The Journal of Foot & Ankle Surgery ■■ (2017) ■■–■■

Contents lists available at ScienceDirect

The Journal of Foot & Ankle Surgery

journal homepage: www.jfas.org

Original Research

# Prognostic Scoring System for Patients Undergoing Reconstructive Foot and Ankle Surgery for Charcot Neuroarthropathy: The Charcot Reconstruction Preoperative Prognostic Score

David Rettedal, DPM [1], Alissa Parker, DPM [2,3], Adam Popchak, PT, PhD, SCS [4], Patrick R. Burns, DPM [5,6,7]

[1]*Foot and Ankle Surgeon, CNOS, PC, Dakota Dunes, SD*
[2]*Foot and Ankle Surgeon, Washington Foot and Ankle Specialists, Washington, PA*
[3]*Faculty, Podiatric Medicine and Surgery Residency Program, University of Pittsburgh Medical Center, Pittsburgh, PA*
[4]*Research Assistant Professor, Department of Physical Therapy, University of Pittsburgh, Pittsburgh, PA*
[5]*Assistant Professor, Department of Orthopedic Surgery, University of Pittsburgh School of Medicine, Pittsburgh, PA*
[6]*Director, Podiatric Medicine and Surgery Residency Program, University of Pittsburgh Medical Center, Pittsburgh, PA*
[7]*Chief, Podiatry Section, University of Pittsburgh Medical Center Mercy Hospital, Pittsburgh, PA*

ARTICLE INFO

*Level of Clinical Evidence:* 3

*Keywords:*
Charcot
diabetes
neuroarthropathy
neuropathy
prognosis
ulcer

ABSTRACT

Charcot neuroarthropathy is a destructive process that occurs in patients with peripheral neuropathy, often due to poorly controlled diabetes mellitus. Surgical reconstruction can be necessary to provide a plantigrade foot that is wound free. A risk of major amputation exists after a Charcot event and after attempted reconstruction. We retrospectively reviewed the data from 34 patients (36 reconstructions) who had undergone reconstructive surgery for Charcot neuroarthropathy. The mean patient age was 56.44 years. The mean follow-up period was 56 months. We collected patient age, body mass index, presence of wound or osteomyelitis, anatomic location, activity of disease, and hemoglobin A1c. Using these data, each patient was given a score using our novel prognostic scoring system, the Charcot Reconstruction Preoperative Prognostic Score (CRPPS). Our primary outcome measure was no wound and no major amputation at the final follow-up visit. The limb salvage rate was 89% (32 of 36), and 78% (28 of 36) had no wound at the final follow-up examination. For patients without a wound or major amputation at the final follow-up visit, the mean CRPPS was 2.96 ± 1.23. The mean CRPPS for those with a wound or major amputation at the final follow-up visit was 4.33 ± 1.07 ($p = .0024$). Univariate logistic regression revealed 2 statistically significant predictors of wound and/or amputation: anatomic location (odds ratio [OR] 5.0, 95% confidence interval [CI] 1.051 to 23.789; $p = .043$) and CRPPS (OR 2.724, 95% CI 1.274 to 5.823, $p = .01$). A CRPPS of ≥4 was also predictive of a negative outcome (OR 7.286, 95% CI 1.508 to 35.211; $p = .013$). This scoring system, with a sensitivity of 75%, specificity of 71%, and negative predictive value of 85%, is a potential starting point when educating patients and making treatment decisions in this exceptionally challenging group.



The Charcot foot and ankle continue to present challenges for the foot and ankle surgeon. Nonsurgical versus surgical intervention continues to be debated in published studies, and no clear consensus has been reached on patient selection when considering reconstruction. The aim of reconstruction is to reduce the risk of ulceration by creating a stable plantigrade foot that will allow the patient to bear weight and remain ambulatory in commercially available shoe gear, decreasing morbidity and the risk of amputation (1). However, the risk of ulceration and reulceration after reconstruction has been high (33%) (2). Patients' cases are often complicated by longstanding diabetes mellitus, increasing the risk of total perioperative complications.

