimic CN consequently deviating the clinician from making the correct diagnosis. The Charcot foot is a significant lower extremity complication that can ultimately result in bone/joint deformity, ulceration and increase the possibility of limb loss.

## EPIDEMIOLOGY

CN currently affects only 1% of diabetics<sup>1,2</sup>. However it has been reported in 29% of diabetic patients who present with peripheral neuropathy and a loss in proprioception<sup>1,2</sup>. The survival rates for diabetic amputations at 5 years are only 50%<sup>1,2</sup>.

## PREDISPOSITIONS

Charcot syndrome may manifest itself in patients with a wide spectrum of unrelated diseases stemming particularly from nerve damage. This pathology may be exacerbated

or activated by:

- Toxins and or infections<sup>4</sup>
- Spinal cord diseases (tabes dorsalis, syringomyelia)<sup>4</sup>
- Parkinson's<sup>4</sup>
- HIV<sup>4</sup>
- Sarcoidosis<sup>4</sup>
- Rheumatoid disease<sup>4</sup>

Peripheral polyneuropathy is a common manifestation caused by chronic alcoholism<sup>10</sup>. Nutritional deficiencies in thiamine secondary to alcohol toxicity can damage the integrity of the peripheral nervous system (autonomic,

motor and sensory elements)<sup>10</sup>. This can cause paraesthesias, pain, polyneuropathy and weakness in the lower extremity making these patients susceptible to CN<sup>10</sup>.

Loss of proprioceptive sensation disrupts the body's biomechanical gait cycle that leads to abnormal loading<sup>4</sup>. This disruption can cause joint collapse and fractures within compromised areas of the lower extremity<sup>4</sup>. Motor neuropathy could potentially result in foot and ankle structural deformation (overstressed plantar arch - distal clawing)<sup>4</sup>.

## **PATHOPHYSIOLOGY**

The pathogenesis of CN is based on a series of complex biochemical, biomechanical and physiologic processes. Autonomic neuropathy disrupts the integrity of the smooth muscle tonus on the arterial wall<sup>3</sup>. This leads to inadequate vaso-regulation and an increase in blood flow to the bone<sup>3</sup>. Consequently, osteoclasts and monocytes storm the affected site causing an increased bone resorption rate that eventually results in osteopenia<sup>3</sup>. This makes lower limb structures more susceptible to dislocations, fractures, and joint collapses. It has been found that the insensate foot is more prone to repetitive unrecognized traumas due to abnormal gait cycles<sup>3</sup>. Chronic inflammation to the damaged site triggers a cascade of events that ultimately leads to CN<sup>4</sup>. The homeostatic balance between anti and pro inflammatory cytokines that help maintain the inflammatory process is compromised<sup>4</sup>. The figure below will give clinicians an idea on the

mechanism behind the "RANKL-RANK" pathway. (Figure 1)

## **DIAGNOSIS**

Diagnostic modalities include: X-rays, CT, bone scans, and MRI. Imaging is an integral factor in the early and diagnostic phases of CN<sup>11</sup>. It should be noted that MRI's are the most sensitive image study in the detection of early/acute stages of CN<sup>11</sup>. Additionally, MRI's may be able to help clinicians distinguish and differentiate between acute neuro-arthropathy from acute osteomyelitis<sup>11</sup>. Other testing may include Ceretec or Indium white blood cell scans. While a triple phase bone scan lacks specificity in the diagnosis of osteomyelitis, it may be used in conjunction with other image studies (MRI, Ceretec) for dual peak imaging<sup>16</sup>. However, despite the specificity and sensitivity of several of these techniques, a diagnosis of Charcot versus osteomyelitis remains challenging especially in the presence of ulceration.

