Charcot arthropathy outcomes after early referral to a regional tertiary care foot clinic

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Background: Community physicians may not encounter Charcot arthropathy frequently, and its symptoms and signs may be nonspecific. Patients often have a delay of several months before receiving a formal diagnosis and referral for specialty care. However, limited Canadian data are available. We evaluated the clinical history, treatment and outcomes of patients treated for Charcot arthropathy after prompt referral and diagnosis.

Methods: We performed a retrospective chart review of 76 patients with diabetes (78 feet) who received nonoperative treatment for Charcot arthropathy in a specialty foot clinic between Jan. 20, 2009, and Mar. 26, 2018. Patients were referred to the foot clinic by community physicians for evaluation or were pre-existing patients at the foot clinic with new-onset Charcot arthropathy.

Results: Of the 78 feet included in our analyses, 52 feet (67%) were evaluated initially by a community physician and referred to the foot clinic, where they were seen within 3 ± 5 weeks. The remaining 26 feet (33%) were already being treated at the foot clinic. Most feet had swelling, erythema, warmth, a palpable pulse and loss of protective sensation. Ulcers were present initially in 23 feet (29%). Sixty-four feet (82%) with Charcot arthropathy were in Eichenholtz classification stage 1 and most had midfoot involvement. Nonoperative treatment included total contact casting (60 feet, 77%). Mean duration of nonoperative treatment until resolution for 55 feet (71%) was 6 ± 5 months. Surgery was performed on 20 feet (26%) for the treatment of infection and recurrent ulcer associated with deformity, including 6 (8%) lower limb amputations.

Conclusion: Charcot arthropathy may resolve in most feet with early referral and nonoperative treatment, but remains a limb-threatening condition.

Contexte : Les médecins en milieu communautaire risquent peu de voir des cas d'arthropathie de Charcot, dont les signes et symptômes sont parfois non spécifiques. Souvent, les malades attendant des mois avant d'obtenir un diagnostic formel et d'être mis en contact avec des spécialistes. Toutefois, on dispose de peu de données canadiennes. Nous avons voulu explorer l'évolution clinique, le traitement et l'issue de la maladie chez les malades traités pour l'arthropathie de Charcot après une consultation et un diagnostics rapides.

Méthodes : Nous avons procédé à une revue rétrospective des dossiers de 76 personnes diabétiques (78 pieds) ayant bénéficié d'un traitement non chirurgical pour l'arthropathie de Charcot dans une clinique du pied entre le 20 janvier 2009 et le 26 mars 2018. Ce sont les médecins en milieu communautaire qui avaient adressé leurs malades à la clinique du pied pour évaluation ou alors, il s'agissait de patients déjà suivis à la clinique du pied qui présentaient une arthropathie de Charcot de novo.

Résultats : Parmi les 78 pieds inclus dans nos analyses, 52 (67 %) ont d'abord été examinés par un médecin en milieu communautaire, puis ont fait l'objet d'une demande consultation à la clinique du pied, consultation qui a été réalisée en l'espace de 3 ± 5 semaines. Les 26 autres pieds (33 %) étaient déjà traités à la clinique du pied. La plupart des pieds présentaient enflure, érythème, chaleur, pouls palpable et perte de sensibilité protectrice. Des ulcères s'observaient initialement sur 23 pieds (29 %). Soixante-quatre pieds (82 %) touchés par l'arthropathie de Charcot se trouvaient au stade 1 de la classification d'Eichenholtz et la majorité présentaient une atteinte au milieu du pied. Le traitement non chirurgical reposait sur l'immobilisation et la décharge au moyen d'un plâtre à contact total (60 pieds, 77 %). La durée moyenne du traitement non chirurgical jusqu'à résolution pour 55 pieds (71 %) a été de 6 ± 5 mois. Vingt pieds (26 %) ont été opérés pour le traitement d'une infection et une récurrence d'ulcère associé à la difformité, incluant 6 amputations (8 %) au membre inférieur.

Conclusion : L'arthropathie de Charcot peut rentrer dans l'ordre la plupart du temps moyennant une consultation et un traitement non chirurgical rapides, mais reste une maladie qui peut menacer la survie du membre affecté.

