Management of Infected Charcot Neuroarthropathy due to Diabetes Mellitus with Half Pins External Fixator and Pinning: A Case Series

Maria Florencia Deslivia*, Claudia Santosa, Putu Teguh Aryanugraha, Sherly Desnita Savio, Ketut Kris Adi Marta, I. Wayan Subawa, Putu Astawa

Department of Orthopaedics and Traumatology, Faculty of Medicine, Udayana University, Sanglah General Hospital, Bali, Indonesia

Abstract

BACKGROUND: Charcot neuroarthropathy (CN) of the foot and ankle, which is complicated with infection, is debilitating disease and presents challenges until now. External fixation with half-pins is useful as provisional treatment.

AIM: The purpose of this retrospective case series is to summarize the patient characteristic, type of surgical intervention, outcome, and complication of infected CN treated in our hospital.

MATERIALS AND METHODS: This case series studied retrospectively patients with CN of the foot and ankle due to diabetes mellitus type II, complicated by infection, who required surgical treatment in a single institution, from 2018 to 2019. Diagnosis was based on chronic deformity (fracture or dislocation) as proven on X-ray and recently developed infection as shown through clinical, laboratory, and radiological evaluation.

RESULTS: We studied seven patients with CN classified as Eichenholtz Stage 3 (100%) and Brodsky type 3A alone (n = 3) (Figure 1), and type 3A with other types (n = 4). The mean age is 44.6 years old (range, 35–60) and mean body mass index was 24.08 kg/m² (range, 21.45–25.39). Signs of infection include leukocytosis (n = 6), soft-tissue swelling (n = 4), ulcer (n = 4), and osteomyelitis (n = 1) at presentation. Operative treatment consisted of debridement, followed by external fixation only (n = 4), combined external fixation and pinning (n = 2), and intramedullary pinning only (n = 1). The mean hospital length of stay was 4.5 days (range, 3–7). We performed short-term follow-up after a mean of 4.12 months (range, 1.3–5.3) and long-term after a mean of 15.02 months (range, 11.27–16.8), the limb salvage rate was 100% in both. One patient had revision of external fixation. As for functional outcome, at the time of long-term follow-up mean visual analogue scale was 0.75 (range, 0–2) and American Orthopaedic Foot and Ankle Score was 66.25 (range, 57–77).

CONCLUSION: In this study, mostly external fixation with half-pins and methyl metacrylate was used based on the bone condition and patient’s compliance. Despite of its limitation, this method is effective when it is combined with strict blood glucose level and infection control.

Introduction

Charcot neuroarthropathy (CN) of the foot and ankle, which is complicated with infection, is debilitating disease and presents challenges until now. Infection worsens the problem of vascularization, bone tissue reserve, and general healing process which is already severe in CN due to diabetes mellitus (DM) [1], [2], [3]. Therefore, the mainstay treatment is to eradicate infection with aggressive debridement of unvital tissues. Sufficient bone was then removed to allow correction of deformity to a plantigrade position. After that, the correction can be maintained using static circular external fixator [4], [5], [6].

In facilities where circular external fixators are not readily available, a number of alternatives could be reasonably utilized to treat infected Charcot foot. In our hospital, we performed staged reconstruction for these cases in which the objectives of the first surgery are to eradicate infection and provide proper condition before definitive reconstruction. Fixation of corrected foot position was performed using external fixation with half pins, or combined external fixation and pinning, or pins only depending on the severity of deformity. The purpose of this retrospective case series is to summarize the patient characteristic, type of surgical intervention, outcome, and complication of infected CN treated in our hospital.
Operative treatment consisted of debridement, followed by external fixation only (n = 4) (Figure 3), combined external fixation and pinning (n = 2) (Figure 4), and intramedullary pinning only (n = 1). The mean hospital LOS was 4.5 days (range, 3–7).

Results

We studied seven patients diagnosed with CN. The mean age is 44.6 years old (range, 35–60) and mean mean body mass index was 24.08 kg/m² (range, 21.45–25.39). All patients were classified as Eichenholtz Stage 3 (100%). As for the anatomic classification, some were categorized into Brodsky type 3A alone (n = 3) (Figure 1), and type 3A with other types (n = 4). As for basic laboratory markers, mean pre-operative Hb was 9.84 g/dL (range, 8.41–11.83), mean white blood cell count was 10.64×10³ (range, 7.12×10³–13.87×10³), and mean HbA1C was 8.2 (range, 7–15.9). Summary of baseline characteristic is presented in Table 1.

Preoperatively, we found that 57.14% of patients had ulcer (Figure 2) and 28.57% patients had osteomyelitis based on X-ray. Signs of infection included leukocytosis (n = 6), soft-tissue swelling (n = 5), ulcer (n = 4), and osteomyelitis (n = 1) at presentation.