Initial symptoms and manifestations of Charcot syndrome maybe mild but can become significant if unperceived repetitive trauma remains unabated. Key diagnostic - pathognomonic features should include the following components for abnormalities:

- Vascular<sup>4</sup>
- Neurological<sup>4</sup>
- Radiographic<sup>4</sup>
- Musculoskeletal<sup>4</sup>

Some early clinical findings include a warm, swollen and erythematous foot with

discomfort and pain in an otherwise insensate foot<sup>4</sup>. Most of the affected population with Charcot syndrome will present with well-preserved vascularity or even amplified arterial blood flow at the designated region<sup>4</sup>. The "washed out" appearance of the bones may be directly correlated to this phenomenon. Due to overlapping symptomatic features, early clinical symptoms can be misdiagnosed as deep vein thrombosis, infection, or acute gout among others<sup>4</sup>. Charcot syndrome patients typically display the classic "rocker-bottom" foot with or without plantar ulceration (Figure 2,3)<sup>4</sup>. Charcot foot is most commonly seen in the mid-foot, however can occur in the digits, forefoot, and ankle. The Eichenholtz classification system is one of the most utilized protocols to pinpoint the evolution of this syndrome based on key pathologic observations (Figure 4).



Figure 2. CN patient



Figure 3. CN patient who presents an ulceration on the medial aspect of the midfoot.

## **CONSERVATIVE TREATMENT**

Conservative management often remains an effective option. Treatment of the patient should factor in the stage of Charcot syndrome, site(s) of involvement, presence or absence of chronic ulceration, presence or absence of infection, overall medical status, and level of compliance<sup>5</sup>.

## **OFFLOADING**

In cases of acute Charcot foot, offloading is paramount<sup>17</sup>. The Charcot Foot in Diabetes Consensus Report advocates immobilization and offloading at the acute stage of CN to prevent progression of deformity<sup>12</sup>. It is recommended that non-weight bearing cast

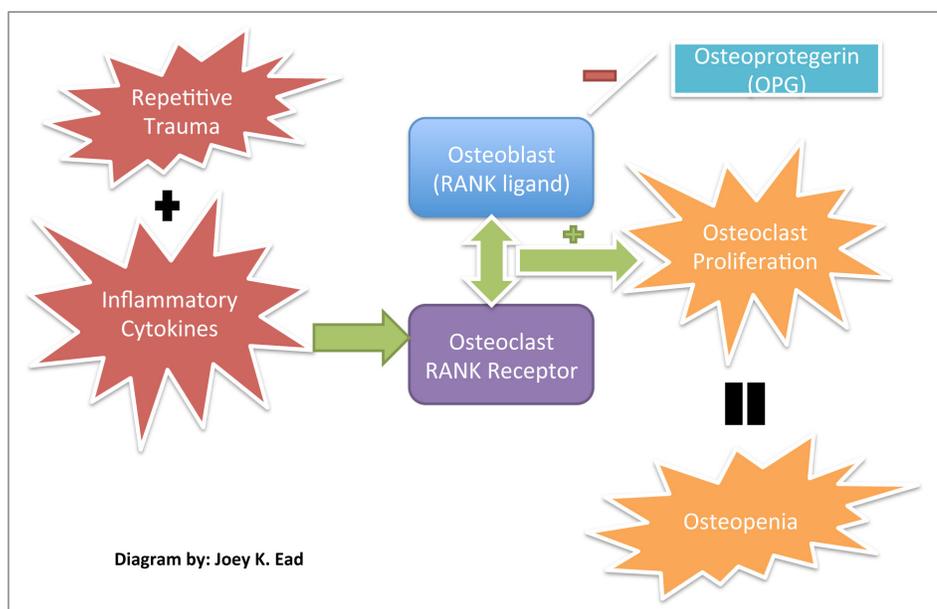
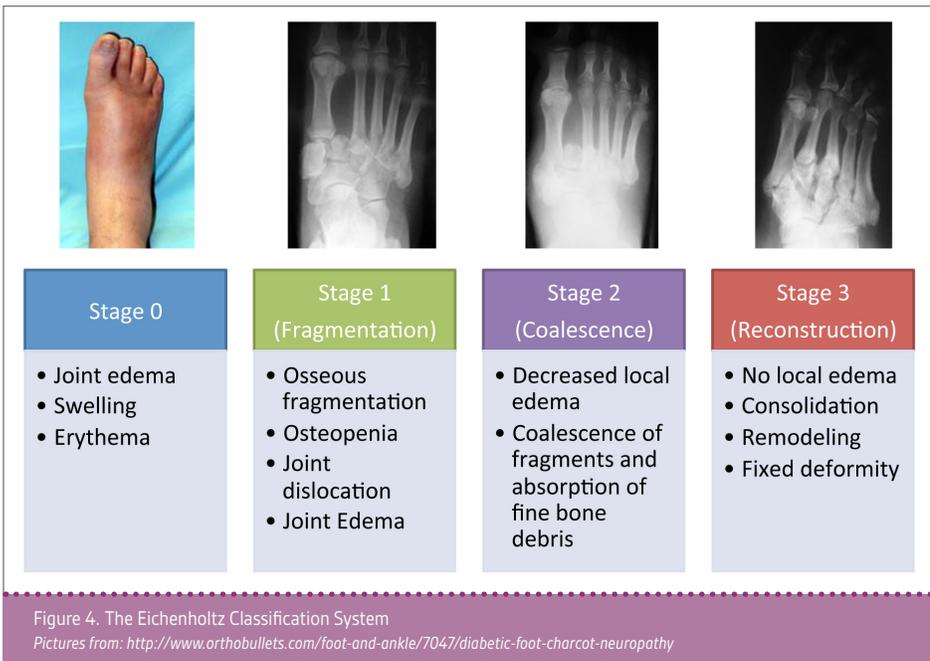