Charcot arthropathy (also known as Charcot neuroarthropathy) is a potentially limb-threatening condition that is observed in patients with diseases that are complicated by peripheral neuropathy, especially diabetes mellitus.[1–3] An estimated 0.2% of the general population living with diabetes and 13% of patients with diabetes presenting to a foot clinic may develop Charcot arthropathy.[4] The pathophysiology of Charcot arthropathy includes sensorimotor neuropathy, autonomic neuropathy, repetitive microtrauma and inflammation. In the presence of peripheral sensory neuropathy and loss of protective sensation, patients with diabetes may be unaware of trauma to the foot and continue weight-bearing activities. Motor neuropathy, resulting in gait changes and abnormal foot loading, may contribute to pathological stresses.[5] Repetitive microtrauma may occur from ongoing ambulation, and proinflammatory cytokines may be produced and released as a result of injury.[6,7] Increased inflammation and autonomic dysfunction may cause osteolysis and diffuse soft tissue edema,[8] fractures, dislocations, bone deformities, ulcers and infections, potentially leading to lower-limb amputation.[9,10]

Patients who have acute Charcot arthropathy typically present with a swollen, warm and erythematous foot. The temperature difference between the affected and contralateral foot may be several degrees and palpable.[11] Pain is usually modest or absent. The Eichenholtz stages summarize the natural history of Charcot arthropathy: foot being at risk because of an acute sprain or fracture (stage 0); active Charcot arthropathy with inflammation, development and fragmentation (stage 1); early healing and coalescence (stage 2); and reconstruction–consolidation with remodelling, resolution and residual deformity (stage 3).[2,3,12,13]

As Charcot arthropathy may be seen infrequently by community physicians and the symptoms and signs may be nonspecific, patients often have a delay of several months before receiving a formal diagnosis and referral for specialty care.[14,15] Delay in treatment may be associated with increased bone destruction, joint subluxation and deformity of the foot and ankle such as midfoot arch collapse (rocker-bottom foot).[5,9]

Although operative treatment may be indicated in the early stages, early Charcot arthropathy is usually treated nonoperatively with foot and ankle immobilization.[2,16–21] However, the decision to protect and immobilize the affected foot and ankle with a total contact cast or another off-loading device is based primarily on expert opinion.[19] There are limited Canadian data available about the effects of Charcot arthropathy on long-term patient outcomes.[22,23] Furthermore, limited information is available in Canada about the frequency of recurrence or need for other interventions such as arthrodesis or amputation.[24,25]

In the province of Manitoba, the age-adjusted prevalence of diabetes has tripled from 2.8% in 1988 to 9.5% in 2018 and is highest in the remote Northern Health Region (20%).[26] Complications from diabetes have also increased in prevalence. The rate of lower-limb amputation was 10.5 per 1000 residents from 2014 to 2019 and Manitobans with diabetes were 30 times more likely to have a lower-limb amputation than the general population.[26,27] Despite the high prevalence of diabetes in Manitoba, limited recent data are available about Charcot arthropathy prevalence, clinical presentation, treatment and long-term outcomes.[27] Furthermore, as the diagnosis of Charcot arthropathy is frequently delayed, there is limited information about the results of treatment started early after onset.

We hypothesized that patients who present with Charcot arthropathy early after onset of symptoms and signs may have a better prognosis than patients who have a prolonged delay in diagnosis. We sought to evaluate the clinical history and treatment outcomes in patients who had Charcot arthropathy and were referred to our foot clinic soon after onset of symptoms and signs.

Methods

Patients

We performed a retrospective chart review of patients at the tertiary care specialty foot clinic at the Health Sciences Centre, University of Manitoba, who were diagnosed with and began nonoperative treatment for Charcot arthropathy between Jan. 20, 2009, and Mar. 26, 2018. Patients were either referred by community physicians for evaluation or were pre-existing patients of the foot clinic who had Charcot arthropathy. During the evaluation on presentation, Charcot arthropathy was confirmed or diagnosed by any of the 3 staff physicians (2 orthopedic surgeons and 1 infectious diseases physician) based on clinical examination and plain radiography. Patients were identified from the billing database and clinic lists. All patients were included in the evaluation, regardless of whether they completed treatment in the foot clinic for Charcot arthropathy or were lost to follow-up. We excluded patients without a diagnosis of Charcot arthropathy and 2 patients whose Charcot arthropathy was treated initially with surgery. We also excluded 4 patients with unilateral tibiotalar Charcot arthropathy (modified Brodsky type 3A)[2,28] because of the small number of patients and because of the mechanical distinction between instability patterns commonly involving the ankle (hypermobility) compared with the foot (rigid).

Our study was reviewed and approved by the Biomedical Research Ethics Board of the University of Manitoba.