Although limb salvage rates after Charcot reconstructive foot and ankle surgery have been reportedly high (~90%) (3), it is difficult to determine which patients will be likely to progress to a functional limb amenable to shoe gear without ulceration. In 2007, Pinzur (4) reported criteria conveying a high risk of complications after Charcot reconstruction, including a large bone deformity, longstanding ulceration with underlying bone infection, regional osteopenia, obesity, and immunocompromised health status. Eschler et al (6) subsequently investigated the outcomes of patients with ≥2 of the 5 of Pinzur's

**Financial Disclosure:** None reported.
**Conflict of Interest:** None reported.
Address correspondence to: Alissa Parker, DPM, University of Pittsburgh Medical Center Mercy, 1400 Locust Street, Building B, Room 9520, Pittsburgh, PA 15219.
*E-mail address:* tothar2@upmc.edu (A. Parker).

1067-2516/$ - see front matter © 2017 by the American College of Foot and Ankle Surgeons. All rights reserved.
https://doi.org/10.1053/j.jfas.2017.10.021

**Table 1**
System for determining the Charcot Reconstruction Preoperative Prognostic Score

| Factor | Score |
|---|---|
| Age (y) | |
| <50 y | 0 |
| >50 y | 1 |
| BMI (kg/m$^2$) | |
| <30 | 0 |
| 30 to 35 | 1 |
| 35 to 40 | 2 |
| >40 | 3 |
| Presence of wound | |
| No | 0 |
| Yes | 1 |
| Presence of osteomyelitis | |
| No | 0 |
| Yes | 1 |
| Anatomic location | |
| Excluding ankle | 0 |
| Including ankle | 1 |
| Active clinical disease | |
| No | 0 |
| Yes | 1 |
| Hemoglobin A1c (%) | |
| <8 | 0 |
| 8 to 10 | 1 |
| >10 | 2 |
| Total CRPPS possible | 10 |

Abbreviations: BMI, body mass index; CRPPS, Charcot Reconstruction Preoperative Prognostic Score.

high-risk criteria and found that a PEDIS score (5) of <7 was associated with successful limb salvage. No other investigations have directly attempted to determine which patient factors affect the reconstruction outcome. Most available studies have focused on technique description rather than patient selection factors.

The purpose of the present study was to retrospectively review the data from patients at a single foot and ankle center with a diagnosis of Charcot foot or ankle who had undergone reconstruction by a single surgeon (P.R.B.) in hopes of identifying how age, body mass index (BMI), hemoglobin A1c (HbA1c), clinical activity of Charcot disease, anatomic location, and the presence of a wound and/or osteomyelitis are associated with the outcomes. A novel prognostic scoring system is presented.

## Patients and Methods

Formal institutional review board approval was obtained. We reviewed the electronic medical records of the senior author (P.R.B.) from March 2006 to October 2013. We included consecutive patients who had undergone arthrodesis reconstructive surgery for Charcot neuroarthropathy (CN). Patients with ICD-9 code 713.5 (Charcot/neuropathic arthropathy) who underwent any combination of the following CPT codes were searched and included: pantalar arthrodesis (28705), ankle arthrodesis (27870), subtalar arthrodesis (28725), midtarsal arthrodesis (28730), midtarsal arthrodesis with osteotomy (28735), talonavicular arthrodesis (28740). Some reconstructions were staged procedures with external fixation if deemed necessary because of an active Charcot disease process, wounds, and/or compromised soft tissue. All definitive reconstructions were arthrodeses using the superconstruct principles (7). We collected each patient's age, BMI, presence of wound or osteomyelitis, anatomic location of Charcot, activity of Charcot at reconstruction, and HbA1c.

The osteomyelitis diagnosis was determined using a probe-to-bone test, complete blood count, erythrocyte sedimentation rate, C-reactive protein, and microbiologic analysis results of bone biopsy. In cases of osteomyelitis, aggressive debridement of the infected bone was performed with organism-specific antibiotic therapy given. It is our treatment protocol to treat such patients in a staged fashion. Active versus nonactive CN was determined by the clinical presence of a red, hot, swollen foot or ankle with radiographic evidence of effusion, subluxation, and periarticular debris. For the anatomic location, we evaluated whether the ankle was involved. Those patients without diabetes were assigned an HbA1c of 5%.