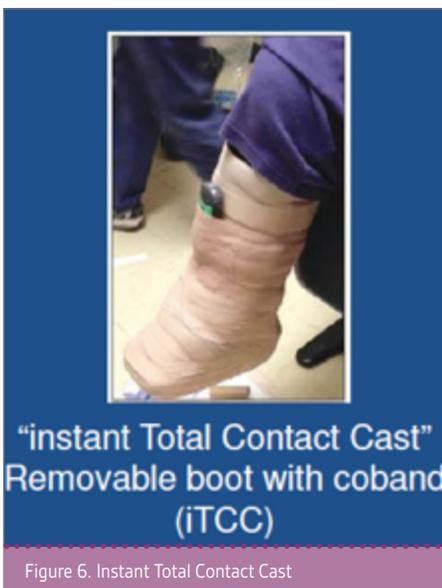
Figure 1. RANKL – RANKPathways: The binding of RANK Ligand to the RANK receptor is an essential component of osteoclast proliferation and bone resorption. The diminished function of the osteoblast derivative OPG hinder its intrinsic ability to regulate bone formation and resorption.



iTCC group had a healing rate of 82.6% versus the RCW group, which had a 51.9% healing rate<sup>7</sup>. Additionally, the iTCC group healed significantly quicker than the latter ( $41.6 \pm 18.7$  vs.  $58.0 \pm 15.2$  days,  $P = 0.02$ )<sup>7</sup>. The Charcot Restraint Orthotic Walker (CROW) may also be utilized during the acute phase of this syndrome (Figure 7)<sup>12</sup>. Some key advantages of the CROW include: the ability to manage edema, minimize joint stiffness and created accessibility to inspect and treat ulcerations that may be affecting CN patients<sup>15</sup>. However, because this is a removable device, patients should be extensively counseled as to the importance of strict adherence.



