Naviculocuneiform Arthrodesis

Adam M. Budny, DPM*, Jordan P. Grossman, DPM, FACFAS

Department of Surgery, Saint Vincent Charity Hospital, 2351 East 22nd Street, Cleveland, OH 44115, USA

The adult acquired flatfoot is a complex, multiplanar, structural deformity characterized by several distinct clinical features and radiographic abnormalities. Typical physical findings include flattening of the medial longitudinal arch, abduction of the forefoot, valgus of the heel, and some degree of equinus contracture [1–6]. Deformity is possible in varying degrees and at a number of joint levels, with multiple soft tissue and osseous influences making objective assessment difficult. Posterior tibial tendon dysfunction has received much attention as a primary etiology for progressive symptomatic collapse of the arch in the adult population, and the classification put forth by Johnson and Strom [5] has been widely accepted with later modification by Myerson [6].

Acquired flatfoot is a continuum from mild to severe deformity in all three cardinal planes and has been termed peritalar subluxation as a result of alterations in the relationships of the midtarsal and subtalar joints; however, faulting can occur at any level of the medial column, including the talonavicular (TN), naviculocuneiform (NC), or first tarsometatarsal (TMT) joints [4,6]. Due to these factors, a myriad of surgical procedures have been described for the correction of pes planus foot types, with no clear-cut approach to the deformity [4,6–14]. In a supple stage II flatfoot, the NC arthrodesis, with appropriate ancillary soft tissue augmentation and other adjunctive osseous procedures as necessary, has been shown to be effective with reproducible success [1,2,4,7,15–17].

Anatomy

The NC joint is comprised of the articulations between the navicular proximally and the three cuneiforms distally, each having a distinct facet.

* Corresponding author.
E-mail address: abudnydpm@gmail.com (A.M. Budny).
The navicular is boat shaped, with the proximal concave surface articulating over the head of the talus and a large tuberosity serving as a significant insertion for the posterior tibial tendon. The NC capsule is reinforced plantarly, with strong ligamentous attachments to aid in supporting the longitudinal arch. The cuneiforms themselves are wedge shaped, with the widest portion dorsally, creating a keystone arch appearance in cross-sectional evaluation. Appreciation of these relationships is paramount for successful placement of internal fixation due to the small surface area available for screw purchase on the plantar aspect of the cuneiforms.

The medial column has been described as a “post” for the talus and is strongly linked to hindfoot valgus [4]. If the post is compromised by medial column faulting, peritalar subluxation will occur. In addition, the NC joint along with the calcaneocuboid, intercuneiform, and medial TMT joints have been defined as “non-essential” for normal gait [2,7], that is, loss of a non-essential joint will not be detrimental to normal foot function. This philosophy suggests that the NC joint may be sacrificed to allow restoration of medial column stability without having a significant effect on gait following arthrodesis.

Clinical evaluation

Patients presenting with symptomatic pes planus generally demonstrate collapse of the medial longitudinal arch, worsening pain with activity, and decreased endurance with extended ambulation. Often, patients describe “ankle pain” along the course of the posterior tibial tendon that has been an insidious process or recurrent problem for weeks to months. In advanced deformity, patients may subjectively relate lateral ankle pain as a result of sinus tarsi or canoefibular impingement, or subtalar joint arthrosis. Examination of the foot and ankle should be comprehensive, taking into account neurovascular status as well as musculoskeletal evaluation in weight-bearing and non–weight-bearing positions including reducibility of the deformity. With the patient in angle and base of gait, one will appreciate collapse of the arch medially, whereas a posterior vantage point will afford assessment of heel valgus and forefoot abduction via the “too many toes sign” (Fig. 1) [5]. Function of the posterior tibial tendon can be tested dynamically through double and single heel rise tests by observing the amount of inversion of the calcaneus. Open kinetic chain evaluation should include the Silverskiold examination for equinus as well as noting any hypermobility of the midtarsal, NC, or first TMT joints. In depth clinical examination of this complex deformity is covered elsewhere in this issue.

Radiographic analysis

Typical findings in a patient requiring NC arthrodesis include a fault or sag on the dorsal side of the joint, resulting in a deviation of the talo–first
metatarsal angle (Meary’s) on a lateral radiograph. Other sagittal plane observations are decreased calcaneal inclination, increased talar declination, and decreased cuneiform height (Fig. 2). Recreation of the longitudinal arch via activation of the windlass mechanism (Jack’s test) [13] will also demonstrate the ability to reduce a flexible flatfoot to aid in planning an NC fusion (Fig. 3). Dorsoplantar radiographs allow evaluation of transverse plane deformity including talar head uncovering, the talo–first metatarsal angle, and cuboid abduction [1–3,18,19]. Periarticular osteophytosis or frank degenerative changes of the NC joint may be appreciated as well. Advanced imaging such as CT and MRI may be used to evaluate the viability of the posterior tibial tendon, spring ligament, and bone quality or extent of joint arthrosis at the proposed surgical site.