We excluded patients missing any single piece of required information or lacking postoperative follow-up data. Each patient was assigned a Charcot Reconstruction Preoperative Prognostic Score (CRPPS) using our novel scoring system (Table 1). Items were selected for inclusion in the scoring system according to the authors' opinion on easily quantifiable, readily available information that could influence surgical outcome (see discussion). The score range is from 0 to 10.

The primary outcome measure was defined as no major amputation and no wound at the final follow-up visit. Two groups were formed according to the primary outcome (group 1, those without a wound or major amputation at the final follow-up

**Table 2**
Group 1 (no wound or major amputation at final follow-up visit) characteristics

| Pt. No. | Age (y) | BMI (kg/m$^2$) | Wound | Osteomyelitis | Location | Active | HbA1c | CRPPS |
|---|---|---|---|---|---|---|---|---|
| 1 | 48.11 | 38.72 | No | No | Ankle | Yes | 9.6 | 5 |
| 2 | 44.71 | 35.62 | No | No | Midfoot | Yes | 6.2 | 3 |
| 2 (Bilateral) | 44.71 | 35.62 | No | No | Midfoot | Yes | 6.2 | 3 |
| 3 | 55.61 | 24.9 | Yes | Yes | Midfoot | No | 9.4 | 4 |
| 4 | 71.3 | 38.2 | No | No | Midfoot | No | 6.4 | 3 |
| 4 (Bilateral) | 71.3 | 38.2 | No | No | STJ | No | 6.4 | 3 |
| 5 | 44.61 | 46.1 | Yes | No | Chopart | No | 7.0 | 4 |
| 6 | 52.64 | 27.3 | No | No | Midfoot | No | 7.5 | 1 |
| 7 | 72.7 | 28.7 | No | No | Midfoot | No | 6.6 | 1 |
| 8 | 37.86 | 30.6 | No | No | Ankle | No | 5.8 | 2 |
| 9 | 50.28 | 23.1 | Yes | Yes | Midfoot | No | 9.1 | 4 |
| 10 | 56.82 | 29.12 | No | No | Midfoot | No | 9.6 | 2 |
| 11 | 50.09 | 31.56 | Yes | No | Ankle | Yes | 8.8 | 6 |
| 12 | 76.03 | 29.6 | Yes | No | Midfoot | No | 7.0 | 2 |
| 13 | 47.67 | 30.11 | Yes | Yes | Chopart | No | 7.5 | 3 |
| 14 | 65.05 | 33.84 | Yes | No | Midfoot | No | 7.0 | 3 |
| 15 | 61.26 | 33.38 | No | No | Midfoot | No | 5.0 | 2 |
| 16 | 59.59 | 33.75 | No | No | Midfoot | No | 8.3 | 3 |
| 17 | 65.48 | 37.07 | Yes | No | Chopart | No | 7.0 | 4 |
| 18 | 58.57 | 36.4 | No | No | STJ | No | 5.0 | 3 |
| 19 | 52.77 | 25.85 | No | No | TNJ | No | 5.0 | 1 |
| 20 | 57.27 | 41.99 | No | No | Midfoot | No | 6.2 | 4 |
| 21 | 54.98 | 23.23 | No | No | Ankle | No | 8.6 | 3 |
| 22 | 67.56 | 24.37 | Yes | No | Midfoot | No | 7.6 | 2 |
| Average (mean) | 56.96 | 32.39 | 9/24 37.5), yes | 3/24 (12.5), yes | 4/24 (16.7), ankle | 4/24 (16.7), yes | 7.2 | 2.96 |

Data in parentheses are percentages.
Abbreviations: BMI, body mass index; CRPPS, Charcot Reconstruction Preoperative Prognostic Score; HbA1c, hemoglobin A1c; Pt. No., patient number; STJ, subtalar joint; TNJ, talonavicular joint.