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Naviculocuneiform Arthrodesis in Adult Flatfoot: A Case Series

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ABSTRACT

Medial column arthrodesis and calcaneal osteotomies are commonly used for adult-acquired flatfoot surgical reconstruction. In this case series, 10 patients (11 feet) with a mean age of 54 ± 13 years underwent a medial column arthrodesis, with or without calcaneal osteotomy, between 2010 and 2017. The indication for surgery was a painful flatfoot deformity with peritalar subluxation and a fault in the naviculocuneiform joint. At a mean of 9.9 (range 2.5 to 33.1) months after surgery, in patients who underwent a medial column arthrodesis, radiographs showed a mean decrease in the talonavicular coverage angle of 8.4° ± 8.5° ($p = .013$), and mean increases in the lateral talometatarsal and calcaneal inclination angle of 10.6° ± 10.3° ($p = .002$) and 2.2° ± 4.4° ($p = .067$), respectively. One nonunion (1 of 11 [9.1%]) occurred at the naviculocuneiform. These findings demonstrate marked improvement of radiographic flatfoot parameters after medial column arthrodesis.

The adult flatfoot is classically described as medial longitudinal arch collapse, hindfoot valgus, and forefoot abduction with posterior tibial tendon disease and insufficiency. Foot structure is maintained by both dynamic and static support. The posterior tibial tendon is the primary extrinsic support of the foot as shown by Thordarson et al (1). Niki et al (2) were able to show that with loading of an intact cadaveric foot after posterior tibial release, there was maintenance of the medial longitudinal arch initially, but with cyclic loading, the osteoligamentous structures eventually fail, and activation of posterior tibial tendon is then insufficient to recreate the arch. The purpose then of the naviculocuneiform (NC) arthrodesis is to recreate and stabilize a portion of the intrinsic architecture of the foot, particularly when combined with adjunctive osseous and soft tissue augmentation.

The purpose of this case series was to add to the literature regarding NC arthrodesis. We propose that NC arthrodesis, when performed as a component of the surgical correction of the adult flatfoot, provides significant and durable correction.

Patients and Methods

The institutional review board of Virginia Mason Medical Center approved the present study (Protocol ID: IRB17-084). A review of the senior author's (M.W.) surgical database back to January 2010 was performed. Patients with NC arthrodesis were included in the initial review. Patients were excluded from the analysis if subtalar or talonavicular (TN) arthrodesis was completed before or at the same time as the NC joint. All patients were >18 years old. Patients with NC arthrodesis for reasons other than flatfoot correction were excluded.

Eleven feet (10 patients) fit the preceding criteria. Patient age, smoking status, and concomitant procedures were recorded, as was the fixation method. Radiographic review consisted of weightbearing anterior-posterior and lateral foot views of the preoperative and most recent postoperative radiographs, which were then compared. Cobb angle measurements were performed using computerized software (IntelliSpace PACS Enterprise; Philips, Amsterdam, Netherlands). For talus–first metatarsal angles (Meary's angle), lines were placed along the central longitudinal axes of the first metatarsal and talus. The calcaneal inclination angle was measured using lines placed along the plantar foot and the anterior inferior margin of the calcaneus. On the anterior-posterior foot, the TN coverage angle was calculated in a similar fashion using Cobb angle measurements, and lines were drawn perpendicular to the longitudinal axes of the talus and navicular. Paired Student's *t* tests were used to compare values that were normally distributed, and Wilcoxon signed-rank tests were used for values with a non-normal distribution. Statistical significance was defined at the 5% ($p < .05$) level using R (version 3.4.4, Vienna, Austria). Two feet had incomplete radiographs and were not included in the radiographic correction statistics.

Radiographic union of the NC arthrodesis was determined by modifying the tibial fracture scoring system, described by Hammer et al (3), who defined union as massive crossing trabeculation at the fracture (arthrodesis) site or homogeneous bone structure and a barely discernible or obliterated fracture line. The fixation method was collected and tabulated in Table 1.