### Preoperative considerations

An optimal outcome is dependent on accurate diagnosis and procedural selection as well as precise surgical execution. The goal is to recreate a functional tripod of the heel and first and fifth metatarsal heads to allow a stable functional foot through the gait cycle. Correction of a multiplanar deformity such as an adult acquired flatfoot requires adjunctive procedures in

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**Fig. 1.** Clinical demonstration of loss of the medial longitudinal arch (A) and heel valgus with too many toes sign (B).

**Fig. 2.** Radiographic features of NC fault, altered Meary’s angle, decreased calcaneal inclination, and increased talar declination.
addition to the NC fusion. Examples of such procedures include musculo-tendon balancing procedures, osteotomies, and arthrodees, which are discussed elsewhere in this issue.

Indications for the NC arthrodesis include a sagittal plane deformity (fault or sag) at the level of the NC joint, hypermobility of the NC joint, and degenerative arthrosis. Relative contraindications in the authors’ practice include patient noncompliance, tobacco/drug abuse, and poor bone stock.

**Surgical technique**

An equinus deformity, if present, is addressed through a gastrocnemius recession or tendoachilles lengthening (TAL) before dissection of the medial foot and ankle. Exposure of the NC joint is accomplished through a medial utility incision that allows access to the posterior tibial tendon, which may require repair or be augmented with a flexor digitorum longus tendon transfer in addition to the arthrodesis (Fig. 4). This incision is curvilinear in nature beginning proximal and posterior to the medial malleolus and extends distally to the first TMT joint (Fig. 5). Upon incision, the superficial venous tributaries of the medial marginal vein are ligated as necessary and dissection performed to the deep fascia. The extensor retinaculum is released distally, at which time attention is directed to the superior aspect of the incision and the course of the anterior tibial tendon identified. The tibialis anterior is protected and retracted dorsally for the remainder of the procedure (Fig. 6).

Next, the NC joint is opened through a medial capsulotomy, followed by release of the dorsal and plantar ligamentous structures. Joint distraction may be necessary for direct visualization and joint preparation. The authors use a Steinman pin retractor (Weinraub joint and calcaneal spreader; Innomed, Savannah, GA), with one pin in the medial cuneiform and one
in the medial navicular (Fig. 7). Joint preparation for arthrodesis is a fundamental principle that necessitates removal of cartilage and debris and violation of the subchondral plate. This preparation can be accomplished through a combination of curettes, ronguers, and osteotomes. Fenestration of the subchondral plate is achieved with a small drill or K-wire. Typically, the medial and intermediate cuneiforms are accessible; however, complete denuding of the cartilage on the lateral cuneiform may not be possible due to the contour of the articular surface and is not required for the final construct. An in situ fusion technique does not require additional bone grafting because there is minimal shortening associated with it; however, packing the joint space with cancellous chips or demineralized bone matrix or augmentation with autologous platelet gel is left to the surgeon’s preference.

Reduction of the deformity via recreation of the windlass mechanism and counter-pressure on the navicular tuberosity is paramount to recreate the tripod effect and establish the longitudinal arch (Fig. 8). While maintaining
this reduction manually, an assistant places three temporary guidewires in the following orientations: (1) from the navicular tuberosity into the medial cuneiform (plantarly), (2) from the medial navicular (just superior to previous wire) to the intermediate cuneiform, and (3) from the distal medial aspect of the medial cuneiform into the lateral body of the navicular (Fig. 9). These wires are replaced by 3.5-mm fully threaded cortical screws in lag technique. Alternative internal fixation constructs include staples and medial cervical or H-plates. Occasionally, a fourth screw can be placed from the medial cuneiform to the lateral body of the navicular (Fig. 10). Intraoperative fluoroscopy is used to confirm placement of internal fixation and deformity reduction. Closure is achieved in layers. An absorbable subcuticular stitch is used for skin, obviating the need for suture removal and allowing placement in a short leg cast at the first postoperative visit (Fig. 11). The patient is placed into a Jones compression dressing and posterior splint in the operating room.

Fig. 6. Tibialis anterior is identified (distal is to the right of the picture).

Fig. 7. Joint exposure with retractor in foreground (distal is to the right of the picture). The medial and intermediate cuneiforms are visible.
Postoperative course

At the first postoperative visit, pending evaluation of soft tissues, a short leg cast is applied. The patient remains non–weight bearing for 6 to 8 weeks with routine radiographic monitoring. Transition to a fracture boot and partial weight bearing is determined by radiographic arthrodesis as evidenced by trabeculation across the fusion site. Physical therapy is usually initiated at 6 weeks, with a return to full weight bearing in shoes at 10 to 12 weeks. Deep venous thrombosis prophylaxis is based on risk stratification.

Fig. 8. Activation of the windlass mechanism for reduction of the deformity and temporary pinning. Pressure is placed on the navicular tuberosity with the left thumb to assist in correction.

