Two Stage Reconstruction of the Diabetic Charcot Foot: A Review of 4 Cases

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INTRODUCTION

Charcot neuroarthropathy is a process of osseous destruction that occurs in neuropathic joints (1). Originally described in patients with tabes dorsalis, the most common cause currently is diabetic peripheral neuropathy (2). In the foot and ankle, it is a process that results in pedal deformities, commonly leading to neuropathic ulceration.

Traditionally, Charcot neuroarthropathy has been treated with conservative offloading measures including non-weightbearing and accommodative shoes or prosthetic devices (3). Currently there is increased interest in surgical stabilization and reconstruction of the Charcot foot. Correction of the resultant midfoot deformities is a challenging task for the foot and ankle surgeon. Previously described in the literature is a two-stage approach to Charcot foot reconstruction (4). This staged approach utilizes external fixation for gradual deformity correction followed by arthrodesis with internal fixation. This technique has the advantages of deformity correction with limited neurovascular compromise, allowing correction without loss of foot length or bone mass and providing the ability to be partial weightbearing while offloading neuropathic ulcerations.

METHODS

Four patients (4 feet) who underwent a two-stage Charcot foot deformity reconstruction during the period of November 2011 to February 2014 were reviewed. All patients were male with an average age of 62.5 years (range 49-71 years). Average follow-up duration after surgery was 28 months (range 13-40 months). All patients were evaluated and treated by the primary surgeon (PW) (Table 1).

All patients had been diagnosed with diabetic peripheral neuropathy and Charcot foot. In each case, the Charcot deformity involved the midfoot resulting in a rocker-bottom foot without subtalar or ankle joint involvement. The indications for reconstruction were recurrent or chronic ulcerations and preulcerative lesions refractive to conservative care. The Charcot process was acute in 2 patients.

The primary measured outcome was the resolution of ulcerations and return to unrestricted weightbearing in shoe gear. Secondary outcomes included radiographic correction of deformity, perioperative complications (pin tract infections, incision dehiscence, and postoperative infection), hardware failure, radiographic fusion rate, and need for subsequent surgery. Weight-bearing radiographic films were reviewed by one of the authors (DKS) to determine degree of deformity both preoperatively and postoperatively. The measurements recorded were Meary's angle (lateral talar/first metatarsal angle) and the calcaneal pitch angle, both recorded on the lateral view.

SURGICAL TECHNIQUE

All patients were placed supine on the operating table and underwent general anesthesia for each procedure. Prophylactic antibiosis was routinely administered 30 minutes before inflation of a thigh tourniquet if one was utilized. A percutaneous triple hemi-section Achilles tendon lengthening was performed prior to the initial application of the external fixator in each case. The two-stage technique consists of gradual deformity correction utilizing a Taylor Spatial Frame (TSF) followed by rigid internal fixation. The specific application of the TSF has been described previously (4). The first stage relies on ligamentotaxis to achieve the

Table 1. Demographics

Patient	Age/Sex	Followup	Preoperative ulcer	Eichenholtz	Sanders/Frykberg	Previous procedures
1	61/M	34 mos	Plantar Cuboid	II	II/III	No
2	69/M	13 mos	Plantar Medial	I	II/III	BKA
3	49/M	23 mos	Plantar Cuboid	I	II/III	No
4	71/M	40 mos	None	II	II/III	No

desired osseous realignment of the dislocated fragments. All 4 feet were incompletely coalesced and did not require an osteotomy. Gradual osseous correction was obtained in an average of 7.5 weeks (range 7-8.5 weeks). Following correction of deformity, the second stage consisting of internal fixation and arthrodesis was performed.

The hardware used for internal fixation varied based on the residual deformity and joints intended for arthrodesis. The techniques used consisted of intramedullary beaming and plating to form fixation "superconstructs" previously described in the literature (5). All arthrodesis procedures were augmented with orthobiologics with osteoinductive potential. A summary of the internal fixation techniques are included in Table 2.

REVIEW OF CASES

Three of the 4 patients were successfully transitioned to full weightbearing in shoe gear with accommodative inserts without recurrence of preoperative wounds (Table 3). Patient 3 experienced recurrence of the plantar cuboid wound that was present preoperatively, after transition to full weightbearing. As a result of the recurrent wound the intended treatment plan was to transition to a Charcot Restraint Orthotic Walker (CROW). Unfortunately, the patient developed Charcot of the ipsilateral ankle prior to obtaining the CROW. Patient 4 developed a new postoperative ulceration of the plantar first metatarsal head, which resolved with a dorsiflexory osteotomy and was therefore considered a successful outcome. Patients 1 and 2 experienced resolution of the preoperative ulcerations without recurrence or new ulcerations at last follow-up. The midfoot deformity was corrected successfully in all 4 patients as shown in Table 4. The obtained correction was preserved at last follow up with only minimal decreases of the calcaneal inclination angle.

Only 1 patient (patient 4) achieved complete union of all attempted arthrodesis sites, consisting of the medial column. The naviculocuneiform joint was the most commonly-fused joint, achieving union in 3 patients. Lateral column fusion was attempted in 2 patients, both of which resulted in a stable nonunion. Overall, fusion was achieved in 8 (47%) of the 17 attempted arthrodesis sites.

Hardware removal occurred in patients 1 and 3, both of whom underwent minimal incision placement of an intramedullary Midfoot Fusion Bolt (MFB). Patient 1 experienced migration of the MFB through the incision site of the plantar first metarsophalangeal joint 6 weeks postoperatively. This occurred after initiating full unprotected weightbearing against medical advice. Revision of the medial column arthrodesis was performed with application of a plantar locking plate. This second procedure resulted in a stable medial column with no evidence of radiographic progression of deformity despite the patient once again initiating full weightbearing against medical advice 5 weeks postoperatively. Patient 3 underwent midfoot fusion bolt removal due to the development of Charcot of the ipsilateral ankle. The bolt was removed because of implant loosening due to significant talar osteolysis and to accommodate subsequent ankle reconstruction.

