Management of Rearfoot Charcot Neuroarthropathy: A Review

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Abstract: Diabetes is a growing problem today. Long-standing diabetics have an increased chance of developing peripheral neuropathy. A small percentage of diabetic patients with peripheral neuropathy will develop a pathologic process known as Charcot neuroarthropathy. Charcot is a difficult pathology to manage both conservatively and surgically.   A prompt diagnosis is paramount to prevent impending ulceration and deformity. Should conservative care fail, surgical management may be warranted. Surgical constructs described include internal as well as external fixation. The purpose of this article is to review the management of Charcot neuropathy mainly involving the rearfoot.

Conclusion: The literature is sparse regarding the management of rearfoot Charcot neuroarthropathy. The goal of surgery is to obtain a plantargrade, ulcer-free braceable foot. Studies are lacking regarding early versus delayed surgical intervention and the appropriate type of fixation modality.

Key words: Charcot, ankle, hindfoot, neuroarthropathy

The American Diabetes Association (ADA) estimates that approximately 26 million people are treated for diabetes mellitus in the United States alone. If current trends continue, 1 in 3 Americans will have diabetes by the year 2050. Diabetes is the most common cause for non-traumatic amputation of the lower limb and will kill more people each year then AIDS and breast cancer combined, according to the ADA. Common complications secondary to diabetes include heart disease, retinopathy, nephropathy, and neuropathy[1]. Profound neuropathy can lead to a destructive bony process termed Charcot neuroarthropathy that is said to affect approximately 8.5 per 1000 people with diabetes[2].

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The Charcot limb is prone to ulceration secondary to deformity, where partial amputation and limb loss may be the end result. This disease process can be a challenging pathology to treat both conservatively and surgically even for a well-trained foot and ankle surgeon[3]. A prompt diagnosis does not always correlate with a resolution of symptoms and successful long-term management.

The literature regarding the management of rearfoot Charcot neuroarthropathy is sparse in comparison to the larger body of literature regarding the midfoot. Research is limited to primarily small, retrospective studies and case reports/series. Where a stable midfoot deformity can be treated with non-operative care and custom shoe wear, mild instability in the rearfoot is less tolerated and more prone to ulceration with potential limb loss. Thus, a high index of suspicion and appropriate management is necessary for a successful outcome[4]. The purpose of this study

is to review the available literature regarding the management of Charcot neuroarthropathy primarily affecting the rearfoot.

Classification

Most Charcot classifications are based on the location of involvement. Whether one uses the Brodsky or Sanders/Frykberg system, the percentage of ankle joint involvement is roughly 10%[4]. The midfoot is involved 60% of the time, which also correlates with a higher rate of surgical management[5]. On the contrary, Schon et al. reviewed 221 Charcot cases and found that 2/3rd of the patients with rearfoot involvement, specifically talar avascular necrosis, underwent surgery in comparison to only 1/2 of the transverse tarsal joints and 1/3rd of the patients with tarsometatarsal joint involvement[6].

The Eichenholtz classification is based on both radiographic and clinical findings and can be used as a modality to determine timing for surgery. Stage I involves destruction, deformation, and collapse noted radiographically. Clinically, there is an erythematous, warm, and edematous foot and/or ankle. Stage II involves coalescence of bone fragments and sclerosis, while clinically the edema and erythema are decreased. Stage III displays possible residual deformity with remodeling of bone fragments and resolution of erythema and edema. Return of skin temperatures to baseline typically correlate with a quiescent, or resolved Charcot process as well[7]. Literature is sparse regarding the appropriate stage for surgical intervention.

Timing of Surgery

Simon et al.[8] showed promising results for early intervention with arthrodesis; however, the study group involved the tarsometatarsal joints only, which is difficult to extrapolate to the rearfoot. A second study by Mittlemeier et al.[9] showed similar results as the previous study with a review of midfoot and rearfoot involvement, however the patients reviewed had surgery for both early and late stages. Based on the recent systematic review by Lowery et al.[5], the literature regarding acute surgical management is inconclusive at this time. Some authors suggest that the decision for surgery should be based more so on that patient's own unique set of circumstances[10]. Most studies today support surgical treatment in the quiescent, or stage III Eichenholtz classification.

