Reconstructive foot and ankle surgeries in destroyed diabetic Charcot’s Neuroarthropathy, stabilized with Amrita-Sling Technique: A one year follow-up

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Abstract:
The primary objectives in the reconstruction of destroyed foot and ankle bones of diabetic Charcot’s Neuroarthropathy (CN) are the reduction of increased plantar pressures and the restoration of function, stability, and proper appearance. Though many techniques exist, long-term success rates once the patient is ambulatory is low. Internal fixation with compression screws and stabilization of the foot and ankle with the ‘Amrita-Sling Technique’ (AST) performed on many patients have shown good results with virtually no post-operative surgical site infections, quick recovery, and no re-collapse after mobilization with follow-up after a year.

Aim: The aims are to assess the rate of post-operative surgical site infection, the time taken to achieve active mobilization, and the rate of re-collapse after mobilization in patients with destroyed Charcot’s foot and ankle who underwent surgical reconstruction and AST stabilization.

Materials and Methods: The audit consists of patients who underwent the procedure between December 2008 and July 2009, and had a one-year follow-up.

Results: Ten patients were included in the clinical audit. No patients developed immediate or major surgical site infection. The mean duration to start mobilization was 19.60 ± 5.854 weeks, and the mean ulcer healing time in patients with pre-existent ulcers was 18 ± 9.165 weeks. The mean total walking period of the patients was 73.6 ± 23.339 weeks. No patients had a re-collapse in the walking period.

Key words: Department of Endocrinology, Diabetic Lower Limb, and Podiatric Surgery, Amrita Institute of Medical Sciences & Research Center, Elammakara, Kochi, Kerala, India

INTRODUCTION

Charcot’s Neuroarthropathy is a chronic and progressive disease of bone and joints.¹,² It is characterized by painful or painless bone and joint destruction in limbs that have lost sensory innervation. Salvage fusions of the foot and ankle present a unique set of problems to foot surgeons. Studies by both Perlman and Thor- darson³ and Frey, et al,⁴ showed an overall 56% complication rate and 55% non-union rate with the use of an external fixator.

Complications of external fixation are very common, and pin tract infections are the most frequent. Literature reports the rate of pin tract infections are between 5–100%, with most studies reporting a range of between 10–20%.⁵,⁶,¹² Hence, AST for stabilization of the unstable mid and hind foot Charcot’s arthropathy after conventional reconstruction may be a suitable alternative to the current line of management for such deformed feet.
The main cause of CN is now diabetic polyneuropathy, with foot joints being most commonly affected. The midfoot bones and ankle joints are most commonly affected in diabetic patients\textsuperscript{14}. Individuals acutely affected exhibit typical signs of inflammation (i.e., oedema, erythema, and warmth), but generally without the protective sensation of pain. Fracture, dislocation, and instability of multiple joints within the foot or ankle are common. The process can potentially result in foot collapse and severe deformity that frequently results in gait abnormalities and ulcer formation.\textsuperscript{15, 16} The entire process leading to gross deformities of the foot and/or ankle is relatively painless.

Management of CN is dependent on the clinical stage. Treatments include medical, physical, and surgical management. Immobilization with the Total Contact Cast (TCC) is considered the gold standard in the initial treatment of Charcot’s arthropathy.\textsuperscript{17, 18} Long-term complications of Charcot’s arthropathy, like deformity or instability, can often lead to ulceration, infection, and ultimately amputation. Charcot’s arthropathy can lead to a significant increase in morbidity and mortality in diabetic patients.\textsuperscript{19}

**MATERIALS AND METHODS**

The audit consists of patients who underwent the procedure between December 1, 2008 to July 31, 2009 at the Department of Endocrinology, Diabetic Lower Limb, and Podiatric Surgery, Amrita Institute of Medical Sciences & Research Center, Kochi, Kerala, India. The patients underwent a one year follow-up, from the 4th post-operative month, when they were advised to start walking in prescribed diabetic footwear.

**DESCRIPTION OF THE TECHNIQUE**

Our institution, a major tertiary referral center, receives a large number of Charcot’s foot cases secondary to diabetes. Patients range in their disease stage and have various foot and ankle deformities, some who have marked bony destruction. Approximately three new cases of acute Charcot’s cases present every week. Most of the cases scheduled for foot and ankle reconstruction were severely osteopenic, all having a DEXA Scan T score value of -2.5 and below. In these cases compression screws, or even threaded Kirschner wires, do not hold well and the chances of re-collapse are very high. An alternative technique to foot and ankle stabilization was developed to overcome this complication and the problems associated with external fixation.
A key component of the procedure is the use of Fiberwire® (Arthrex), one of the strongest non-absorbable suture materials available. Fiberwire suture is constructed of a multi-stranded long chain polyethylene core with a polyester braided jacket that gives fiberwire superior strength, soft, feel, and abrasion resistance. Suture breakage during knot-tying is virtually eliminated. Fiberwire has greater strength than comparable size standard polyester suture. Studies document significant strength, stiffness, and knot strength with much less elongation. Fiberwire demonstrates biocompatibility characteristics equivalent to standard polyester sutures. Compared to standard polyester sutures, this superior strength allows tighter loop security during knot-tying and increased knot integrity while reducing the knot profile.13

The Amrita-Sling Technique

The following seven steps outline the AST procedure.