Table 2. Procedures

Patient	ExFix Time (weeks)	Procedures	Fixation technique	Hardware complications
1	7	TAL, MCF, LCF	MFB x2; converted to plantar locking plate	Loosened implant, extrusion through wound
2	8.5	TAL, MCF, LCF	Medial Column locking plate, 4.0 screws x2	None
3	8	TAL, MCF, LCF	MFB x2	Loosened implate, removed for Charcot ankle resonstruction
4	7	TAL, MCF	Plantar locking plate, Medial locking plate	None

Table 3. Results

Patient	Wound recurrence	FWB in shoes	Time to FWB (months)	Fusion result
1	No	Yes	13.5	Partial Nonunion
2	No	Yes	8.5	Partial Nonunion
3	Yes	No	-	Nonunion
4	No	Yes	8.0	Full Union

Postoperative complications were common and occurred in each of the 4 patients (Table 5). There were 2 pin site infections occurring in separate patients, which were treated successfully with oral antibiotics. All 4 patients experienced some form of incisional dehiscence after each internal fixation procedure, all of which healed with local wound care. Two patients experienced an episode of cellulitis associated with the incision dehiscence, which were treated successfully with oral antibiotics. Patient 1 received 6 weeks of IV antibiotic therapy after the extrusion of the MFB for presumed osteomyelitis prior to undergoing the revision procedure.

DISCUSSION

Charcot midfoot deformity is the result of maligned osseous architecture secondary to the process of osseous destruction. When present, midfoot deformity often results in ulceration. Intractable ulcers and instability are the primary indications for reconstruction although these indications have not been clearly defined in the literature (6). These procedures are currently reserved as a last resort to amputation.

Early reported results of surgical correction of Charcot deformity were discouraging due to high deformity recurrence and nonunion rates (7). Central to the disease process leading to deformity is the fragmentation and dissolution of the involved osseous structure. This results in fixation and fusion failure if standard fixation techniques are utilized as the bone is often not structurally capable of supporting the fixation (8). In addition, these patients are often overweight and have "inflexible" soft tissue due to glycosylation, increasing the force across the intended fusion sites with weightbearing. To address the challenges, the recent literature has described the use of "superconstructs" (5). Superconstructs extend fixation proximally and distally into areas where bone is not affected by the Charcot process, thereby increasing stability. There is also focus on stronger fixation constructs that maximize mechanical function such as axial intramedullary screw fixation and plantar plating. Locking plate fixation can also be utilized as a superconstruct and has obvious advantages in the use of the osteopenic and fragmented bone found in this disease process.

An advantage of our described technique allows the use of superconstructs without the need for bone resection. Gradual deformity correction creates a soft tissue envelope without vascular compromise. Due to the gradual correction through the external device the surgeon has the ability to "fine tune" the osseous correction. This can be an advantage in some difficult and long-standing deformities as the surgeon does not need to accept the correction he is able to obtain at the time of internal fixation. In addition, the correction can take place while simultaneously offloading any neuropathic wounds. Although the use of the TSF added an additional 8-10 weeks of treatment time in our series, its use does have the potential to shorten overall treatment times as deformity correction can occur while healing of an open wound is taking place.

Our small series highlights the complexity and high complication rate association with reconstruction of the diabetic Charcot foot. Despite the high complication, rate we were successful in returning 3 of the 4 patients to full weightbearing in custom shoes. Of note, only 1 of these 3 patients achieved union of all attempted arthrodesis sites. As a salvage procedure it is important for the surgeon to realize that the end result of a shoeable plantigrade foot is the goal regardless of the radiographic appearance postoperatively. Our results suggest that in the short term, the use of supercontructs may be sufficient to maintain the corrected osseous structure despite a high percentage of nonunion.

The most common postoperative complications we encountered were incisional dehiscence and infection. Every patient had an incision dehiscence of some degree

Table 4. Radiographic analysis

Patient	Meary's		Calcaneal Inclination	
	Preoperative	Postoperative	Preoperative	Postoperative
1	44	24	10	15
2	31	7	2	5.5
3	9	0	7	10
4	43	5	11	18

Table 5. Complications

Patient	Postoperative complications	Subsequent operations
1	Incision Dehiscence; Osteomyelitis; Pin Tract Infection	HWR with revision arthrodesis
2	Incision Dehiscence; Cellulitis	None
3	Incision Dehiscence; Cellulitis	HWR; Charcot ankle Reconstruction
4	Incision Dehiscence; New ulcer plantar 1st MH	1ST MT Dorsiflexory Osteotomy

postoperatively, all of which healed with local wound care. We also had failure of fixation in both patients that were fixated with the axial midfoot fusion bolt. This is in contrast to the success with this technique reported in the literature (9). It is important to note that the failure occurred due to postoperative noncompliance and the development of a Charcot process in the ipsilateral talus. Our results should not discourage foot and ankle surgeons from utilizing this fixation technique and encourage reference to other series reported in the literature (4,9-14).

Our case series has demonstrated that the use of a two-staged technique for Charcot midfoot reconstruction may be an effective salvage option in these difficult cases. It is important for the surgeon attempting these reconstructions to understand the complexity of the surgical technique and postoperative management associated with these procedures. The process is both physically and mentally taxing for both the patient and surgeon with a high rate of complications. Even so, reconstruction has the potential to salvage limbs although further high-quality research is needed to guide procedure and patient selection.

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