The Diabetic Charcot Foot: A Primer on Conservative and Surgical Management

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Abstract: The diabetic Charcot foot is a potentially limb-threatening disorder that is being recognized with increasing frequency in persons with longstanding diabetes and concomitant peripheral sensory neuropathy. While actually considered a rare complication of diabetes, it can be a devastating complication requiring months of treatment to arrest its progression. Early diagnosis is a key factor in the management of the Charcot foot and plays a central role in the prevention of severe deformity. If diagnosed early, medical and conservative measures will usually be sufficient. Surgery is most often reserved for those patients with severe or unstable deformities that are not amenable to long-term bracing or footwear therapy alone. A team approach is recommended to manage these high risk patients in an effort to prevent severe foot deformities that can lead to ulceration, infection, and possible limb loss.

Key words: Charcot foot, diabetic foot infection, diabetic ulcer, limb loss, limb salvage, Ilizarov external fixation device.

Introduction

Charcot neuroarthropathy is potentially a limb-threatening condition that can affect the feet or ankles of those persons with significant peripheral neuropathy of almost any etiology. While first described in patients with tertiary syphilis, diabetes mellitus has become the disease most commonly associated with this devastating condition.¹ Although there have been no large population based studies to ascertain its true frequency, reports from numerous centers domestically and abroad place the estimated incidence of Charcot foot at less than 1% of all those persons with diabetes. These studies indicate a trend for a higher frequency in those persons with peripheral neuropathy and in specialty clinics.² The specialty clinic providers may have a higher clinical suspicion, thus arriving at a diagnosis more rapidly and definitively. The risk of amputation increases as the Charcot foot becomes more deformed, making early intervention paramount to prevent deformity and ulceration. Effective management of the Charcot foot emphasizes early diagnosis, medical therapies, and surgical interventions.

Management

The well known Eichenholtz staging system is important in helping to determine appropriate treatment, since it emphasizes physiologic activity of the disorder as recognized by radiographic parameters.³
<table>
<thead>
<tr>
<th>Medication</th>
<th>Dosage</th>
<th>Side Effects</th>
<th>Contra-indications</th>
</tr>
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<tbody>
<tr>
<td>Pamidronate (Aredia®)</td>
<td>90 mg intravenous (IV) over 2-4 hours</td>
<td>Fever, fatigue, myalgias, nausea, vomiting (flu-like symptoms)</td>
<td>Renal failure, Pregnancy (Cat. D)</td>
</tr>
<tr>
<td>Alendronate (Fosamax®)</td>
<td>70 mg orally (PO) weekly</td>
<td>Acid reflux, abdominal pain, nausea, musculoskeletal pain</td>
<td>Renal insufficiency, pregnancy (Cat. C), esophageal disorders, those at risk for aspiration</td>
</tr>
<tr>
<td>Calcitonin (Miacalcin®)</td>
<td>1 spray (200 IU) in nostril daily, alternate nostrils</td>
<td>Rhinitis, epistaxis, other nasal symptoms</td>
<td>Pregnancy (Cat. C)</td>
</tr>
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Table 1  Antiresorptive treatments for the Charcot foot.  Note: these medications are not FDA approved for the treatment of Charcot foot.

The developmental stage is characterized by significant soft tissue edema, joint effusions, osteochondral fragmentation, fractures and dislocation of varying degrees. The stage of coalescence is noted by a reduction in soft tissue swelling, bone callus proliferation and consolidation of fractures. Finally, the reconstructive stage is indicated by bone healing, joint ankylosis, and osseous hypertrophy without further clinical signs of inflammation. While this system is very descriptive from a radiological standpoint, its clinical usefulness is less so. Therefore, most clinicians will simply consider the initial stage as being active, while the coalescent and reconstructive stages combined are regarded the quiescent or reparative stages. In 1990, Shibata proposed an additional preliminary stage, Stage 0. This represents an earlier prodromal period shortly after an occult injury that is often unrecognized in the neuropathic patient. Although a good deal of inflammatory changes might be evident at this point, radiographs are typically negative. Therefore, Chantelau has recommended that magnetic resonance imaging (MRI) used as a diagnostic tool at this stage is the most sensitive indicator of the underlying “bone stress injury” that can lead to a fully manifested Charcot arthropathy if left undiagnosed or untreated.

There are several other classification schemes in the literature as well, although none have been uniformly adopted as being superior or predictive of outcome.

The goals of either treatment are to prevent deformity, avoid further trauma, obtain a plantigrade foot, and avoid excess pressure on the skin which might lead to ulceration. We do not consider the Charcot foot to be primarily a surgical disorder, at least in its earliest stages. Therefore, offloading becomes an important component of early management. The best method of offloading is non-weight-bearing, but this is not always practical. The total contact cast (TCC) reduces peak plantar pressure and can be utilized with partial weight-bearing. TCCs are time consuming to apply and can cause ulcerations if improperly applied. The instant TCC (iTCC) is another option, whereby the practitioner uses a removable cast walker rendered irremovable. This is accomplished by securing the device with fiberglass, plaster, or cohesive bandage. The mean length of time required for TCC before the Charcot foot becomes quiescent is 18.5 weeks, illustrating the prolonged time needed for the conservative treatment of this disorder.
Pharmacologic therapy with bisphosphonates\textsuperscript{15} and calcitonin\textsuperscript{16} have been studied to arrest the bone resorptive process.\textsuperscript{17} While they have shown promise in normalizing foot temperatures and reducing urinary markers of bone turnover, they have not generally been proven to result in a faster time to bony consolidation of fractures.

