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# Combined Internal and External Fixation for Diabetic Charcot Reconstruction: A Retrospective Case Series

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ABSTRACT

Diabetic Charcot neuroarthropathy is a complex, limb-threatening disease process with major lifestyle-altering repercussions for patients. When Charcot neuroarthropathy leads to unstable deformity, ulceration, and potential infection despite conservative therapies, foot and ankle surgeons often consider reconstructive limb salvage procedures to restore function. The purpose of the present study was to evaluate the clinical and radiographic outcomes of diabetic Charcot reconstruction using combined internal and external fixation. A total of 22 patients were reviewed; 16 (72.73%) midfoot and 6 (27.27%) tibiotalocalcaneal arthrodesis procedures were consecutively performed from March 2009 to May 2013. All surgical procedures were performed in nonacute phases of the Charcot process in patients with diagnosed diabetes mellitus and documented peripheral neuropathy. Patients were excluded from the study if they were not diabetic despite having undergone Charcot reconstruction, regardless of the fixation method, or if they did not complete radiographic imaging. During a mean follow-up period of 58.60 ± 42.37 (range 16 to 164) weeks, limb salvage was achieved in 20 patients (90.91%), and 2 (9.09%) required below-the-knee amputation at a mean of 42 ± 14.14 weeks. Wound dehiscence occurred in 8 (36.36%), pin tract infection in 10 (45.45%), and superficial wound infection in 9 (40.91%) and peaked in bimodal fashion at 4 and 8 weeks postoperatively. Radiographic analysis of the pre- versus postoperative alignment showed statistically significant changes in the lateral talo-first metatarsal angle ($p = .02$) and lateral talar declination angle ($p = .01$). The limb salvage rates with diabetic Charcot reconstruction are improving in part because of the continued development of increasingly superior modalities for both internal and external fixation.

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Charcot neuroarthropathy of the foot and ankle is a disease process characterized by various stages of soft tissue swelling with bone and joint destruction, often leading to acquired foot and ankle deformity (1–4). The disease process, first described by William Musgrave in 1703 (5), has multiple etiological factors, with diabetes mellitus among the most common (4,6). Charcot events are often preceded by subtle injury to a neuropathic foot and/or ankle that goes unrecognized by the patient in many cases. This subtle injury can occur simply from progressive joint rigidity and foot deformity, which causes increases in functional forces and repetitive stress (7–15). Surgical treatment options are typically reserved for severe deformity and instability of the foot and ankle after conservative measures have failed (16). The goals of surgical intervention are generally aimed at restoring alignment and stability of the foot and ankle and achieving a plantigrade orientation of the foot amenable to bracing (17–23). The methods of reconstruction typically involve open reduction of the deformity with use of internal or external fixation and combined techniques. Although each fixation method has its advantages, the most favorable method of fixation for reconstruction of diabetic Charcot neuroarthropathy is unknown. Combined internal and external fixation for diabetic Charcot reconstruction (DCR) might have benefits in poor quality bone with insufficient strength to rely solely on internal fixation, thus requiring stabilization away from the site of correction and/or when immobilization might not be in the patient's best interest, despite their need for surgical correction and limb salvage (17). The purpose of the present study was to review the outcomes of DCR for foot and ankle deformities using combined internal and external ring fixation. The

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primary outcome was limb salvage; however, the secondary outcomes, such as clinically significant improvement in foot stability, correction of deformity objectively determined by radiographic parameters, and the incidence of ulceration postoperatively at the final follow-up visit were reviewed.

## Patients and Methods

Our institutional review board approved the present study. A manual search of the medical records was conducted of foot and ankle DCR using a combination of both internal and external fixation consecutively performed from March 2009 to May 2013 at a single institution. This search revealed 23 patients. This study included all surgical procedures performed in nonacute phases of the Charcot process in patients with diagnosed diabetes mellitus and clinically documented peripheral neuropathy (i.e., loss of protective sensation, diminished vibratory perception threshold, diminished or absent deep tendon reflexes). Patients were excluded from the study if they were not diabetic despite having undergone Charcot reconstruction, regardless of the fixation method. One patient (4.35%) was excluded because of incomplete radiographic imaging and clinical data. The medical records were reviewed (K.W.H., M.L.W., T.M.C.) for demographic data, postoperative complications, and clinical and radiographic outcomes. The present study included 22 patients with a mean age of 54 ± 11.40 (range 31 to 75) years. Of the 22 DCRs, 11 (50%) were performed on the left lower extremity and 11 (50%) on the right. Of the 22 patients, 10 (44.45%) were male and 12 (54.55%) were female. The mean body mass index was 33.59 ± 7.34 (range 20 to 48) kg/m$^2$, and the mean hemoglobin A1c (HbA1c) was 8.15% ± 2.33% (range 5.80% to 13.90%). Two patients (9.09%) were current tobacco users at DCR, and the comorbidities, present in >30% of the patients, were hypertension in 15 (68.18%), depression in 8 (36.36%), and hyperlipidemia in 7 (31.82%). The vascular status was clinically intact in all patients preoperatively, and all necessary vascular evaluations and/or intervention had been completed before their referral to the primary surgeon. The surgical indication included ulcerative or preulcerative skin breakdown due to deformity that was not controlled by conservative measures. Of the 22 patients, 8 (36.36%) had an open ulceration at surgery and 14 (63.64%) had an intact skin envelope. Clinical and radiographic evaluations were performed preoperatively, at 1, 2, 4, 6, 8, and 12 weeks postoperatively, and at the final follow-up visit at 12 months postoperatively by 2 of us (B.L.H., K.W.H.). The demographic data from the patients included in the study are listed in Table 1.