Evaluation and treatment

We reviewed patient charts (paper files for clinical information and electronic records for drugs and laboratory studies) for history, initial presentation, treatment and outcomes. The extracted data were recorded in a spreadsheet, and spreadsheet cells were kept unfilled for incomplete data. Medical history included diabetes status,

duration and treatment. Demographic information included age, sex and urban or rural place of residence.

Presenting history included information about whether patients were referred by a community physician or were preexisting patients of the foot clinic. When the patient was referred, we recorded the duration between the observation of the foot problem by the community physician and evaluation in the foot clinic and whether the community physician treated the foot with a removable walker brace, total contact cast or other type of off-loading device. Details about the initial presentation to the foot clinic included affected side, history of trauma in the preceding 6 months and most recent hemoglobin A_{1c} level within 6 months before presentation. Physical examination findings were recorded, including swelling, erythema, warmth and change in morphology of the affected compared with the contralateral foot. We also recorded the presence of ulcer, infection, palpable pedal pulses and protective sensation tested with Semmes–Weinstein monofilaments. All patients underwent foot and ankle radiography in the foot clinic upon presentation. The radiographs and reports were reviewed for soft tissue and osseous features of Charcot arthropathy. The feet were staged using Eichenholtz classification[12,13] and graded for anatomic site using modified Brodsky classification (type 1, midfoot; type 2, hindfoot; type 3A, tibiotalar joint [excluded]; type 3B, calcaneal tuberosity; type 4, multiple regions; type 5, forefoot).[2,28]

Initial treatment at the foot clinic was nonoperative, including an off-loading immobilization device such as a total contact cast, removable walker brace or Charcot Restraint Orthotic Walker (CROW). We documented complications that occurred during nonoperative treatment, including superficial skin irritation, noninfected ulcer or infected ulcer. The duration of nonoperative treatment in the foot clinic was recorded as the time from initial foot clinic evaluation until the Charcot arthropathy resolved or was treated surgically because of persistent infection or deformity with associated ulcer. The type of surgery was recorded, including exostectomy with or without irrigation and debridement, lower-limb amputation or arthrodesis.

After Charcot arthropathy resolution was documented, subsequent treatment with a permanent off-loading device, including removable walker brace, CROW, leather gauntlet ankle foot orthosis or custom foot orthosis, was recorded. When Charcot arthropathy recurred (defined as Charcot arthropathy that occurred in the ipsilateral or contralateral foot and ankle after a minimum 1 month after disease resolution), we documented the side affected and time from resolution to recurrence.

Statistical analysis

Descriptive statistics were calculated for all variables. Numerical data were calculated based on the number of feet with complete data for the variable. Average values are reported as mean ± standard deviation (SD).

RESULTS

After exclusions, 76 patients (78 feet) with Charcot arthropathy remained for inclusion in our study, including 3 patients (3 feet) who were lost to follow-up before completing treatment. Most patients were men who were urban dwellers and had long-standing diabetes treated with insulin (Table 1). Most patients were evaluated initially by a community physician, promptly referred to the foot clinic without treatment and seen in the foot clinic within a mean of 3 ± 5 weeks after referral (Table 2). Most feet were in Eichenholtz stage 1 and had swelling, erythema, warmth, a palpable pulse, absence of protective sensation and radiographs consistent with Charcot arthropathy, but no ulcer (Table 2). There were 10 patients (11 feet) who had intact protective sensation on monofilament testing, and 4 of these patients had a history of trauma before the onset of Charcot arthropathy.

Charcot arthropathy resolved in 55 feet (70%) with nonoperative treatment involving total contact casting or a removable walker brace at a mean of 6 ± 5 months after initial presentation to the foot clinic (Table 3). Three patients (2 rural and 1 urban, 3 feet) were lost to follow-up. Surgery was performed on 20 feet (26%) for treatment of infection or a deformity causing recurrent ulcer. Surgical procedures included exostectomy alone in 8 (10%) of 78 feet, treatment of infection with exostectomy and irrigation and debridement in 5 (6%) feet, lower-limb amputation in 6 (8%) feet or arthrodesis of an unstable joint in 1 (1%) foot (Table 3). After resolution of Charcot arthropathy in patients who did not undergo amputation, 38 of 62 feet

Table 1. Demographic and clinical characteristics of patients presenting with Charcot arthropathy*

Characteristic	No. of feet (%)†
Age at presentation, yr, mean ± SD	57 ± 10
Sex	
Men	54 (69)
Women	24 (31)
Residence	
Urban	44 (56)
Rural	34 (44)
Diabetes duration, yr, mean ± SD‡	19 ± 10
Diabetes treatment§	
Insulin	25 (33)
Oral hypoglycemic drug and insulin	24 (32)
Oral hypoglycemic drug	24 (32)
Controlled by diet	2 (3)

SD = standard deviation.

