CHAPTER 37

Medial and Lateral Column Beaming: A Literature Review

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INTRODUCTION

Neuropathic arthropathy, often referred to as Charcot arthropathy, is a condition that compromises the bony architecture of the foot and ankle. Although Charcot is most commonly associated with diabetes mellitus, it can occur in any patient with neuropathy. The exact pathophysiology remains unknown; however, the two theories that predominate are the neurotraumatic and the neurovascular theories. The condition results in the commonly recognized "rocker bottom foot" deformity secondary to bone changes and ligamentous failure. In the acute phase, Charcot often requires an initial immobilization period. Once bony consolidation occurs in Eichenholtz stage III, the need for surgical intervention is usually required to correct the bony deformity and prevent recurrent ulcerations.

CONCEPT OF BEAMING

The Charcot foot is predisposed to abnormal bending forces acting on the medial and lateral longitudinal arches of the foot (1). The beam shares the load along the column with the ligaments and joints in order to decrease these bending forces. Grant et al compares the beam to a steel rebar used to reinforce surrounding concrete; although it does not create compression, it takes on the axial load (1). Most commonly in beaming, a large diameter cannulated screw is the rebar that redistributes the axial load on the bone. Many different techniques have been described for both medial and lateral column beaming in literature and will be outlined in this article.

ADVANTAGES OF BEAMING

Fusion of medial and lateral column joints is a surgical technique that is often used for Charcot reconstructive surgery. The primary goals of reconstruction with internal and interosseous fixation are the same: to restore anatomic alignment and to reestablish a plantigrade foot. In the technique paper, Lamm et al highlighted several advantages of intrameduallary foot fixation. Unlike plate and screw fixation, which is often used for fusion, beaming does not place cortical stress on the bone because it is in the intramedullary canal of the bones it is supporting (2). Lamm et al compares limited dissection of the beaming technique to the more extensive periosteal capsular dissection required for plating. The author suggests the limited dissection allows for preservation of foot length and thus, optimization of foot function (2). Beaming also allows for fixation beyond the site of collapse creating the capacity for a more stable construct (2). In addition, in the event of a dehiscence, the beaming fixation is not at immediate exposure risk as a plate would be because it is interosseous. One potential disadvantage is that beaming traditionally involves the entry of the screw through the metatarsal head. This may possibly predispose the patient to arthritic changes at the first metatarsophalangeal joint, although it was not reported as a complication in any of the articles reviewed (3).

SURGICAL TECHNIQUE IN LITERATURE

In the retrospective study by Grant et al, the postoperative radiographic outcomes of 71 Charcot reconstructive procedures (70 patients) by the same surgeon are reviewed. The technique described combines fracture dislocation realignment arthrodesis with beaming. The surgeon used adjunct procedures consisting of an open Achilles tendon lengthening, use of growth factors, external fixation for compression, and occasionally subtalar joint (STJ) arthroereisis or arthrodesis to augment the reconstruction. Standard medial and lateral incisions were used to resect the cartilage of the joints. Separate small linear, dorsal incisions were used for the introduction of a 6.5-mm partially-threaded, titanium, cannulated screw. The medial column screw was inserted into the metatarsal head and across the medial cuneiform, navicular and into the body of talus. The lateral column beam ran from bases of the third and fourth metatarsal, across the calcaneocuboid joint and into the calcaneal body. Both were inserted under fluoroscopic guidance. Only 12 patients (17%) underwent an isolated medial column beaming. Grant et al support beaming of both columns to allow for maximum control of the transverse arch (1). The patients who underwent both medial and lateral column beaming without STJ procedures had statistically significant improvement in the Meary's angle and the calcaneal inclination angle (CIA) (1).

In a limited study by Cullen et al, the use of a midfoot fusion bolt, a 6.5-mm solid core steel screw, was presented in 4 patients who underwent Charcot reconstruction. The authors suggested the use of solid core and stainless steel would make the construct stronger and increase the ability to withstand greater compressive and tensile loads in comparison to cannulated, titanium screws (3). After the joints were prepared, the bolt was inserted through a small incision whether dorsal or plantar to the first metatarsophalangeal joint. The lateral column was not typically addressed with beaming as in the other articles reviewed. The surgeon performed isolated calcaneocuboid joint fusions in 3 patients (3). The adjunct procedures consisted of a percutaneous tendo-Achilles lengthening and subtalar joint fusion for 2 of the patients. The first 2 patients were placed in an external fixation device postoperatively. The subsequent 2 patients, however, did not have external fixation, which is related to the authors' confidence in the stability of the bolt (3). The article does not, however, discuss any pearls for inserting the solid core screw, which is often viewed as technically challenging (2).

In a more recent technique paper by Lamm et al, the surgical pearls of the percutaneous technique used to introduce the beaming fixation are detailed. The authors discuss the use of anteroposterior (AP) and lateral views on fluoroscopy to ensure proper positioning of the guidewire more than the other articles in this review (2). With the hallux held in maximum dorsiflexion, a small incision is made plantar to the first metatarsophalangeal joint. Before the guidewire for the 7.0/8.0-mm cannulated, titanium screw is introduced, the wire should sit on cortical bone without being superimposed on the metatarsal on the AP fluoroscopic image. The authors refer to this as the "equator" of the metatarsal head (2). The wire should be parallel to the central aspect of the metatarsal on the lateral view (2). Manual advancement of the wire with a mallet to the metatarsal base is recommended to ensure intramedullary placement (2).