Figure 1a. Valgus ankle deformity status post ankle injury. Swelling of the soft tissues is also noted.

Figures 1b. Hemorrhagic fracture blister noted to medial ankle.

Acute vs. Chronic

Acute surgical intervention may be warranted if the limb is too unstable or there is frank dislocation. This may involve application of a static frame external fixator with transcalcaneal pin fixation after the deformity has been reduced by closed or minimal incision techniques. A staged arthrodesis can then be planned down the road[4]. One study mentions the use of a Taylor Spatial Frame (Smith and Nephew, Inc., Memphis, Tennessee) for management of acute Charcot fracture/dislocations. Despite the effectiveness of its use, the study concluded that the literature is lacking regarding external fixator application for the "acutely unstable or chronically malaligned" Charcot limb and that higher level studies are needed[11].

Figure 2. Radiographic exam (Anterior/Posterior; (A/P)) view revealing a tri-malleolar, ankle fracture with syndesmotic rupture and concurrent ankle joint dislocation.

Chronic deformity correction may involve a staged procedure as well. Long standing varus or valgus malalignment places the limb at risk for neurovascular compromise, so some authors advocate prophylactic tarsal tunnel release specifically for varus contractures[4]. Various fixation options can be utilized including internal and external fixation[12]. Based on the available literature, there is no consensus as too which surgical fixation modality should be utilized. Also, there is no study to date comparing surgical versus non-surgical management or primary amputation, so the benefit of surgical management is debatable[5].

If surgery is warranted, arthrodesis is the most predictable option and most supported in the literature[13,14]. Options include a triple, ankle, tibiotalocalcaneal (TTC), tibiocalcaneal (TC), or pantalar arthrodesis. Proper alignment includes an ankle in neutral to 5 degrees of dorsiflexion, 5-10 degrees of hindfoot valgus, and slight external rotation[15]. As described for knee Charcot arthropathy, factors for successful fusion include removal of all cartilage, presence of bleeding subchondral bone, optimizing bone surfaces for fusion, removal of all synovial material, and stable internal fixation. These principles, though described for higher-level joints, can still be applied to the foot and ankle[4]. The authors will add that external fixation is a viable option as well. Based on the available literature, complete osseous union rates are reported at 76.4%[5].

Internal vs. External Fixation

There are advantages and disadvantages to both internal and external fixation. Internal fixation options include blade plates, anatomic plates, femoral/humeral plates, intramedullary (IM) nails, and screws[12,15]. Internal fixation is technically easier to apply and usually better tolerated by patients where "cage-rage" can be an issue with its counterpart. Disadvantages to internal fixation include lack of use with concurrent infection, lack of adjustability, and application in later stages of Charcot. Advantages of external fixation include the ability to apply it with concurrent infection/deformity and offers staged correction. It can be applied during all stages of Charcot and is ideal for patients with poor soft tissues and bone[12,16].

Figure 3. Reduction was achieved intra-operatively and maintained with external fixation. Management of the soft tissues was also employed.

Biomechanical studies have shown that IM nails have similar stability to other forms of fixation. Regarding TTC fusions, no one implant has been shown to have superior strength. Surgical decision-making should really come down to the quality of the soft tissues, the quality of the bone and the surgeon's experience or preference[10]. Benefits of IM nail fixation include the ability to maintain alignment and length with minimal soft tissue disruption. The construct serves as a rigid, load-sharing device. An IM nail is ideal in that it can resist large forces across the ankle especially with the long lever arm that the foot exerts on this area[15]. Others advocate external fixation application in addition to IM nail fixation whenever possible for added stability[10].

