

The role of an extended medial column arthrodesis for Charcot midfoot neuroarthropathy

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The etiology of diabetic Charcot neuroarthropathy involving the midfoot often includes an inciting traumatic event or repetitive micro-trauma from an uncompensated biomechanical imbalance that potentiates an incompletely understood pathway leading to a rocker-bottom foot deformity and ulceration. In the setting of a severe Charcot foot fracture and/or dislocation with obvious osseous instability, diagnostic delay can potentiate the limb-threatening sequelae of infected midfoot ulcerations in this patient population. In this article, the authors discuss the thought process as well as the advantages of performing an extended medial column arthrodesis for selected Charcot midfoot deformities.

Keywords: *diabetes mellitus; Charcot foot; midfoot arthrodesis; locking plate technology; external fixation*

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Of the known diabetic population, between 0.3 and 2.5% of the patients will be diagnosed as affected by Charcot neuroarthropathy (1–4). As the condition is often misdiagnosed or not detected, the authors speculate that the true numbers are significantly higher. The Charcot process may also present identically in patients with leprosy and alcoholic, toxic, or spinal-derived neuropathies (2, 5). In these types of neuropathies, pain and proprioception are blunted, such that patients are often oblivious to the devastating effects of the disease process until after irreversible progression of deformity has occurred. At times, subchondral cystic degeneration and subsequent polyarticular micro-fractures are evident radiographically prior to gross collapse of pedal architecture. Conservative management, immobilization, and custom bracing of the Charcot foot deformity may fail in the setting of significant midfoot, hindfoot, and/or ankle instability. Additionally, Charcot midfoot deformities with acute or chronic plantar ulcerations may develop into recalcitrant wounds, or heal with unstable scar formation prone to future skin breakdown despite appropriate local wound care and offloading techniques, thus subjecting the patient to increased risk of contiguous osteomyelitis or severe limb-threatening infection (6, 7).

Rationale

The authors' approach to the diabetic Charcot midfoot deformity is recommended in a patient-specific, but largely algorithmic manner, the complete expansion of which is beyond the scope of this article. Patient and procedure selection for reconstructive Charcot foot surgery depends on the patient's baseline functional capacity, the failure or inability to treat with conservative and therapeutic modalities, the presence or absence of ulceration or pre-ulcerative lesions, the presence or absence of underlying osteomyelitis, and the overall stability of the deformity. The authors and others (5, 8) typically favor intervening surgically when the deformity is associated with a limb-threatening ulceration or pre-ulcerous lesion, complicated with underlying osteomyelitis, and/or is grossly, unstable resulting in soft tissue compromise.

In these patients, in order to restore a stable plantigrade foot that is amenable to functional ambulation and not prone to future skin breakdown, an arthrodesis or stable osseous pseudoarthrosis is often required. For these reasons, the authors typically advocate an extended medial column fusion when managing Charcot midfoot deformities. An extended medial column arthrodesis can be performed with internal fixation, external fixation or a

combination of both. The main reasons that usually determine the choice of fixation are often dependent on cortical integrity, presence of bone defects and dislocations, soft tissue envelope, history of deep infection, and body mass index of the patient. This approach has been corroborated by others, using various fixation techniques (4, 9–15). The authors also advocate stabilization of the subtalar and ankle joints in the presence of subjective instability and arthrodesis of these joints if significant concomitant deformity exists. Elimination of frontal plane motion through the subtalar joint theoretically decreases the pronatory and supinatory lever arms across the newly fused medial column, and, though no evidence-based data exist at this time, a theoretic argument could be made for adjunctive subtalar arthrodesis with medial column arthrodesis. Finally, the authors also recommend adjunctive offloading external fixation in cases where significant Chopart-level deformity exists, and when concomitant soft tissue reconstructive procedures are being performed (16–19).