Pin tract infections were classified separately from superficial and deep space infections and were defined by clinical evaluation. A pin tract infection was considered when any combination of erythema, pain, and drainage was noted around a pin site. Superficial infections were considered present if cellulitis, erythema, or epidermolysis, where present, led to a delay in wound healing. Deep space infections were documented as such when the infectious process had invaded into the subcutaneous tissue or bone and required surgical treatment. Treatment of pin tract infections was determined by severity and ranged from oral antibiotics to pin removal. Superficial and deep space infections were treated similarly with oral or intravenous (IV) antibiotics and surgical debridement. A standard postoperative protocol was used that consisted of 6 to 8 weeks of non-weightbearing, followed by 2 to 4 weeks of protected frame loading. The patients were instructed to clean and dress the pin sites daily with alcohol. After external fixation removal, the patients were allowed progressive weightbearing in a cast boot or Charcot restraint orthotic walker. On completion of reconstruction and rehabilitation, it is the protocol of the surgeon to prescribe or return patients to a Charcot restraint orthotic walker for ongoing use to aid in the prevention of recurrence and/or the development of additional deformity.

**Table 1**
Patient demographics (N = 22)

| Variable | Value |
|---|---|
| Age (y) | |
| Range | 31 to 75 |
| Mean ± SD | 54 ± 11.4 |
| Sex | |
| Male | 10 (45.45) |
| Female | 12 (54.55) |
| Laterality | |
| Left | 11 (50) |
| Right | 11 (50) |
| BMI (kg/m$^2$) | |
| Range | 20 to 48 |
| Mean ± SD | 33.59 ± 7.34 |
| HbA1c (%) | |
| Range | 5.8 to 13.9 |
| Mean ± SD | 8.15 ± 2.33 |
| Etiology | |
| DM | 22 (100) |
| Other | 0 (0) |
| Comorbidities | |
| DM | 22 (100) |
| HTN | 15 (68.18) |
| Depression | 8 (36.36) |
| Hyperlipidemia | 7 (31.82) |
| CAD | 4 (18.18) |
| Thyroid disease | 1 (4.55) |
| RA | 1 (4.55) |
| CKD | 6 (27.27) |
| CBP | 5 (22.73) |
| Smoking | 2 (9.09) |
| Follow-up period (wk) | |
| Range | 16.0 to 164.0 |
| Mean ± SD | 58.60 ± 42.37 |
| Frame duration (wk) | |
| Range | 7.0 to 16.0 |
| Mean ± SD | 10.27 ± 2.37 |
| Charcot anatomy | |
| Midfoot | 16 (72.73) |
| TMT | 10 (45.45) |
| Mid-tarsal joint | 9 (40.9) |
| Rearfoot/ankle | 6 (27.27) |
| STJ | 1 (4.54) |
| Ankle | 6 (27.27) |
| Ankle/STJ | 1 (4.54) |

Abbreviations: BMI, body mass index; CAD, coronary artery disease; CBP, chronic back pain; CKD, chronic kidney disease; DM, diabetes mellitus; HbA1c, hemoglobin A1c; HTN, hypertension; RA, rheumatoid arthritis; SD, standard deviation; STJ, subtalar joint; TMT, tarsometatarsal.
Data presented as n (%), unless otherwise noted.

### *Radiographic Data*

Final follow-up radiographs were obtained at a mean of 58.60 ± 42.37 (range 16 to 164) weeks after surgical reconstruction. The pre- and final postoperative weightbearing radiographic angular measurements were obtained as described by Mehta et al (24). The talo-first metatarsal and talocalcaneal measurements on the anteroposterior view and the talo-first metatarsal, calcaneal inclination, talar declination, and talocalcaneal measurements on the lateral view were recorded. Weightbearing anteroposterior ankle radiographs were obtained similarly for cases involving ankle or subtalar joint Charcot neuroarthropathy. The weightbearing frontal plane tibiotalar deformity was measured and recorded. All angles were measured by the principal investigator (K.W.H.) to reduce inter-rater variance using picture archiving and communication system computerized radiographic software (McKesson's Horizon Rad System, San Francisco, CA)

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