Figure 4. Radiographic exam (A/P view) displaying open reduction and internal fixation for the tri-malleolar, ankle fracture.
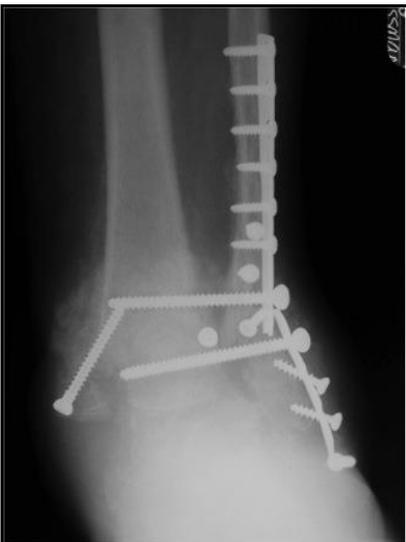
Figure 5. Radiographic exam (A/P view) revealing loss of reduction, failure of internal fixation, and acute Charcot process of the hindfoot.

Internal Fixation

Papa et al.[17] reviewed 29 patients with the large majority having rearfoot Charcot arthropathy. The ankle joint was fused in 21 patients and the subtalar joint in six patients. Internal fixation was employed in the large majority with four patients receiving external fixation alone. Results showed a 66% union rate at five months. A fibrous union was observed in 4/11 patients who underwent TTC fusion.

Myerson et al.[18] reviewed 26 patients who underwent rearfoot fusion with the use of a blade plate in combination with allogenic bone mixed with

antibiotic powder. Fusion was observed at 16 weeks in 28/30 feet.

Tisdel et al.[19] presented their results of eight patients who underwent triple arthrodesis for Charcot arthropathy using Steinman pins and staples. They reported a 44 month follow up. Results showed a 100% union rate. Complications included one infection and one resultant rocker-bottom deformity. They concluded that arthrodesis is an effective treatment modality for peritalar neuropathy.

Rammelt et al.[20] recently reviewed 38 patients who underwent TTC fusion. Reasons for surgical intervention included failed total ankle replacement (TAR), non-union, deformity, neglected fractures, Charcot-Marie-Tooth (CMT), and Charcot arthropathy. Only 13% of the patients had Charcot. They reported a 15.8% non-union rate with six patients requiring revision. Overall union rate was 84%. Most patients (15/19) were able to return to their previous occupation.

Pinzur et al.[21] reviewed 21 cases of TTC fusion via IM nail fixation. Fusion was achieved in 19 patients at 12-31 months post-operatively when talectomy was not required. They did report increased morbidity when talectomy was needed and that primary amputation should be considered in this subset. Complications included wound infections in 8/21 patients and three patients requiring rod removal.

Paola et al.[22] reported on 18 patients who underwent surgery for ankle joint Charcot. No patients had ulcers present at the time of intervention. They reported union in 14/18 patients and 100% limb salvage rate.

Caravaggi et al[23] reviewed 45 diabetic patients who underwent TC fusion via an IM nail for ankle and hindfoot CA. Surgery was performed during late stage 1/early stage 2. Postoperatively patients were non weight-bearing for 90 days. Ulcers were present in 15.56% of the study group prior to arthrodesis. The average duration of follow-up was 5.25 years. Results showed a limb salvage rate of 86.67% with two patients undergoing a BKA shortly after the arthrodesis. They concluded that surgery in the acute stages of ankle Charcot arthropathy was safe and effective.

Devries et al.[24] reviewed 179 limbs that underwent TTC fusion via an IM nail only. Charcot patients encompassed 25% of the group with the remainder being revisional surgery patients. Results showed an 88.2% salvage rate. The highest predictors for amputation were diabetes, revisional surgery, and ulceration, with relative risk ratios of 7.01, 6.23, and 2.99, respectively. Based on their study, one could predict the relative risk of amputation preoperatively that one may have following a TTC fusion on the basis of certain patient variables.