Results

Ten patients (11 feet) met the criteria for inclusion. One (10.0%) patient underwent bilateral corrections. The mean age of the patients at the time of the surgery was 54 ± 13 (range 28 to 73) years. Surgeries were performed on 7 (70.0%) females and 3 (30.0%) males, and each of the operations was performed by the senior

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Table 1
Method of fixation (N = 11 feet)

Fixation	N (%feet)
Medial locking plate with crossed screw(s)	4 (36.4%) (3 including TMT/NC arthrodesis)
Crossed screws only	6 (54.6%) (1 including TMT/NC arthrodesis)
Medial locking plate only	1 (9.1%) (TMT/NC arthrodesis)

Abbreviations: NC, naviculocuneiform; TMT, tarsometatarsal.

author (M.W.). An ancillary medial displacement calcaneal osteotomy (MDCO) was performed in 5 (45.5%) extremities, and first tarsometatarsal (TMT) joint fusion was performed in 5 (45.5%) of the 11 extremities in this study. In 9 (81.8%) extremities, flexor digitorum tendon transfers to the posterior tibial tendon were performed. A gastrocnemius recession was completed in 1 (9.1%) extremity, whereas an Achilles tendon lengthening was completed in 7 (63.6%) extremities to address the associated equinus contracture (Table 2). The most recent weightbearing postoperative radiographs used to measure outcome angles were taken at a mean of 9.9 (range 2.5 to 33.2) months. Mean radiographic parameters showed statistically significant improvement ($p < .05$) from preoperative values, with the exception of calcaneal inclination ($p = .067$) (Table 3). There was no significant difference in the correction comparing patients with and without an MDCO, the TN coverage increased by an average of 5.3° ($p = .33$), Meary's angle increased by 6.4° ($p = .27$), and the calcaneal inclination increased by 3.6° ($p = .08$). Similarly, there was no significant difference in correction noted comparing those performed in conjunction with or without TMT arthrodesis (Fig. 1). The TN coverage decreased by an average of 6.9° ($p = .27$), Meary's angle decreased by 5.3° ($p = .46$), and the calcaneal inclination increased by 2.3° ($p = .46$).

An isolated nonunion occurred in the NC joint in 1 (9.1%) of 11 cases, and combined nonunion of the NC and TMT joints did not occur. The NC nonunion is awaiting reoperation; in the interim, no loss of radiographic angular correction has been seen at this point. One patient had progressive collapse through the TN joint and underwent a TN arthrodesis at 33 months after index procedures; radiographic angular measurements after the revision procedure were not included in this study. The was an isolated TMT nonunion in 1 (9.1%) of 11 cases, and this nonunion was treated with a revision TMT arthrodesis with lag screw and locking plate fixation 1 year after the index procedure. Slow loss of calcaneal inclination and Meary's angle were seen with the TMT nonunion until revision was performed.

The average time to radiographic union was 16.6 ± 7.0 (range 10 to 31) weeks. There was no statistical significance when comparing union time in smokers and nonsmokers (Table 4).

Table 2
Ancillary procedures (N = 11 feet in 10 patients)

Procedure	Count (% of extremities)
Medical displacement calcaneal osteotomy	5 (45.5%)
First tarsometatarsal arthrodesis	5 (45.5%)
Flexor digitorum longus transfer	9 (81.8%)
Gastrocnemius recession	1 (9.1%)
Tendo-Achilles lengthening	7 (63.6%)

Table 4
Radiographic union analysis in smokers

	Radiographic Union (weeks)	
Smokers (n = 5)	16.4 ± 8.7 (10 to 31)*	$p = .83$
Nonsmokers (n = 5)	16.8 ± 5.9 (10 to 24)*	

* Results are shown as mean ± standard deviation (minimum to maximum range).

Discussion

Unlike many adult flatfoot topics, there is a relative paucity of qualitative literature around NC arthrodesis. There have been 4 series published looking at radiographic correction of the NC arthrodesis, with 106 fusions and only a single series reviewing time to radiographic arthrodesis (4–8). Nonunion rates for NC arthrodesis have been reported as between 0% and 12.5% (4–8).

