Treatment of Acute Charcot
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Abstract: The acute stage of Charcot is classified under Eichenholtz’s classification as stage I. The gold standard for treatment of acute Charcot is offloading, usually non-weight-bearing. Discrepancy in the literature exists about the method of total contact cast application, frequency of cast changes, duration of cast therapy, the use of removable versus non-removable casts, and whether the patient should remain non-weight bearing. The literature trend is to allow full weight-bearing in a total contact cast for forefoot or midfoot Charcot and restrict to non-weight-bearing in a device for rearfoot Charcot. The contralateral foot is placed in an orthosis or offloading device to avoid bilateral Charcot development. Pharmacological management of acute Charcot is currently unsupported.

Key words: Diabetes, Total Contact Casting, Removable cast walker, Bisphosphonates, iatrogenic cast complications

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The acute stage of Charcot is classified under Eichenholtz’s classification as stage I. During this stage, which is approximately 2-6 months in duration, the patient’s foot presents with calor, edema, and erythema. Radiographic destructive changes develop at the end of this stage and consist of peri-articular fracture and joint subluxation.

Offloading
The gold standard of acute Charcot treatment is the patient should be offloaded, usually non-weight-bearing in a total contact cast (TCC), until the acute stage has resolved. Offloading is necessary in patients with peripheral neuropathy as an insensate foot hinders the body’s innate response to offload a painful foot. Offloading reduces weight bearing forces during the inflammatory and destructive stage and is continued until the foot stabilizes and osseous structures are able to withstand the stresses of weight-bearing without deformity formation. The goal of acute Charcot treatment is to allow the foot to stabilize in a position of minimal deformity which can be accommodated in a shoe or appropriate orthosis. The effect of offloading was documented by Piaggesi et al in 2003 which revealed offloading results in the reduction of inflammatory and reactive components and accelerates wound healing.

A delay in treatment results in irreversible pedal deformity secondary to the patient walking on an insensate foot. An example of this mechanism is weight-bearing induced Chopart’s joint fragmentation and dislocation resulting in mid-foot collapse or a...
rocker-bottom foot. Such pedal deformities increase the patient's risk of ulceration which thereby increases the risk of amputation and subsequent mortality of the patient. In a study by Van Baal et al in 2010, patients with acute Charcot foot or neuropathic foot ulcers had a 5-year mortality rate of 40%.

### Total Contact Casting

Numerous studies have documented the efficacy of total contact casting. Total contact casting increases the pedal contact surface area, redistributes the total pressure over this larger area, and avoids excessive concentration of pressure over prominences. A weight bearing TCC offloads the forefoot and midfoot by 80% and this pressure is transferred to the hind-foot. Therefore it is not recommended that a weight-bearing TCC be used to treat hind-foot Charcot. One study revealed that a TCC increases the load under the heel approximately 37%.

Other limitations to TCC are its application is consuming, material availability dependent, and it requires clinical attention and skill to avoid severe iatrogenic complications. In addition, discrepancy in the literature exists about the method of application, frequency of cast changes, duration of cast therapy, the use of removable versus non-removable casts, and whether the patient should remain non-weight bearing.

### Method of TCC Application

There is currently no universally accepted method of application and there are a variety of different modifications.

The snug fit of a total contact cast minimizes the repetitive microtrauma and shear forces which can result in ulceration formation. Cotton or lamb’s wool is placed in between the toes to avoid such irritation. A stockinette followed by webril is then applied. Sifoam can be used to cover the toes and any ulcer site since it has been shown to reduce pressure by 50%. One-eighth inch felt is used to cover bony prominences, such as the malleoli and tibial crest, for protection from the cast. If an ulceration is present, a dry sterile dressing is applied or else a cast windowing technique can be utilized for more frequent dressing changes.

![Figure 1: Bilateral Total Contact casting with felt applied to areas of bony prominence, sifoam covering the toes, and webril.](image)

### Cost

Although the materials required for TCC application are numerous and costly, TCC is cost effective. Myerson et al revealed that the average total cost for outpatient TCC treatment was approximately equivalent to the cost of a single day as an inpatient.