1. Lateral and medial incisions, 3 x 5 centimeters long and slightly dorsally placed, are made at the midfoot level. A hole is drilled just above the medial and lateral malleolus with a K wire, through the tibia and fibula. (Figures 1 and 2)

![Figure 1. Lateral and medial incisions](image1)

![Figure 2. Hole drilled above the medial and lateral malleolus](image2)

2. A polypropylene mesh of 10 x 7 centimeter dimensions (Figure 3) is then folded.

3. The mesh is then placed just plantar to the bones of the midfoot area. The plantar incision is for the intramedullary nail placement. (Figure 4)

![Figure 3. Polypropylene Mesh](image3)

![Figure 4. Mesh placed plantar to the bones](image4)
4. A hole is drilled just above the medial and lateral malleolus, and a number 2 Fiberwire suture is passed through the hole. (Figure 5)

5. The suture is pulled down subcutaneously on the medial and lateral aspect of the ankle and foot, to the site of the polypropylene mesh. (Figure 6)

6. The medial and lateral ends of the suture are then tied to the two ends of the mesh, with proper tension and proper positioning of the ankle and subtalar joints. (Figure 7)

7. The wound is sutured, and the surgery is complete. (Figure 8)

**Study Design**

This study consists of a clinical audit of patients who underwent the procedure at the Amrita Institute of Medical Sciences & Research Center, Kochi, Kerala, India between December 1, 2008 and July 31, 2009, with an approximately one-year follow-up from the 4th post-operative month after observing adequate bony union on x-ray. By the fourth post-operative month, bony consolidation is adequate and the patient is advised to ambulate in a plastazote-molded insole diabetic shoe, with an ankle-foot-orthosis (AFO) for ankle support. The AFO is advised for a period of 18 months, after which patients can use diabetic footwear with plastazote-molded insole and a high heel counter.
Inclusion Criteria

We included patients attending the Endocrinology and Podiatric surgery clinic that had a history of diabetes mellitus, under treatment, and/or have recent or previous venous plasma glucose values satisfying the American Diabetes Association criteria for diagnosis of diabetes mellitus. Patients were between 30 and 75 years old with chronic deformed Charcot’s arthropathy, as suggested by clinical features and radiographic studies.

Exclusion Criteria

Patients with the following characteristics were excluded from the study.

1) Non-diabetic patients
2) Patients with a cardiac event in the past two months
3) Patients with a cardiac ejection fraction < 40%
4) Serum creatinine >2.5 mg%
5) Documented Peripheral Obstructive Vascular Disease (POVD) – Non palpable pulses, TcPo2<40, ABI <0.9, or >1.3
6) Patients with dementia and psychiatric problems
7) Acute Charcot foot
8) Active ulcers over the affected limb
9) Clinical or radiological evidence of osteomyelitis
10) Patients with rheumatoid arthritis or gout

Intervention

Each patient underwent a conventional midfoot/hind foot reconstruction using titanium cannulated compression screws, rush nails, and onlay plates based on foot and ankle x-rays and three dimensional computerized tomography scans. After the reconstruction, each patient underwent stabilization using the AST with fiberwire ligature as previously described. Immediately after the procedure a posterior slab (splint) was applied for immobilization. The surgical site was inspected after a day or so, and once the patient was deemed to be healthy he or she was discharged from the hospital. The patient remained in the posterior slab with total offloading of the affected limb. An x-ray of the foot was taken monthly and used for patient review. Once complete bony consolidation was confirmed, the patient was permitted to mobilize with molded footwear and an ankle foot orthoses for 18 months. Subsequently, the patient was transitioned to a molded foot-wear with a high heel counter.
Representative Case Study

A 55 year-old male patient, who was diagnosed with type 2 diabetes mellitus since he was 12 years old and also had peripheral neuropathy, systemic hypertension, dyslipidemia, and chronic Charcot’s left foot with ankle deformity, was admitted for reconstructive surgery. Since 2006, the patient has been status post (s/p) incision and drainage for abscess of the left sole. Subsequently, he started developing deformity of the left foot once he resumed walking. There was a history of a non-healing ulcer lateral aspect left foot, s/p split thickness skin graft (STSG) in 2008. The patient had neither active ulcers at the time of admission nor a history of peripheral arterial disease (PAD), nephropathy, or coronary artery disease.