immobilization be administered for at least 3 months<sup>5</sup>. If available, an irremovable total contact cast (TCC) should be applied and then replaced after three days<sup>4</sup> (Figure 5). Any edema present may be substantially reduced due to the compressive forces of the dressing<sup>4</sup> and these dressings may subsequently be changed weekly or as needed. Other offloading modalities could include the instant TCC (iTCC) that converts a removable cast walker (RCW) to one that is less easily removed (Figure 6)<sup>6,12</sup>. In a randomized control trial, 50 patients with diabetic foot ulcerations were randomly assigned in one of two offloading treatments groups: (RCW) or the same RCW wrapped with cohesive bandage (iTCC)<sup>7</sup>. The subjects were evaluated for 12 weeks or until complete epithelialization was evident<sup>7</sup>. By week 12, the



Picture source: Snyder RJ, et al. The Management of Diabetic Foot Ulcers through Optimal Off-loading. Building Consensus Guidelines and Practical Recommendations to Improve Outcomes. Journal of the American Podiatric Medical Association. Vol 104. No. 6. Nov/Dec 2014

## PHARMACOLOGIC THERAPIES

Due to the excess bone turn over in patients with active Charcot syndrome, anti-resorptive drugs are frequently included in the treatment protocol. However, there is currently no conclusive evidence supporting the use of agents such as oral bisphosphonates in the active Charcot foot. However, research has found the utilization of intravenous bisphosphonate therapy (i.e. Pamidronate) lead to a reduction in bone turnover in the diabetic CN patient<sup>13</sup>. Intranasal calcitonin (IC) therapy is another viable option<sup>8</sup>. Some advocates have opined the pharmacologic properties of IC are more efficacious than bisphosphonates because it has direct action on the RANKL/osteoprotegerin pathway<sup>6,8</sup>(Figure 1). More clinical trials are required to further elucidate the mechanism of action behind anti-resorptive therapy and future benefits.

## ADVANCED MEDICAL DEVICES

Wound care guidelines, quality measures

and pay for performance are now at the forefront of the health care industry and will translate to reimbursement pathways<sup>12</sup>. Unfortunately, only few of these guidelines address patient centered concerns (i.e. nutrition, vascularity and comorbidities)<sup>14</sup>. Patient history and etiology are critical factors when tackling chronic wounds. The DIME model incorporates key principles for the assessment and treatment of chronic wounds by tackling the etiology and biochemistry of wound healing<sup>14</sup>. This model encompasses robust wound bed preparation methods that accelerate endogenous healing and help eliminate factors that impede the wound-healing cascade<sup>14</sup>. This strategy includes; removal of devitalized tissue, control of infection/inflammation, moisture balance (exudate), and the need for wound edge preparation and depth management<sup>14</sup>. The DIME model utilizes active and passive treatments that approach wound bed preparation by including advanced therapies such as ORC/Collagen, negative pressure wound therapy (NPWT), NPWT with instillation, epidermal blister grafts, and hyperbaric oxygen therapy among others<sup>14</sup>. According to the Charcot consensus panel, advanced wound care therapies that require daily or frequent applications may not be suitable for use with TCC or other non-removable devices<sup>12, 15</sup>.

Electrical bone stimulation has been used to foster osteogenesis in the early stages of the pathology. Cell culture studies have shown that low energy electromagnetic fields stimulate insulin-like growth factor II<sup>6</sup>. This may create an intrinsic ability to increase calcium flux and bone cell proliferation<sup>6</sup>. It should be emphasized that the magnitude of the actual benefit is not clearly understood<sup>6,9</sup>. Even though these studies are promising, its use has been supported only as an adjunct therapy mainly after the postsurgical phase of treatment<sup>4,9</sup>.

## CONCLUSION

Conservative treatment remains challenging for CN but has evolved over the years. Immobilization and mechanical protection is essential in order to prevent further collapse and permanent deformation in the Charcot foot. There are a variety of conservative treatment options; however additional evidence-based studies are warranted. All treatment modalities should

be tailored to the patient based on the current state of their Charcot foot, medical status, and compliance tendencies. In the event that conservative treatment is not sufficient, surgical reconstruction may be necessary to restore functionality.

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