A recent study by Jeng et al.[25] reviewed 32 patients that underwent TTC fusion with bulk femoral allograft. Indications for surgery included degenerative arthritis, failed ankle replacement, talar avascular necrosis, ankle non-union, Charcot arthropathy, and pilon fracture non-union. IM nail fixation was used in 32 patients, a blade plate in 6 patients, and an external fixator in 1 patient. Results showed a 72% limb salvage rate and a 50% union rate. All diabetic patients experienced a non-union with 44% having a stable pseudoarthrosis. There was an average loss of height of ~4mm of the femoral head allograft. There was no statistical difference in fusion rate or non-union when reviewing hardware, approach, or joint preparation. A rate of amputation of 19% was reported. A below knee amputation (BKA) was required in two of the Charcot patients. They concluded that more research is needed to determine whether TTC fusion with bulk allograft in the diabetic population is a viable surgical option.

Herscovici et al[26] reviewed the fusion rates of patients with post-traumatic osteoarthritis (OA) to patients having ankle/hindfoot Charcot neuroarthropathy (NA). All patients underwent a pantalar fusion. It was a Level IV study in which 12 patients in the OA group and 8 patients in the NA group were compared. Fixation constructs included combinations of plates, screws, and IM nails. Results showed no amputations in the study groups. Average casting period was roughly 14.5 weeks. A 96% fusion rate was reported.

Combined Fixation

There is a relatively high rate of amputation following TTC fusion with internal fixation for revision ankle fusion surgery. Rates of amputation are reported to be as high as 16.7%[27]. With the high rate of amputation with internal fixation, one may consider a combination of internal and external fixation as an ideal construct.

Devries et al.[28] performed a retrospective review of Charcot ankle stabilization with IM nail fixation with and without circular external fixator application. They reported 52 patients with Brodsky type 3a ankle involvement. IM nail fixation was utilized alone in 45 patients and with an external fixator in seven patients. End points were amputation or a braceable foot. Results showed a 75.6% salvage rate. Regardless of fixation, there was no affect on the overall salvage or complication rate. They concluded that, despite their findings, a combination of internal and external fixation may be indicated in patients with marked deformity and those at increased risk of complications.

Grant et al.[29] reported on 50 Charcot neuropathic deformities in a Level II study that were treated with a combination of internal and external fixation as well. Results showed that 88.0% of patients achieved fusion or a stable pseudoarthrosis.
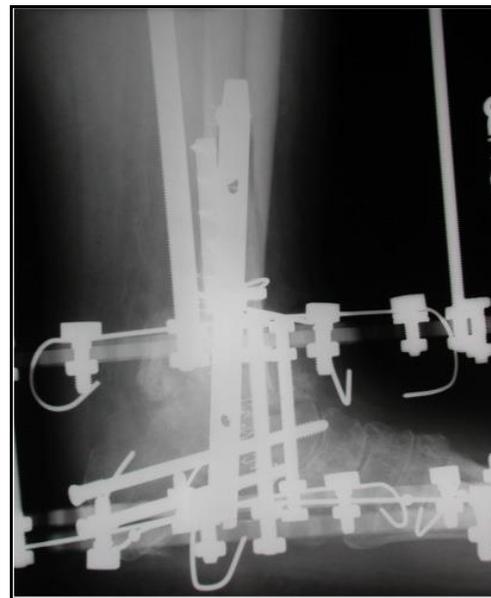

Figure 6. Lateral radiograph displaying IM nail fixation and a static frame external fixator.

External Fixation

External Fixation has also been utilized as a treatment modality for surgical management of Charcot arthropathy. Device options include static frames, stabilization off-loading frames, and dynamic fixators. Static frames can be applied for added stability to augment internal fixation, but can be used as a single
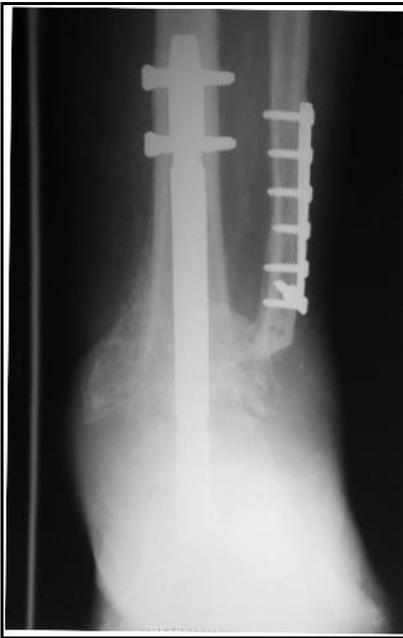
Figure 7a. Radiographic A/P view demonstrating solid arthrodesis of the ankle and subtalar joint with maintenance of reduction noted status post removal of external fixator.