On focused clinical examination he was found to have a chronic (inactive) Charcot’s arthropathy of the left foot and ankle with varus deformity. (Figures 9 A and B) The previously grafted site was healthy. Both peripheral pedal pulses were present bilaterally. At the time of admission, random blood glucose was at 370 mg/dl and HbA1c was 8.5%. There was neither leukocytosis nor evidence of renal disease. The erythrocyte sedimentation rate was 12 mm.

The Ankle Brachial Index (ABI) on the left was 1.1. Vibration Perception threshold (VPT) was 50, indicative of profound neuropathy. Transcutaneous partial oxygen pressure (TcPO2) was 42 mm mercury pressure in the supine position and 36 mm mercury pressure in the elevated position at the posterior tibial position of the left leg.

On plain radiographs there was complete disorganization, collapse, and subluxation of the ankle joint. (Figure 10) There was bone loss at the distal end of the tibia, fibula, and tarsal bones. Magnetic resonance imaging (MRI) showed severe hypertrophy of synovium at the ankle, intertarsal, and tarsometatarsal joints. No significant joint effusion or soft tissue abscess was identified. The fourth and fifth metatarsal bones appeared thickened with mild marrow edema. (Figures 11 A and 11 B)
The patient was initially started on empiric intravenous antibiotics (i.e., Cefoperazone-Sulbactam, Clindamycin, and Ampicillin). These antibiotics were chosen per the department protocol for limb threatening infections. After obtaining cardiac consultation for surgery, the patient underwent a left tibio-calcaneal arthrodesis using titanium compression screws and fiberwire ligature (AST) under spinal anesthesia. (Figures 12 and 13) He was advised to remain strictly non-weight bearing on the left foot. A posterior splint was applied for ankle immobilization. Strict glycemic control was maintained throughout his hospitalization.

Using strict sterile precautions, the surgical site was inspected the first post-operative day. Once the drainage was less than 5 ml, the indwelling drain was removed. Mobilization with a walker with total offloading of the left leg was then advised.

Hospital Course

Figure 11A. MRI images demonstrating chronic Charcot changes at the ankle and midfoot

Figure 11B. Another MRI demonstrating chronic Charcot changes

Figure 12. Post-operative appearance of left foot with drain in place

Figure 13. Post-operative x-ray
Follow-up

The patient was discharged after one week, and his first review was approximately two weeks later. He was offloading at home with a walker. The surgical site was clean and showed no evidence of infection. Suture removal was completed and offloading was continued.

The patient had monthly follow-up, and serial x-rays showed good progressive bony union. He had a medial malleolar ulcer, which improved with routine care, and healed in six months. The patient was advised to begin mobilization with a plastazote molded footwear and AFO at approximately seven months. The AFO was removed after 18 months and the patient was transitioned to a molded footwear with a high heel counter. The patient was reviewed frequently from the time of mobilization. His activity was good with the prescribed molded diabetic footwear, and he noted no complaints after 20 months of active mobilization without the AFO.

Study Group Summary Results

The mean age of the ten patients in this audit was 53 ± 6.510 years old. The number of days of hospital stay and the HbA1c showed a mean value of 11.50 ± 5.462 days and 9.783 ± 1.734% respectively. Assessment of the vascular status with an ankle brachial index of the right and left leg yielded a mean of 1.04 ± 0.211 and 0.97 ± 0.149 respectively. All patients had peripheral neuropathy as evidenced by a mean VPT of the left and right great toe with 46 ± 6.583 volts and 47 ± 6.325 respectively. The same was confirmed with a mean VPT of the left and right ankles which were 45 ± 6.667 and 46 ±6.583 respectively. The patients were mobilized at 19.60 ± 5.854 weeks and the mean ulcer healing time in patients with pre-existent ulcers was 18 ± 9.165 weeks. The total walking period, after provision of prescriptive footwear since most recent follow-up of the patients was 73.6 ± 23.339 weeks. (Table 1)

Table 1. Descriptive Statistics of the Audit Patients

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AST was used in 10 patients to stabilize the deformed Charcot’s foot after reconstruction using the conventional technique.