### Frequency of TCC Changing

Generally, casts should be checked regularly and replaced as necessary. A review of the literature...
reveals that the first cast should be changed within the first 3 days and be performed either weekly or biweekly thereafter to allow for the decrease in edema and the continuance of a snug fit cast. The patient should be instructed to inspect their cast daily for cracks and immediately report any signs of complications. The patient should also monitor their blood glucose and body temperature daily to alert their physician of possible infection.

**Duration of Casting**

The duration of casting has been cited in the literature to range from 5.8 weeks to 12 months, with approximately 6 months on average. Insufficient duration can result in deformity or deterioration of an existing foot deformity.

The response to therapy, and thus duration determination, is identified clinically using visual monitoring of erythema and edema reduction, and by measuring temperature differences using infrared thermometry. Patients should be offloaded until signs of inflammation have resolved, serial radiographs reveal evidence of osseous consolidation, and the affected foot temperature is within 2 degrees Celsius of the contralateral foot at 2 consecutive visits. Milne et al states that temperatures should be assessed approximately 15 minutes after the cast and footwear is removed. Absolute skin temperatures have been cited to range from 34-36 degrees Celsius in the acute Charcot foot and about 26-30 degrees Celsius in the non-Charcot foot. Although, McCrory et al in 1998 stated skin temperature was unreliable in determining treatment duration and recommended a fixed period of total contact casting of 6 months.

There is some evidence of the use of ancillary imaging to determine phase resolution. In one study by McGill et al in 2000, there was a strong correlation between temperature difference and the bone scanning ratio of isotope uptake of the effected and non-affected foot. Zampa et al in 2011 revealed that there was a strong correlation between clinical and MRI findings in the healing of bony lesions.

**Weight-bearing versus Non-Weight-bearing casts**

There is insufficient evidence to support that either weight-bearing status is superior to the other. The reasoning behind non-weight-bearing is to prevent the progression of osseous deformity in the insensate foot. Non-weight-bearing prevents the foot from continuing to fracture and the propensity of inflammation during ambulation.

However, patients tend to be non-compliant with complete non-weight-bearing for extended periods of time. McDermott revealed that patients bear weight because of decreased sensation (patients are unsure if they are placing weight on the foot or not), frank non-compliance, and deficiencies in health, function, proprioception and balance which result in the inability to use assistive devices such as a walker or crutches.

Pinzur et al conducted a prospective study on 9 Charcot patients treated with biweekly weight-bearing TCC. Patients were casted for an average of 5.8 weeks (4-10 weeks) and were transitioned to specialized shoegear when they were deemed “stable,” which was at an average of 12 weeks. They found a
TCC reliably arrested the short term destructive disease process and that weight-bearing in a TCC did not increase morbidity. They concluded that weight-bearing in a TCC allowed all of their subjects to transition to prescription footwear without subsequent morbidity at 5 months.

De Souza also conducted a prospective 18 year study on 27 patients with early Charcot to evaluate the results of weight-bearing in TCC. Lesions were Brodsky type I-III, average follow-up duration was 5.5 years and casts were changed at weekly intervals until disease resolution. The average period of immobilization was 14 weeks with a range of 4-20 weeks. A Brodsky type IIIA lesion was found to have a longer duration of casting (16 weeks) than type I and type II lesions, which were casted for averages of 9 and 13 weeks, respectively. Only 1 patient (Brodsky type I lesion) had progression of deformity while weight-bearing in a total contact cast. None of the patients developed ulcerations in the total contact casts but 10/34 feet developed ulcerations after they were put into orthosis. They concluded that weight-bearing in a TCC did not result in increased deformity or increased risk of ulceration and did not prolong time of immobilization.

There are several other advantages of weight-bearing in a TCC. Ambulating while in a TCC has been associated with increased venous return and decreased local edema, and thus improved microcirculation. Another advantage is the avoidance of bilateral Charcot development.

Bilateral Charcot

Sanders and Frykberg in 2000 stated that development of contralateral Charcot has been reported in up to 40% of patients treated with non-weight-bearing secondary to increased mechanical forces in the opposite foot. The literature reveals that even a three-point gait using crutch offloading may still increase the load to the contralateral foot enough for Charcot development. Clohisy and Thompson recommended that prophylactic immobilization be performed on the contralateral extremity in a protective cast or orthosis in order to prevent the development of Charcot on the contralateral limb.