Figure 7b. Lateral view displaying solid arthrodesis of both the subtalar and ankle joint.

fixation modality as well. Stabilization off-loading frames can be applied to assist with wound care/debridement and can be converted to a static or dynamic frame. Dynamic frames are utilized for patients with multiple planes of deformity where single stage correction is unattainable and/or where neurovascular compromise may be a major concern[12].

Cooper[16] in 2002 published the largest study to date utilizing external fixation for surgical management of CN. He retrospectively reviewed the first 100 patients he treated with Ilizarov frame application for Charcot deformities. Of those patients, eighty-three were available for follow-up. The study group was mixed between rearfoot and midfoot involvement. All patients had Charcot for at least 15 months with 80% having concurrent ulcers not amenable to conservative care. He reported a 96% salvage rate. Amputations were required in 3/83 patients secondary to infection or an unstable pseudoarthrosis. Initially the majority of frames were static in nature; however, as time and experience progressed the frames became more customized to the patient. Complications included pin tract infections (7), tibial fracture (2), new ulcers (4), and new onset rearfoot Charcot post-midfoot correction (5).

Another study performed in 2007 by Fabrin et al.[30] reviewed 12 feet who underwent rearfoot fusion for ankle Charcot via external fixation. Indications for surgery included the presence of ulceration and/or instability. Union was achieved in 50% of the patients with five patients having a stable fibrous union. One patient had a below knee amputation.

Conclusion
Charcot arthropathy is undoubtedly on the rise given the increased number of people expected to have diabetes in the years to come. A high index of suspicion and prolonged non weight-bearing is paramount to prevent disease progression if caught early. Based on the review by Lowery et al.[5], regardless of midfoot or rearfoot involvement, there is insufficient evidence to say that early surgical intervention provides better outcomes as compared to delayed treatment at this time. Should surgical management be warranted there is no data to support one fixation construct over another. The surgical construct should be based on the specific patient and surgeon experience. Arthrodesis should be the treatment of choice, with union rates around 76.4%. More data is needed to determine whether these patients benefit from surgery or whether they would be better served with a primary amputation.

Case Repot

A 58-year-old female presented to our outpatient clinics with a past medical history of long standing diabetes with peripheral neuropathy and a recent right ankle injury. Clinical exam revealed palpable pedal pulses with absent protective sensation. Dermatological findings revealed a large, hemorrhagic fracture blister over the medial malleolus with significant soft tissue edema (Figure 1a-b). Orthopedic exam revealed a valgus ankle deformity. Compartment syndrome was ruled out. Radiographs showed a tri-malleolar ankle fracture with concurrent ankle joint dislocation (Figure 2). Initial management included reduction and stabilization of the fractures with an external fixator (Figure 3). Soft tissue management was also employed at this time, consisting of local wound care for fractures blisters and a Jones compression dressing to reduce edema. Delayed open reduction and internal fixation (ORIF) (Figure 4) was performed 10-12 days later, after edema had resolved and skin wrinkles returned. The planned post-operative course involved prolonged non weight-bearing and immobilization with plans for a solid ankle foot orthoses long-term. However, the patient was non-compliant and lost to follow up, initially. She returned seven months later with an acute Charcot process of the ankle (Figure 5). The patient was treated with an IM rod with the addition of a static frame external fixator (Figure 6). The external fixator was removed three months later after the patient had clinically and radiographically achieved a solid fusion. Maintenance of reduction was also noted (Figure 7a-b). She wore a solid ankle foot orthoses long term.

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