Although the role of equinus is understood to be a significant exacerbating factor in collapse of the medial column (20), the authors do not routinely lengthen the tendo-Achilles or triceps surae complex on primary fusion of the medial column in Charcot feet unless it is required to achieve osseous correction. The extended arthrodesis procedures of the medial column lend significant stability and rigidity to the foot, and because the talonavicular joint is fused, rearfoot frontal plane motion is severely restricted (21). Because of this inherent conferred biomechanical stability, the tendo-achilles or gastrocnemius lengthening is usually only performed in patients with Charcot foot deformity if they re-ulcerate or have recurrent deformity following surgical reconstruction of the foot.

Technique

After induction of anesthesia and application of a thigh tourniquet, a curvilinear incision extending from one centimeter distal to the anterior colliculus of the medial malleolus to the base of the first metatarsal is used. The medial venous plexus is preserved as much as possible proximally and distally, for post-operative edema management. Dorsal soft tissue mobilization is minimal, but is necessary to facilitate exostectomy, ostectomy, and realignment. A linear medial capsulotomy is performed based on the apex of the Charcot deformity and often extends from the talonavicular joint to the first tarsometatarsal joint. A linear tenotomy of the tibialis anterior tendon may be performed to facilitate necessary exposure and access the entire medial column; the dorsal and plantar tendon stumps are tagged for re-approximation on closure.

Resection of the articular surfaces of the unstable segments of the medial column is achieved with osteotomes,

and/or sagittal saw osteotomies when necessary. Ostectomy is performed if necessary to facilitate improved sagittal and transverse plane alignment of the medial column. Any extirpated bone that appears non-sclerotic and viable is morselized for autografting, or maintained and utilized as a free bone graft. Intraoperative fluoroscopy is utilized to confirm satisfactory reduction of the deformity, and to size and select the proper medially applied locking plate if this is to be used. Prior to application of the plate, a commercially available mixture of cancellous chip and demineralized bone matrix allograft is applied to the arthrodesis sites if needed, as is any available morselized autograft. Additional bone graft may also be utilized after fixation to fill any small bone defects that may remain.

When a medial column plate is being used, the most proximal talar screws are inserted first, followed by the most distal metatarsal or cuneiform screw. It is advantageous to obtain manual compression of the medial column by having an assistant dorsiflex the hallux and simultaneously apply pressure across the medial column while the most distal screws are placed. This technical tip prevents distraction at the arthrodesis sites while the plate is being applied. Typically, 3.5 mm fully threaded cortical non-locking screws are placed in these locations to minimize the chance of stress risers (22). Next, the remaining holes are filled using fluoroscopic guidance with 3.5 mm fully threaded cortical locking or non-locking screws, and any temporary fixation may be removed at that time. In cases in which screw purchase is not ideal, the authors recommend utilizing higher diameter screws with a pitch that is designed for cancellous or osteopenic bone. The capsular and subcutaneous layers are closed with absorbable sutures in a simple interrupted fashion, and the skin is closed with staples and/or non-absorbable sutures in a simple interrupted fashion. If significant instability or deformity exists in the subtalar or ankle joints, stabilization and/or arthrodesis of these joints may also be performed.

The tourniquet is usually deflated before closure and the application of an external fixator for further stabilization or offloading is applied if required (12, 18, 23). All incisions and pin or wire sites are dressed with povidone iodine-soaked petroleum gauze, and multiple fluffed gauze rolls are packed into the external fixator around the pin or wire sites for compression. An impervious outer dressing is then applied over the external fixation if utilized.

After surgery and during the patient's hospitalization, appropriate protocols are followed for antibiotics, pain control, and deep vein thrombosis prophylaxis. Graduated physical therapy is initiated early in the post-operative period, and subsequent transition to rehabilitation or skilled nursing facilities is largely

patient-dependent; patients with strong social support networks may be safe to transfer home.