*n = 78 feet in 76 patients including bilateral Charcot arthropathy in 2 men (1 urban and 1 rural). All patients had diabetes.

†Unless indicated otherwise.

‡Data available for 30 feet.

§Data treatment available for 75 feet.

(61%) for which there was follow-up documentation of footwear had been fitted with a custom foot orthosis, and 61 of all 75 feet (81%) for which there was follow-up information had no complications (Table 4). Recurrence was observed in 14 of the 75 feet (19%) with follow-up within a mean of 7 months after resolution (Table 4).

Discussion

We showed that most patients with acute Charcot arthropathy were evaluated in this tertiary-care referral foot clinic within several weeks of initial observation by the community physician and healed with nonoperative treatment. The mean time of 3 weeks between the initial

Table 2. Clinical history and findings on evaluation of Charcot arthropathy at a tertiary care specialty foot clinic*

Variable	No. of feet (%)†
Treatment setting at initial diagnosis	
Community physician‡	52 (67)
Time between community physician and foot clinic evaluations, wk, mean ± SD	3 ± 5
Already a patient at foot clinic	26 (33)
Affected foot	
Right	41 (53)
Left	37 (47)
Foot trauma in preceding 6 mo	
Yes	17 (22)
No	61 (78)
Swollen, erythematous, warm foot	
Yes	75 (96)
No	3 (4)
Skin status of affected foot	
Ulcer present§	23 (29)
No ulcer	55 (71)
Palpation of pedal pulse	
Normal or increased	65 (83)
Decreased	13 (17)
Foot protective sensation (monofilament testing)	
Intact	11 (14)
Absent	67 (86)
Hemoglobin A_{1c} 6 mo before presentation (% glycated), mean ± SD¶	9 ± 2
Charcot arthropathy confirmed by radiograph	
Yes	73 (94)
No	5 (6)
Eichenholtz stage	
0 (at risk because of acute sprain or fracture)	5 (6)
1 (development–fragmentation)	64 (82)
2 (coalescence)	9 (12)
3 (reconstruction–consolidation)	0 (0)
Modified Brodsky classification**	
Type 1 (midfoot)	63 (83)
Type 2 (hindfoot)	7 (9)
Type 4 (multiple)	1 (1)
Type 5 (forefoot)	5 (7)

SD = standard deviation.

*n = 78 feet in 76 patients. Median time from initial observation of problem until evaluation in foot clinic for all feet, 1 wk.

†Unless indicated otherwise.

‡Treatment by community physician: removable walker brace, 9 feet (17%); total contact cast, 5 feet (10%); other orthosis, 2 feet (4%); none, 36 feet (69%).

§Ulcer: not infected, 13 ulcers (57%); infected, 10 ulcers (43%).

¶Hemoglobin A_{1c} available for only 25 feet (25 patients).

**Modified Brodsky type unknown in 2 feet (2 patients). There were 4 patients with unilateral type 3A (tibiotalar) who were excluded and no feet with type 3B (calcaneus).

Table 3. Treatment of Charcot arthropathy at a tertiary care specialty foot clinic*

Variable	No. of feet (%)†
Clinical course	
Nonoperative treatment, resolved	55 (70)
Nonoperative treatment and surgery	20 (26)
Nonoperative treatment, lost to follow-up	3 (4)
Nonoperative treatment‡§¶	
Total contact cast	60 (77)
Removable walker brace	17 (22)
CROW	1 (1)
Duration of nonoperative treatment, mo, mean ± SD**	
Until resolution	
All feet (55 feet)	6 ± 5
Total contact cast (40 feet)	5 ± 3
Removable walker brace (15 feet)	8 ± 7
Until surgery	
All surgery including amputation (20 feet)	5 ± 5
Amputation (6 feet)	3 ± 2
Complications during nonoperative treatment	
Superficial skin irritation	5 (6)
Noninfected ulcer	5 (6)
Infected ulcer	5 (6)
None	63 (81)
Outcome of ulcers present at initial evaluation (23 feet)	
Resolved with nonoperative treatment††	17 (74)
Required surgery	4 (17)
Lost to follow-up	2 (9)
Surgery	
Indications for surgery	
Infection	11 (14)
Deformity causing recurrent ulcer	9 (12)
Procedures	
Exostectomy alone	8 (10)
Exostectomy with irrigation and débridement	5 (6)
Lower limb amputation	6 (8)
Arthrodesis	1 (1)
Total	20 (26)

CROW = Charcot Restraint Orthotic Walker; SD = standard deviation.