Table 1: Baseline characteristic of patients in the case series

| No | Age | Sex | Body mass index | Hb | White blood cells | HbA1C | Eichenholtz | Brodsky |
|----|-----|-----|-----------------|----|-------------------|-------|-------------|---------|
| 1  | 35  | M   | 25.42           | 11.83 | 10.99            | 13.87 | 5.9         | 3       |
| 2  | 37  | F   | 27.23           | 10.99 | 13.87            | 7.4   | 3           | 3A, 1   |
| 3  | 43  | F   | 23.89           | 9.3   | 7.12             | 10.7  | 3           | 3A, 3B  |
| 4  | 41  | F   | 25.39           | 9.88  | 10.87            | 7.8   | 3           | 3A      |
| 5  | 53  | M   | 21.45           | 8.41  | 11.34            | 7     | 3           | 3A      |
| 6  | 43  | M   | 22.3            | 10.2  | 9.33             | 8.6   | 3           | 3A      |
| 7  | 60  | M   | 22.87           | 10.26 | 11.3             | 7.6   | 3           | 3A, 1   |

Operative treatment consisted of debridement, followed by external fixation only (n = 4) (Figure 3), combined external fixation and pinning (n = 2) (Figure 4), and intramedullary pinning only (n = 1). The mean hospital LOS was 4.5 days (range, 3–7).

After a mean period of 4.56 months (range, 1.3–5.3), we performed the first assessment. Limb salvage rate was 100%. One patient needed revision of external fixation due to loosening of pins on dorsum pedis by this time. We assessed the pain scale with VAS and the functional outcome through AOFAS score.
Mean pre-operative VAS was 7.4 (range, 7–8) and mean post-operative VAS was 2.6 (range, 2–3). All patients experienced VAS improvement with a mean score of 4.86 (range, 4–6). Mean pre-operative AOFAS score was 22 (range, 14–35) and post-operative was 59.57 (range, 52–67), with all patients experiencing score improvement of 37.57 (range, 24–52).

As for the second assessment, the mean period was 15.02 months (range, 11.27–16.8). Limb salvage rate is still 100%. Three patients had external fixation removed with one of them undergoing arthrodesis. One more patient needed external fixation revision for loosening of pins on dorsum pedis. Three other patients were lost to follow-up. Mean VAS was 0.75 (range, 0–2). The mean improvement of VAS compared to last follow-up was 1.75 (range, 0–3). Mean AOFAS score was 66.25 (range, 57–77), with all patients experiencing score improvement of 8.5 (range, 5–12). Ulcer wounds healed satisfactorily for all patients (Figure 5).

In this case series, revision was performed due to loosening of external fixator pins on the foot. The revision was performed with the same technique as original procedure which has been described elsewhere [7]. We fixed the ankle joint using half-pins on tibia bone and metatarsal bones and fixed them with wire and methyl methacrylate in plantigrade position. The combined procedure (external fixator and pinning with K-wires) was performed with similar technique. The addition was fixation with pinning as seen fit intraoperatively.

The summary of outcome is presented in Table 2.

### Table 2: Type of fixation on each patient and the resulting VAS and AOFAS improvement

| No | Type of fixation | LOS | VAS pre/first follow-up/ second follow-up | AOFAS pre/first follow-up/ second follow-up |
|----|-----------------|-----|------------------------------------------|--------------------------------------------|
| 1  | Internal fixation | 7   | 7/2/NA                                   | 15/62/NA                                   |
| 2  | Combined         | 5   | 7/2/NA                                   | 14/57/NA                                   |
| 3  | Combined         | 6   | 8/2/2                                    | 28/52/57                                   |
| 4  | External fixation| 6   | 8/3/NA                                   | 15/67/NA                                   |
| 5  | External fixation| 3   | 7/2/0                                    | 32/65/77                                   |
| 6  | External fixation| 3   | 8/3/1                                    | 15/52/62                                   |
| 7  | External fixation| 4   | 7/3/0                                    | 35/62/89                                   |

LOS: Length of stay, VAS: Visual analog scale, AOFAS: American Orthopedic Foot and Ankle Score.

### Discussion

Charcot foot is especially complex when combined with diabetes. Hyperglycemic condition in diabetic patients has been shown to increase levels of advanced glycosylation end products (AGEs). This may partially explain the association between poor diabetic control and the development of Charcot as the AGEs are able to upregulate the receptor activator of nuclear factor κ B (RANK)–RANK Ligand pathway by interacting with their receptor, the RANK receptor, especially after a fracture or repetitive trauma [8]. Therefore, a multidisciplinary approach is needed to treat infected Charcot foot [4], [8].