Table 1 reviews the currently available antiresorptive therapies which have been studied for acute Charcot foot. Another type of adjunctive therapy commonly used to manage Charcot arthropathy is electrical or ultrasonic bone stimulation. Although not proven by rigorous clinical trials, these biophysical modalities have shown some promise in speeding up the healing of fractures.\textsuperscript{18, 19} Additionally, during operative treatment the use of implantable direct current (DC) electric bone stimulators may be of benefit when used in combination with surgical arthrodesis.\textsuperscript{20}

\section*{Surgical Interventions}

In recent years, reconstructive foot surgery has assumed an important role in the management of Charcot feet that cannot be effectively treated by casting, bracing, or footwear therapy.\textsuperscript{21} While the appropriateness of reconstructive surgery during the acute phase is still a matter of debate,\textsuperscript{22} surgery on the chronically deformed or unstable quiescent Charcot foot has become rather common in current practice. The majority of operations consist of plantar exostectomies in combination with Achilles tendon lengthening to remove bony prominences associated with recurrent ulcers and high plantar foot pressures.\textsuperscript{23}

Complex reconstructive procedures with arthrodeses are more frequently reserved for realignment and stabilization of severely deformed feet or ankles in an effort to avoid amputation.\textsuperscript{24}
The choice of internal or external fixation depends on the quality of the bone. Generally in Charcot syndrome, the bone stock is poor and external fixation provides better compression with fewer fixation failures. When internal fixation is used, locking plates may prevent backing out of hardware. Due to its ability to correct multiplanar deformities in osteopenic bone even in the presence of open wounds, we prefer to utilize circular (Ilizarov) external fixation for most of our Charcot foot reconstructions. (Fig. 1)

For midfoot deformities a plantar based wedge resection across the tarsometatarsal joint or naviculocuneiform joints is performed. The external fixator is applied with 2 tibial rings for stability and smooth or olive wires are driven proximal and distal to the fusion site. A bent wire technique is used wherein the distal wires are walked back on the foot plate and “Russian” tensioning is applied at each slotted bolt. This provides transverse plane compression across the fusion site. (Fig. 2)

Although post operative recommendations vary, we have found that non-weight-bearing reduces complications in Charcot midfoot fusions fixated externally.

For rearfoot and ankle arthrodeses in the Charcot foot, the technique is slightly different. Two tibial rings plus a foot plate are used, but the decision to use a talar ring depends on surgeon preference. (Fig. 3) The addition of this ring allows one to isolate the subtalar joint or the ankle joint for compression.
In the neuropathic patient requiring an ankle fusion, we tend not to use a talar ring in most cases. Compression between the foot and tibia at the tibiotalar fusion site is accomplished with threaded rods or specially designed “clickers” that can easily be adjusted by the patient or surgeon as required.

While the correction is generally done at the time of operation and a “static” frame is applied, we will frequently increase our compression during the course of bone consolidation. Other methods can provide similar compression without completely isolating the non-operative joint, but are not generally used in the presence of open wounds. In fact, the open wound can be accessed easily and managed while in an external fixator. (Fig. 4) Alternatively, if there is severe frontal plane deformity of the ankle or subtalar joints and both joints require fusion, consideration can be given to intramedullary rod fixation.28

In rearfoot and ankle deformities, dynamization with protected weight-bearing after surgery might improve union rates, although this has not specifically been studied with regard to the Charcot foot.

External fixation is associated with a high rate of complications (pin tract infections and wire breakage),26, 29 but if recognized early these can be easily treated and are non-limb-threatening. Nonetheless, the surgeon should not apply circular frames without anticipating such complications at the outset and be prepared to manage them accordingly.

The use of silver impregnated foam as a pin site dressing can help to prevent pin tract infections. (Fig. 5) Heat moldable plastic can be used to protect the external fixation device which may prevent wire breakages. (Figs. 6A and B)30
Figure 7  A reconstructed foot in a Charcot restraint orthotic walker (CROW).

Long-term Management

The post-treatment prevention of recurrence, contralateral Charcot’s joint, and ulceration is equally as important as the treatment phase. Once the foot becomes stable through medical or surgical means, the emphasis must be on prevention of recurrent ulcers. Custom braces and orthoses such as the Charcot restraint orthotic walker (CROW) can be an effective method to brace a deformed extremity. (Fig. 7)  

We recommend using custom fabricated patellar tendon bearing braces, CROW devices, or ankle-foot orthoses (AFO) for at least 6 months after reconstructive surgery; some patients may require the device for their lifetime.

Critically important, appropriately designed or fitted shoes with weight dispersing accommodative insoles are necessary for protection and gentle support. These patients are at high risk for subsequent ulceration and therefore require close follow-up and life-long surveillance.

Early diagnosis is a key factor in the management of the Charcot foot and plays a central role in the prevention of severe deformity. If diagnosed early, medical and conservative measures will usually suffice in this regard. Surgery is most often reserved for those patients with severe or unstable deformities that are not amenable to long-term bracing or footwear therapy alone. A team approach is recommended to prevent patients with these high risk foot deformities from succumbing to limb loss.
References