In a similar manner, the authors insert guidewires for the lateral column and also into the second metatarsal for additional stability. Unlike the technique by Grant et al, Lamm et al inserted the lateral column screw into the third or fourth metatarsal heads instead of the bases in their technique. The land of all the screws sits at the metatarsal neck. In the article, the largest and longest screws possible are chosen. The authors compare their fixation technique to the principles of other intramedullary nail devices, in which greater contact areas have been shown to increase stability throughout bone healing (2). Additional care is taken by the authors to use final fluoroscopic images to ensure realignment along Meary's angle and that there is no violation of the ankle joint (2). There is no mention of use of external fixation in this paper.

In a previous article by Lamm et al published in 2010, the technique of a 2-stage percutaneous approach used on 11 reconstructions (8 patients) was outlined. The first stage involved gradual distraction and realignment using a spatial frame and a percutaneous tendo-Achilles lengthening. Once adequate position was achieved (approximately 1 to 2 months), the joints, which have been distracted with the external fixator, are prepared through minimal incision techniques (4). Then the second stage of percutaneous beaming begins in a similar manner as the Lamm et al technique described above (4). The frame is removed only after the guidewires are inserted. At the time, the gradual correction allowed for more accurate realignment (4). As the use of external fixation is not described in the more recent technique article, it is difficult to assess if the author maintain support of gradual correction. The results were impressive with no nonunions, no deep infections, and no recurrent ulcerations in an average follow-up period of 22 months (4). Two cases required additional operations for adjustment of the intramedullary screw.

COMPLICATIONS

After a mean follow-up time of 31 months, the major complications in the study by Grant et al were as follows: 7 (14%) of the patients had medial incision dehiscence and 4 (6%) had a medial column nonunion secondary to hardware failure occurring at the runout of the screw (1). Three of these nonunions were at the naviculocuneiform and one nonunion was at the talonavicular joint. The authors relate the failure to the bending moment occurring at the midtarsal joint, thus explaining isolated failure of the medial column (1). They also suggest the use of titanium screws instead of stainless steel, which has a greater tensile strength, may have contributed (1).

Cullen et al reported 1 out of the 4 patients developed a lateral abscess and migration of the midfoot fusion bolt distally requiring removal of the implant (3). The correction at the fusion sites, however, was maintained. There were no reports of implant breaking. The paper suggests that based upon their results and the experience of the primary surgeon, a solid core implant is sufficient to maintain correction and does not require additional external fixation (3).

Using the 2-stage approach, Lamm et al reported 4 (36%) broken external fixation wires or half pins, 2 (18%) broken external fixation rings, and 11 (100%) pin tract infections (4). There were no complications described in the technique paper.

VARIATIONS IN THE POSTOPERATIVE COURSE

In the study by Grant et al, all subjects wore a frame for an average of 9 weeks (1). After frame removal, all patients were nonweight-bearing in a splint for 2 weeks then transitioned in a walking boot to be partial weightbearing. The patients were fitted for AFO and full ambulation allowed at 6 weeks after frame removal. In contrast, Lamm et al allowed patients to bear weight immediately as tolerated with an external fixation device, but without it, patients were kept nonweight-bearing for 2 months (2,4). Cullen et al were the most conservative and maintained nonweight-bearing until evidence of bony consolidation was apparent ranging from 12 to 14 weeks (3).

In conclusion, the use of medial and lateral column beaming for Charcot reconstruction is a valuable technique with many advantages. The literature reviewed in this article describe a number of variations in techniques and adjunct procedures. The most notable differences were in regard to the type of interossoeus fixation used and what adjunct procedures were chosen. In review of the recent literature, technique using stainless steel screws appears to be more favorable and is supported by the need of greater tensile strength in this challenging patient population. In 2014, Grant et al wrote an additional article in which they support the use of stainless steel screws over titanium in contrast to the hardware used in the original article described above (5). In the senior author's opinion beaming of both the lateral and medial columns allows for the greatest stability. The columns both have differing functions and beaming both provides equilibrium to the biomechanics of the foot. Considering stability and the level of technical difficulty, the use of a large diameter, cannulated screw is the most reliable method of fixation in the senior author's experience.

The literature shows the use of many adjunct procedures with intramedullary foot fixation. The tendo-Achilles lengthening is a widely accepted adjunct procedure that was always performed in the literature discussed in this article. In addition, the use of an external fixation device can allow for gradual correction and earlier weight-bearing with significant benefit. However, it is not without risk of complication as evidenced by the study by Lamm et al. In the senior author's opinion concomitant use of external fixation with beaming is surgeon dependent and should be determined on a case-by-case basis.

Beaming has been described as a solution to the complex Charcot foot, which is known to experience hardware failure and fracturing even after arthrodesis (5). The lack of proprioception combined with ligamentous and bony destruction can often lead these patients with a poor prognosis. Further developments and studies on medial and lateral column beaming will be beneficial to limb salvage in the Charcot patient.

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