Removable versus Non-Removable Casts

Although a TCC is well accepted as the gold standard therapy, there is no randomized controlled study revealing the superiority of one device in the treatment of Charcot. In a study by Game et al in 2012, they revealed that total contact casting was used as for initial Charcot treatment in the United States in only 49% of cases. This same UK study demonstrated that non-removable casts had a superior outcome and a shorter time to resolution (9 months) than removable casts (12 months) in the treatment of Charcot. Boulton in 2004 conducted a randomized controlled trial comparing TCC with other offloading devices and healing of diabetic foot ulcers and found that healing was most rapid in patients treated with a TCC.

Removal cast walkers redistribute pressure in a similar manner to TCC but the most likely reason why TCC therapy has better outcome is because of non-compliance issues. A study by Armstrong et al in 2003 consisted of recording total activity with a waist-worn computerized accelerometer (pedometer) and correlated activity with a hidden pedometer in the removable cast walker (RCW). This study revealed that only 28% of daily activity was performed while wearing the RCW.

The “instant total contact cast” (iTCC) was made to curbside RCW compliance issues. The iTCC is constructed by wrapping 2 bands of plaster over the RCW making the device non-removable. Advantages of an iTCC include that it’s inexpensive, quick and easy to apply, generally more acceptable to the patient, and no specialist cast clinician is needed.

Christensen et al in 2012 conducted a retrospective 5 year study on 56 diabetic patients with acute Charcot
on the duration and recurrence rate of patients treated with non-weight-bearing removable walker with the assistance of crutches.\textsuperscript{14} Average offloading duration was 141 +/- 21 days, which is 20 weeks or approximately 5 months. Seven patients (12%) were re-casted after recurrence within an average of 69 days (11 weeks or 3 months).\textsuperscript{14} The re-casting duration was 79 +/- 44 days. There was no significant difference between duration of primary offloading and re-casting offloading, 142 and 134 days respectively.\textsuperscript{14} The authors concluded that less restrictive off-loading in a removable cast is a safe treatment for the treatment of Charcot.\textsuperscript{14}

**TCC Complications**

Total contact casting can induce unnatural stress patterns which result in ulceration and amputation.\textsuperscript{5,14} Casting may also increase instability and affect proprioception, resulting in an increased fall and fracture risk.\textsuperscript{5} It also can result in a reduction in muscle tone, bone density, and muscle tone and strength.\textsuperscript{5} However, Pakarinen et al in 2013 reported that the bone mineral density in the proximal femur and lumbar spine is only slightly decreased or equivalent to a control population after immobilization treatment for Charcot.\textsuperscript{16}

Guyton in 2005 performed a prospective study on 70 peripheral neuropathic patients who completed a series of 398 walking total contact casts during a 28 month period.\textsuperscript{17} The overall complication rate was 5.52%, and 30% of patients had one complication during their treatment course. Complications occurred in 22 casts: 6 new pretibial ulcers, 6 new mid-foot ulcers, 4 forefoot or toe ulcers, 5 hind-foot ulcers, and 1 malleolar ulcer. No previous ulcers were made worse and 100% new ulcers healed within 3 weeks (often with TCC). One cast led to a proximal inter-phalangeal joint ulceration which led to digital amputation. They concluded that a frequently changed TCC is a safe modality for the offloading and immobilization of the neuropathic foot. Complications tend to be prevalent but minor and reversible, even in an experienced clinician’s hands. They advised that patients should be informed of potential complications and risks before cast application.

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patellar strap.\textsuperscript{18} Two of six patients in their study resulted in symptom resolution, in 7 months and 13 months duration. The brace was seldom used in 4 of the 6 patients because of general debility, discomfort using the lift, difficulty with balance, and poor compliance. The most common complaint was improper fitting which resulting in the orthosis sliding down or “pistoning” on the leg. Minor problems were experienced including superficial skin breakdown along the pretibial area. They stated that patient selection was important for patient benefit since the patients who most benefited were those that were functionally active and motivated.