Fig. 9. Cartoon illustrating ideal placement of internal fixation (A). Intraoperative fluoroscopy indicating placement of temporary K-wire fixation (B).
Potential complications

As is true for most arthrodeses and reconstructive foot and ankle procedures, there are several potential complications. These complications include wound dehiscence, infection (superficial or deep), deep venous thrombosis, nerve entrapment, hardware failure, and delayed union, malunion, or non-union along with over- or undercorrection of deformity.

Discussion

In a comprehensive surgical approach to the adult acquired flatfoot, one needs to address each aspect of the deformity including soft tissue influences and osseous abnormalities in addition to alterations in joint function. Medial column stabilization through NC fusion, with appropriately selected ancillary procedures, will allow reconstruction and stabilization of the medial column and preservation of essential joint motion. In a retrospective review of 52 patients by Chi and colleagues [2], the results of isolated medial
column stabilization, lateral column lengthening (calcaneocuboid joint bone block arthrodesis), and combined medial and lateral procedures were analyzed. All of the osseous procedures were augmented with a flexor digitorum longus transfer and gastrocnemius recession or TAL. Objectively, in the medial column fusion group they found a decrease in Meary’s angle from a preoperative value of $25 \pm 1$ degrees to a postoperative value of $5 \pm 2$ degrees. In addition, the anteroposterior TN coverage decreased from $25 \pm 6$ degrees to $15 \pm 1$ degrees, with 80% of patients less painful or pain free at 1 to 3 year follow-up. The authors developed a clinical algorithm for decision making based on their findings (Fig. 12). They concluded that medial column stabilization is a valuable procedure in patients with radiographic midfoot sag through the NC joint and forefoot abduction without significant hindfoot valgus. If hindfoot valgus is present, a concomitant posterior calcaneal osteotomy is recommended.

Radiographic outcomes following medial column fusion have also been analyzed in regard to alignment of the forefoot and rearfoot via measurement of established roentgenographic parameters [4]. Although restorations of the longitudinal arch and normal bony architecture are postoperative goals, no study has clearly demonstrated how much correction is required for positive outcomes. In a retrospective radiographic evaluation, 19 patients who underwent medial column fusion were reviewed to determine how much correction could be obtained through changes in Meary’s angle, calcaneal inclination, and TN coverage. Mean improvements were found in all three on the order of 16, 5, and 14 degrees, respectively. All of the procedures were performed in conjunction with flexor digitorum longus transfer and TAL or gastrocnemius recession. It was concluded that isolated arthrodesis of the medial column can realign and improve rearfoot deformity associated with peritalar

![Clinical algorithm](image)

Fig. 12. Clinical algorithm. (Adapted from Chi T, Toolan B, Sangeorzan B, et al. The lateral column lengthening and medial column stabilization procedures. Clin Orthop Relat Res 1999;365:88; with permission.)
subluxation. In addition, the procedure allows three-dimensional correction while maintaining motion at the tri-tarsal joint complex. The study was limited by a small cohort with no control, as well as by a lack of evaluation of frontal plane deformity. Because the study was a review of radiographic findings, the researchers could not assess the amount of correction influenced by ancillary soft tissue procedures.

Other investigators have described the NC fusion in conjunction with various combinations of soft tissue augmentation, arthrodeses, or osteotomies and using a wide assortment of fixation [1,15–17,20–23]. The primary indications in adult acquired flatfoot, as previously outlined, include loss of structural integrity, deformity, or both along the medial column with radiographic evidence of a breach at the NC joint. The subjective complaints of progressive deformity, pain, and a decrease in arch height aid in procedural selection. Often, hypermobility or arthrosis of the medial column including the NC and first TMT may require primary arthrodesis of both joints. This approach allows adequate correction and restoration of the tripod effect for efficient load transfer and stability during gait.

The surgeon must be cognizant of the fact that there are few indications for an isolated NC arthrodesis. It is most commonly employed in conjunction with posterior tibial tendon repair with or without flexor digitorum longus transfer, selected calcaneal osteotomies, and hindfoot arthrodesis. Lengthening of the posterior muscle group via a TAL or gastrocnemius recession is also typically performed. Although there is limited evidence-based medicine, based on small cohorts and short-term outcomes, this procedure has a distinct niche in the foot and ankle surgeon’s armamentarium.

Summary

The NC arthrodesis may be used to balance a symptomatic flatfoot, re-establishing medial column stability and alignment while maintaining essential tri-tarsal joint motion. The clinical findings, perioperative decision making, and surgical technique for NC arthrodesis have been described, in addition to a review of the limited literature concerning outcomes in correction of the adult acquired flatfoot. When used appropriately, excellent results are possible in regard to patient satisfaction, a decrease in pain and deformity, and restoration of normal function. Although it does not have the power to correct significant heel valgus, it provides an alternative to hindfoot fusions that would significantly decrease biomechanical accommodation and affect reduced mobility of the foot during gait.

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References