The patients are monitored closely in the outpatient setting and the circular fixator, if applied, is usually removed within 8–10 weeks after the surgery. A non-weight-bearing below-the-knee cast is applied for up to 6–8 weeks after external fixation removal, and for about 12–16 weeks if an external fixator is not placed. Ultimately, the length of immobilization is dependent on clinical and radiographic signs of healing. The patient is then transitioned into a walking boot for an additional 6–8 weeks, followed by fitting for either a double-upright brace or a high-top custom diabetic shoe with accommodative inserts. Activity modification is emphasized with the patient and his/her family after weight-bearing is permitted, and the potential risks for development of contralateral foot Charcot are discussed. For this reason, the contralateral non-operative foot is often protected

with a walking boot during the non-weight bearing portion of the rehabilitation period (Figs. 1 and 2).

Because non-compliance is frequent in the insensate patient population, complications, both minor and major, are frequently seen (24). Pin and/or wire tract infection, hardware failure, dehiscence, superficial or deep infection, non-union/pseudoarthrosis, recurrence of deformity, and amputation are all potential complicating factors in the post-operative recovery period (12, 24).

Discussion

Recently, the published surgical literature on the reconstruction of unstable Charcot neuroarthropathy of the midfoot has focused on the so-called superconstructs, as coined by Sammarco (25). These fixation approaches include: intramedullary rod fixation, locking plate fixation, and external fixation. Because the bone is predictably osteopenic and often comminuted, and because



Fig. 1. Pre-operative anteroposterior (A) and lateral (B) radiographic views showing a severe Charcot foot fracture and dislocation mainly at the tarsometatarsal joints. An entire medial column arthrodesis was performed with a combination of a locking plate internal fixation and a circular external fixator (C, D). Final outcome of the patient being ambulatory at 6 months follow-up (E, F).



Fig. 2. Pre-operative anteroposterior (A) and lateral (B) radiographic views showing a severe Charcot foot fracture and dislocation mainly at the talo-navicular-cuneiform joints. An entire medial column arthrodesis was performed with a locking plate internal fixation and final outcomes at 8 months follow-up (C, D).

dysregulated hyperemia may occur, construct stiffness for Charcot reconstruction is of the utmost importance. Moreover, the absence of a normal pain feedback loop in neuropathic patients frequently results in premature and inappropriate weight-bearing post-operatively, which must be anticipated when choosing operative fixation approaches (4, 26).

Intramedullary rod fixation of the medial column of the foot was initially described by Rooney et al. (27) and has since been supported in the literature by various authors (4, 14, 15, 25, 28). Retrograde or anterograde approaches have been described, and multiple implant designs exist, ranging from large partially or fully threaded screws (12, 15) to proprietary compression bolts (25) or two-part morse taper interlocking devices (14). A paucity of outcomes data exists for analysis of fixation in Charcot midfoot reconstruction, but Assal and Stern recently published a case series of fifteen patients who underwent reconstruction with a medial column intramedullary rod, and reported largely favorable outcomes over a mean follow-up of 42 months. Although the authors did report a fairly high incidence of non-unions (17%) post-operatively, they otherwise favored this approach (4).

External fixation has been described for multiple tarsal arthrodesis procedures in the Charcot foot in isolation (8, 29) or in combination with internal fixation (12, 15). Hybrid or offloading external fixation augments the stability of the surgical construct by resisting torsional and axial stresses, and thereby shields the midfoot arthrodesis. Additionally, the external fixator inherently prevents heel decubitus ulceration, allows quiescence of

the soft tissues, and offloading of any adjunctive soft tissue reconstructive procedures (9). In some cases, it may also act as a deterrent for premature weight-bearing.

Conclusion

The authors recommend operative fixation of unstable Charcot midfoot deformity in previously ambulatory patients, and present their current preferred methods using both internal locking plate fixation and/or stabilization circular external fixation when indicated. Short- and long-term outcome studies are warranted to assess the durability of the described methods prior to widespread adoption of this technique.

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