**Patient Profile**

Four (40%) males and six (60%) females underwent the procedure. The average age of the patients was 68.9 years old; the youngest was 42 years old, and the oldest was 65 years old. All of the patients were diabetic, having the condition for an average of 14.7 years. The patient having diabetes for the least duration had it for four years; the patient having diabetes for the longest duration had it for 27 years. All patients (100%) had peripheral neuropathy, which was confirmed with a vibration perception threshold (VPT) system. Seven patients had hypertension (70%), eight patients had dyslipidemia (80%), three patients had diabetic nephropathy (30%), and one patient had coronary artery disease (10%). None of the patients had peripheral occlusive vascular disease.

All patients were new to our care. However, we treated one patient (10%) for acute Charcot’s foot in 2005. The patient was then treated with intravenous Zoledronic Acid and non-walking total contact cast (TCC) for a period of four months. Eight patients (80%) did not have a prior diagnosis of Charcot’s foot. One patient had a history of trimalleolar fracture with a failed open reduction with internal fixation procedure.

**Hospitalization**

The average hospital stay was 11.5 days; the shortest was six days and the longest was 25 days. The average number of days from surgery to discharge was 4.2 days. The average number of days for work-up and stabilization of the patient prior to surgery was 5.9 days.

The left foot was affected in six patients (60%), and the right foot was affected in the remaining four patients (40%). All patients who had their right foot affected were women. Three patients (30%) had an active non-infected ulcer at the time of admission. Out of the three patients, two (20%) had it in the plantar aspect of the foot while one had an ulcer in the lateral malleolar area. Five patients (50%) had a history of ulcerations which had completely healed. Only 1(10%) patient had a history of prior amputation (5th toe). Two patients (20%) had no active ulcers or prior history of ulcerations out of which one(10%) had calluses and one(10%) had difficulty walking.

**Procedure**

The average foot ABI was 1.0, bilaterally and the mean supine measurement for the patients who underwent TcPO2 was 44 mm Hg. The average VPT ranged between 45-47 volts, indicating severe peripheral neuropathy in all patients. Computerized Tomography images showed involvement of tarsal bones (50%), talus (50%), distal tibia and fibula (30%), calcaneus (20%), ankle joint (30%), cuboid (30%), navicular (30%), and cuneiform (20%). Intra-operatively a serous fluid collection in the soft tissues was noted in one patient who showed sterile growth on aspiration and culture. Four patients (40%) underwent tibio-calcaneal arthrodesis with fiberwire ligature; two patients (20%) had talocalcaneal arthrodesis with fiberwire ligature; two patients (20%) underwent triple arthrodesis with fiberwire ligature; one patient (10%) underwent calcaneo-navicular arthrodesis with fiberwire ligature; and one patient (10%) underwent bony prominence excision (cuboid) with fiberwire ligature. All patients underwent surgery under spinal anesthesia. None of the patients had any adverse events during the three hour surgery.

The study period was from December 1, 2008 to July 31, 2009.
Post-operative Period

Nine patients (90%) had no adverse events in the post-operative period, while one had worsening renal failure which was attributed to antibiotics. This promptly resolved upon discontinuation of the antibiotics. No patient had post-operative surgical site infection (100%), until the time of discharge. Six patients (60%) chose a walker as a mode of mobilization aiding offloading of the affected foot, three patients (30%) opted for wheelchairs, and one patient continued with crutches. Nine patients (90%) had been mobilized successfully without any incidence of infection related to the procedure. Out of the nine patients, one patient had an abscess that was noticed on the foot two days after walking and healed with surgical drainage and antibiotics.

Complications

Currently, no side-by-side comparison of fixation methods for Charcot’s foot and ankle reconstruction exists in the literature. Complications after CN foot reconstruction are frequent and include hardware failure, deep and superficial infection, wound dehiscence, pseudoarthrosis, instability, and amputation. External fixation has been described in the literature as a primary or adjunctive procedure for Charcot’s foot and ankle reconstruction.

Potential complications associated with the use of external fixation include pin or wire tract infections, hardware failure requiring premature discontinuation of the external fixator, stress fractures, osteomyelitis, and psychological difficulties acclimating to the device. Pin and wire complications are widely known as the most frequent complications in the application of external fixation devices in any patient population. In a retrospective study evaluating circular ring external fixation, Wukich et al related a seven-fold increase in wire complications in diabetic patients versus non-diabetic subjects. When comparing the existing data with the AST, none of our patients had any serious surgical site infections post-operatively. Mobilization was initiated within a few months, and no patient had re-collapse after ambulating in specialized footwear even after one year.

CONCLUSION

In stabilization using the AST with fiberwire ligature, no patient had an immediate or major surgical site infection. While recovery was typically prolonged in such a patient population, no patient had re-collapsed while under observation. This type of method has far reaching effects in reducing the morbidity of the high-risk patient who would have otherwise required a major amputation.
References