**Anti-Resorptive Therapies**

Various pharmacological treatments aim to correct the imbalance between bone resorption and bone formation.\textsuperscript{10} However there is no proven pharmacological treatment currently available for Charcot treatment.\textsuperscript{19} Since there is evidence that the acute stage of Charcot is associated with increased osteoclastic activity and bone resorption, there has been some success with the use of antiresorptive therapies, such as bisphosphonates and calcitonin, which reduce bone turnover and inhibit bone resorption.\textsuperscript{10,19}

**Calcitonin**

Calcitonin may impact bone resorption at the cellular level.\textsuperscript{19} Bem et al in 2006 revealed that intranasal calcitonin (200 U daily) with calcium supplementations significantly decreased bone turnover compared with calcium supplementation alone.\textsuperscript{19} However, Calcitonin did not reveal an effect on skin temperature.

**Bisphosphonates**

Frith et al suggested that bisphosphonates may have direct anti-inflammatory properties, inhibit osteoclastic resorption and slow or arrest bone destruction through promotion of macrophage apoptosis.\textsuperscript{19} Bisphosphonate effects have been reported to last for approximately 6 months.\textsuperscript{5} A twelve month duration randomized controlled study by Jude et al in 2001 compared pamidronate with a placebo in the treatment of Charcot. They found symptomatic improvement and reduction in bone turnover markers (urinary deoxypyridinoline and bone-specific alkaline phosphatase) were greater in the bisphosphonate treatment group, but there was no significant difference in reduction in temperature.\textsuperscript{20}

However, the literature reveals that anti-resorptive therapy doesn’t have a significant effect on temperature reduction, has an unknown effect on Charcot resolution, and may increase immobilization duration.\textsuperscript{10} Pitocco et al in 2005 revealed that patients treated with zolendronic acid required a longer duration of immobilization compared with a placebo group.\textsuperscript{10} This was consistent with a study by Pakarenin et al. in 2011 which reported that bisphosphate use may increase the duration of immobilization.\textsuperscript{19} Another study by Pakarenin et al in 2013 reported total immobilization time was 31 weeks in the bisphosphonate group (14 weeks in a cast and 17 weeks in orthosis) versus 23 weeks in the placebo group (11 weeks in a cast and 12 weeks in orthosis).\textsuperscript{16} A multicenter observational study in the UK has also revealed that the bisphosphonate treated patients have a longer time until Charcot resolution.\textsuperscript{10,19} Contraindications to bisphosphonate use include patients with chronic kidney disease.\textsuperscript{19} In addition, the FDA has not approved bisphosphonates for Charcot treatment.

As systematic review by Richard et al in 2012 revealed the evidence to support bisphosphonate in the treatment of Charcot use is weak.\textsuperscript{10,19} They reviewed 10 studies, 3 were randomized, and all patients were appropriately immobilized.\textsuperscript{19} They found that bisphosphonates significantly reduced skin temperature and bone turnover markers compared with placebo.\textsuperscript{19} However, the reduction in skin temperature was transient and the bone turnover marker most consistently reduced in serum was the (bone-specific) ALP level; a marker of osteoblastic rather
than osteoclastic activity). One reviewed study by Anderson et al reported that 60% of the patients treated with pamidronate had transient fever, suggesting a possible pro-inflammatory effect. Bisphosphonates were shown to not shorten the duration of immobilization and may lengthen the resolution phase of the disease.

**Human Parathyroid Hormone**

Human parathyroid hormone (teriparatide) is an anabolic agent which may be used to improve bone remodeling. Anabolic agents shorten duration and improve fracture healing. Brosky et al in 2005 reported that teriparatide in patients with rapid fracture consolidation, edema control, temperature stabilization, and return to weight-bearing. There is currently a double blind, randomized control study being undertaken on human parathyroid hormone’s effect on fracture healing in acute Charcot.

**Bone Stimulation**

There is limited evidence for the use of external bone stimulators in the treatment of Charcot. Studies only support its use as an adjunct post-surgical treatment.

**Conclusion**

The gold standard of therapy is to offload the acute Charcot foot. The literature trend is to allow full weight-bearing in a TCC for forefoot or midfoot Charcot and restrict to non-weight-bearing in a device for rearfoot Charcot. The contralateral foot is placed in an orthosis or offloading device to avoid bilateral Charcot development. Care and skill are required for TCC application to avoid iatrogenic complications. Weekly to bi-weekly cast changes are recommended, casting duration is guided by clinical measures, and frequent monitoring is required. Also, pharmacological management of acute Charcot is currently unsupported.

**References**