*n = 78 feet in 76 patients.

†Unless indicated otherwise.

‡No feet had more than 1 type of nonoperative treatment documented.

§Urban residence: 44 feet in 43 patients: total contact cast, 35 feet (80%); removable walker brace, 9 feet (20%).

¶Rural residence: 34 feet in 33 patients: total contact cast, 25 feet (74%); removable walker brace, 8 feet (24%); CROW, 1 foot (3%).

**Duration from initial evaluation in the foot clinic until resolution or surgery; total = 75 feet because 3 feet were lost to follow-up.

††In these 17 feet, time from initial presentation to healed ulcer with nonoperative treatment, 5 ± 5 months.

Table 4. Follow-up after treatment of Charcot arthropathy at a tertiary care specialty foot clinic*

Variable	No. of feet (%)†
Footwear after Charcot resolution (*n* = 62 feet)‡	
Custom foot orthosis	38 (61)
Leather gauntlet ankle–foot orthosis	11 (18)
Removable walker brace	9 (15)
CROW	4 (6)
Complications after Charcot resolution (*n* = 75 feet)§¶	
None	61 (81)
Noninfected ulcer	11 (15)
Infection	3 (4)
Charcot recurrence (*n* = 75 feet)§	
Total**	14 (19)
Time from resolution to recurrence, mo, mean ± SD	7 ± 7

CROW = Charcot Restraint Orthotic Walker; SD = standard deviation.

**n* = 78 feet in 76 patients.

†Unless indicated otherwise.

‡Footwear: information available for 62 feet; the other 16 feet had no footwear documentation (7 feet), had amputation (6 feet) or were lost to follow-up (3 feet).

§Information available for 75 feet; the other 3 feet were lost to follow-up.

¶Complications: After Charcot arthropathy resolution, all 3 infections were associated with an ulcer. There were 2 feet with noninfected ulcers associated with contralateral Charcot recurrence, and 1 foot with an infection associated with ipsilateral Charcot recurrence.

**Charcot recurrence: ipsilateral, 9 feet (64%); contralateral, 5 feet (36%).

observation by the community physician and evaluation at the foot clinic was shorter than typical delays of several months reported previously,[14,15] possibly associated with the long-standing local culture of physician education about foot problems in patients with diabetes and the practice of scheduling referred patients as soon as possible to ensure timely evaluation at the foot clinic.[29–32] During the past 20 years, the medical school affiliated with the foot clinic (Max Rady College of Medicine, University of Manitoba) has included a formal mandatory educational session about foot complications in patients with diabetes in the second year of the undergraduate medical curriculum. In addition, 1 or 2 postgraduate courses are conducted each year. As a result, program graduates, local front-line clinicians and staff radiologists are aware of the clinical findings of Charcot arthropathy, evidenced by the early referrals and radiology reports that indicate the findings of Charcot arthropathy. The success of nonoperative treatment may be attributed in part to early treatment, frequent follow-up and multidisciplinary collaboration in the clinic between 2 orthopedic surgeons, 1 infectious diseases specialist, other physician specialists, nurses, orthopedic cast technologists and certified pedorthists.

Our results provide benchmark information, from a substantial number of limbs and clinical variables, about the evaluation and treatment of Charcot arthropathy at a foot clinic in a province that has a high prevalence of diabetes. Our study confirms, complements and enables comparisons with the results from benchmark studies in other foot and ankle treatment centres for people with diabetes globally that have reported a wide range of clinical volume of Charcot arthropathy from 2 to 30 lower limbs or patients treated per year.[33–38] However, the incidence of Charcot arthropathy in Manitoba is unknown because some patients may receive treatment at other facilities in the province. Previous studies at our clinic showed an active caseload of 60 patients who had an initial evaluation, ongoing treatment or follow-up for Charcot arthropathy, including 21 patients (25 lower limbs) who had treatment with a removable walker brace and custom insole.[22,23]

Our results confirm the typical risk factors for Charcot arthropathy in patients with diabetes, its presentation and associated practice patterns that have been reported previously.[2,11,19,38] Most patients had long-standing diabetes treated with insulin and had loss of protective sensation, consistent with the findings of a previous epidemiological review.[4] In addition to peripheral neuropathy as a risk factor for Charcot arthropathy, hyperglycemia may cause a proinflammatory state that may contribute to the development of Charcot arthropathy.[39] Furthermore, a meta-analysis published previously about the diagnostic accuracy of monofilament testing showed limited sensitivity in diagnosing peripheral neuropathy (53%) in patients with diabetes,[40] suggesting that several of our 10 patients who had normal monofilament testing may have had loss of protective sensation.