In our series, infection was thoroughly eradicated through the choice of antibiotics, surgical debridement, and blood glucose control through medication. American Diabetes Association and the Infectious Disease Society of North America have examined evidence regarding treatment of Charcot foot with concurrent osteomyelitis and concluded that surgical excision of infected bone combined with monitored parenteral culture-specific antibiotic therapy is recommended [4], [9].
As for the surgical treatment, the general consensus is that correction of deformity and placement of implants should be performed after bone infection is resolved. However, recent publication offered evidence that combination of debridement and correction of deformity in one single operation yielded satisfying result [9]. Here, we performed the procedures in single stage with external fixation only, or combined internal and external fixation, or internal fixation only (Figure 2). The choice of fixation was based on the bone condition and patient's compliance.

The half-pins external fixation with methyl methacrylate is still our main choice of provisional treatment for Charcot foot fixation due to its efficiency yet relatively low cost. Most patients have good compliance with this method. The down side is the risk of pin loosening due to the osteopenic bone which commended revision. We believe this method can be widely utilized in facilities with limited resources.

In this study, we observed satisfying clinical outcome. Mean hospital LOS was 4.5 days and after a follow-up of 15 months, the limb salvage rate was 100%. One patient needed revision of external fixation due to loosening of screws on metatarsal bones. Functional outcome in both short-term and long-term was satisfactory, despite the choice of fixation. Even though there were limitations, the half-pins external fixation with methyl methacrylate can be the go-to provisional treatment for CN as long as there is strong commitment to control blood sugar level and to minimize or eradicate infection. This method is a useful adjunct to improve the outcome in terms of eradicating infection and maintaining optimal foot position before arthrodesis.

**Conclusion**

In our institution, patients seek for treatment for the CN foot when the chronic deformity is complicated already by infection. The surgical treatment option might include external fixation, with or without internal fixation, with the aim of stabilizing the deformed joint and preparing the bone and soft tissue for definitive treatment (arthrodesis), while optimizing patients' general condition. In this study, mostly external fixation with half-pins and methyl methacrylate was used based on the bone condition and patient’s compliance. Despite of its limitation, this method is effective when it is combined with strict blood glucose level and infection control.

**Availability of data and material**

All data generated or analyzed during this study are included in this published article.

**Authors’ Contributions**

MFD, CS, PTA, SDS, and KKAM collected the literatures to be involved in the study. MFD and CS performed systematic analysis the literatures. MFD and IWS worked to formulate the discussion and conclusion. MFD, IWS, and PA read and approved the final manuscript.

**References**

1. Goldsmith L, Barlow M, Evans PJ, Srinivas-Shankar U. Acute hot foot: Charcot neuroarthropathy or osteomyelitis? Untangling a diagnostic web. BMJ Case Rep. 2019;12(5):e228597. https://doi.org/10.1136/bcr-2018-228597 PMid:31088814
2. Ramanujam CL, Stapleton JJ, Zgonis T. Diabetic Charcot neuroarthropathy of the foot and ankle with osteomyelitis. Clin Podiatr Med Surg. 2014;31(4):487-92. https://doi.org/10.1016/j.cpm.2013.12.001 PMid:25281510
3. Short DJ, Zgonis T. Management of osteomyelitis and bone loss in the diabetic Charcot foot and ankle. Clin Podiatr Med Surg. 2017;34(3):381-7. https://doi.org/10.1016/j.cpm.2017.02.008 PMid:28576196
4. Pinzur MS, Gil J, Belmares J. Treatment of osteomyelitis in Charcot foot with single-stage resection of infection, correction of deformity, and maintenance with ring fixation. Foot Ankle Int. 2012;33(12):1069-74. https://doi.org/10.3113/FAI.2012.1069 PMid:23199855
5. Saltzman CL. Salvage of diffuse ankle osteomyelitis by single-stage resection and circumferential frame compression arthrodesis. Iowa Orthop J. 2005;25:47-52. PMid:16089072
6. El-Gafary KA, Mostafa KM, Al-Adly WY. The management of Charcot joint disease affecting the ankle and foot by arthrodesis controlled by an ilizarov frame. J Bone Joint Surg Br. 2009;91(10):1322-5. https://doi.org/10.1302/0301-620x.91b10.22431 PMid:19794167
7. Hemigou P. History of external fixation of treatment for fractures. Int Orthop. 2017;41(4):845-53. https://doi.org/10.1007/s00264-016-3324-y PMid:27853817
8. Haslbeck KM, schleicher E, Bierhaus A, Nawroth P, Haslbeck M, Neundörfer B, et al. The AGE/RAGE/NF-(kappa)B pathway may contribute to the pathogenesis of polyneuropathy in impaired glucose tolerance (IGT). Exp Clin Endocrinol Diabetes. 2005;113(5):288-91. https://doi.org/10.1055/s-2005-856500 PMid:15926115
9. Rogers LC, Frykberg RG, Armstrong DG. The diabetic Charcot foot syndrome: A report of the joint task force on the Charcot foot by the American diabetes association and the American podiatric medical association. Diabetes Care. 2011;34:2123-9. https://doi.org/10.1177/0971442511400268