Most patients in our study presented with the typical signs of Charcot arthropathy, including a swollen, erythematous and warm foot. Some patients had a history of trauma. Delay in referral typically occurs because of nonspecific clinical signs, infrequency of encountering Charcot arthropathy in general practice and misdiagnosis as deep venous thrombosis, cellulitis, gout or ankle sprain.[14] It is important to have a high clinical index of suspicion for the presence of Charcot arthropathy in patients with neuropathy because radiographs may appear normal, and delays in diagnosis and treatment may increase the risks of developing severe deformities, associated ulcers and infections that may be refractory to nonoperative treatment and lead to amputation.[41]

Most patients were treated in the foot clinic with total contact casting despite potential complications reported previously.[17] Total contact casting is reliable and effective in the treatment of Charcot arthropathy. We prefer this method, in part because of the availability of 4–7 full-time experienced orthopedic technologists in the hospital centre, including 2 technologists who typically are present in the foot clinic during clinic hours, but total contact casting is not used when it is not acceptable to the patient or when there is evidence of active infection.[42] The inconvenience of repeat follow-up visits for cast changes did not affect the choice of immobilization method because the frequency of treatment with total contact casting was similar in the feet of patients in urban and rural residences

(Table 3). The mean 6-month duration of off-loading and immobilization until Charcot arthropathy resolution is consistent with the results of previous studies (3–20 mo).[43] The duration of treatment using a removable walker brace for Charcot arthropathy was similar in the present study (Table 3) and in a previous study by our group (mean, 7 ± 4 mo), even though the duration of Charcot arthropathy before brace use was longer in the previous study (12 wk).[23] Other studies[44,45] showed that the healing of foot ulcers in patients with diabetes may be better or similar with total contact casting than a removable walker boot, and a comparative study of these methods in Charcot arthropathy is warranted.

The frequency of lower-limb amputation in our study was similar to that reported in a systematic review (8.9%) published previously.[46] The frequency of recurrence of Charcot arthropathy also was comparable with other reports (12%–33%).[46–48] In feet with ipsilateral recurrence, it may be difficult to distinguish between recurrence and incomplete resolution.

Limitations

Limitations of our study include its retrospective design and lack of a comparison group that may be associated with incomplete data. The duration of symptoms and signs of Charcot arthropathy before evaluation by a community physician is unknown, and estimates of duration may be unreliable because of the loss of protective sensation caused by neuropathy. We were unable to evaluate the epidemiology of Charcot arthropathy in the province because our study was limited to 1 clinic, and there may have been other patients with Charcot arthropathy who were treated elsewhere in the region. A rigorous comparison of the efficacy of the various nonoperative treatment methods on outcomes was not feasible because of the small number of patients who were treated with a removable walker brace or CROW. In addition, sampling bias may have occurred because patients were identified from the billing database and clinic lists that may have missed some patients who were treated during the study period. Furthermore, there may have been patients missed who had mild disease that was undetected or who were not referred from remote and northern regions.

Conclusion

Our study shows that satisfactory resolution of Charcot arthropathy in patients with diabetes may be achieved frequently with early referral, nonoperative treatment and surgery as needed for the treatment of infection and recurrent ulcer associated with deformity. Nevertheless, Charcot arthropathy continues to be a limb-threatening problem, and sequelae after resolution may include recurrence and the development of ulcers associated with residual deformity.

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Competing interests: J.M.A. Embil participated on a clinical trial advisory board for MicuRx for a new antibiotic. He was also a member of the infection group for the International Working Group for the Diabetic Foot (IWGDF). No other competing interests were declared.

Contributors: J.M.A. Embil and T.M. Huynh designed the study. T.M. Huynh, M. Dascal and B. Pilkey acquired the data, which T.M. Huynh, E. Trepman and J.M.A. Embil analyzed. T.M. Huynh and E. Trepman wrote the article, which M. Dascal, J.M.A. Embil and B. Pilkey reviewed. All authors approved the final version to be published.

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