We were unable to show a significant difference between radiographic correction with or without an MDCO, as reported by Jordan et al (5). We evaluated the reason for extended medial column arthrodesis at the index procedure (adding a first TMT arthrodesis). On chart and radiographic review, it was evident that the extended arthrodesis was for TMT arthritis, all patients had a medial column fault at the NC joint or centered on the medial cuneiform.

One patient had subsequent collapse through the TN joint requiring an arthrodesis of that joint at a later procedure. Although the postoperative lateral Meary's angle was improved, there was little change in the TN coverage angle, leading to easy plantar medial talar head escape once weightbearing was resumed (Fig. 2). The preoperative imaging in this instance shows an apex of deformity through the TN joint; in retrospect initial arthrodesis of the NC and TN joints might have been the better initial procedure.

Ajis and Geary (4) reported a 3% nonunion rate using a locked plate with crossing screw. Radiographic correction was evaluated with Meary's angle and TN coverage angle; both of these angles showed statistically significant improvement after arthrodesis. This was the first article to report time to radiographic union, which averaged 21.7 weeks. Our radiographic union results were slightly faster at an average 16.6 weeks. The difference in union times could represent a difference in union criteria or imaging intervals (4).

Jordan et al (5) had a nonunion rate of 8.5% (3 isolated NC, 1 combined NC/TMT) using crossing screws. Radiographic improvement of Meary's angle, TN coverage, and the calcaneal inclination angle was statistically significant. Interestingly, when looking at correction with and without a medializing calcaneal osteotomy, there was no difference in correction obtained, as noted previously (5).

Barg et al (6) had a 100% union rate using a medial locking plate and crossed screws. Evaluating NC arthrodesis in combination with medializing calcaneal osteotomy, they found that the radiographic improvement was statistically significant across all parameters (TN coverage, Meary's angle, calcaneal inclination) at 6 months after surgery (6). Greisberg et al (7) reported 12.5% nonunion at the NC joint using crossed screws. Radiographic improvement of Meary's angle, calcaneal inclination, and TN coverage were statistically significant (7).

Table 3
Radiographic correction (n = 9 feet [8 extremities])

Radiographic parameter (degree)	Preoperative*	Postoperative*	Difference	*p* Value
Talonavicular coverage	22.2 ± 8.5 (12 to 41)	13.8 ± 12.4 (4 to 43)	−8.4 ± 8.5	.013
Talar-first metatarsal	−20.1 ± 10.3 (−6 to -39)	−9.6 ± 7.8 (0 to −19)	10.6 ± 10.3	.002
Calcaneal inclination	18.7 ± 4.4 (13 to 25)	20.9 ± 3.6 (15 to 25)	2.2 ± 4.4	.067

* Results for the preoperative and postoperative measurements are shown as mean ± standard deviation (minimum to maximum range).

Fig. 1. Preoperative and postoperative images of naviculocuneiform (*A*) and tarsometatarsal (*B*) arthrodesis with a flexor digitorum longus–posterior tibial tendon transfer. (*C, D*) Postoperative images at 7.5 months.

Our radiographic correction and nonunion rate are in alignment with the existing published data. We believe that NC arthrodesis provides durable correction of the adult flatfoot regardless of ancillary procedures. Ajis and Geary (4) commented on the use of medial locking plates to increase stiffness, particularly in the sagittal plane of the arthrodesis site and how this could explain the union rates published by Barg et al (6). There is a trend toward higher rates of union with medial locking plates (97% to 100%) (4,6). Our NC

Fig. 2. (*A, B*) Preoperative images showing collapse through the talonavicular (TN) joint sagittal and significant TN uncovering. (*C, D*) Initial weightbearing postoperative images, 2 months after surgery; lateral view with good correction of Meary's angle. Anterior-posterior (AP) image with improved TN but still abnormal TN coverage angle. (*E, F*) Images obtained before TN arthrodesis, 33 months after index procedures. Increased sag through the TN joint was noted on the lateral with increasing TN noncoverage on the AP image.

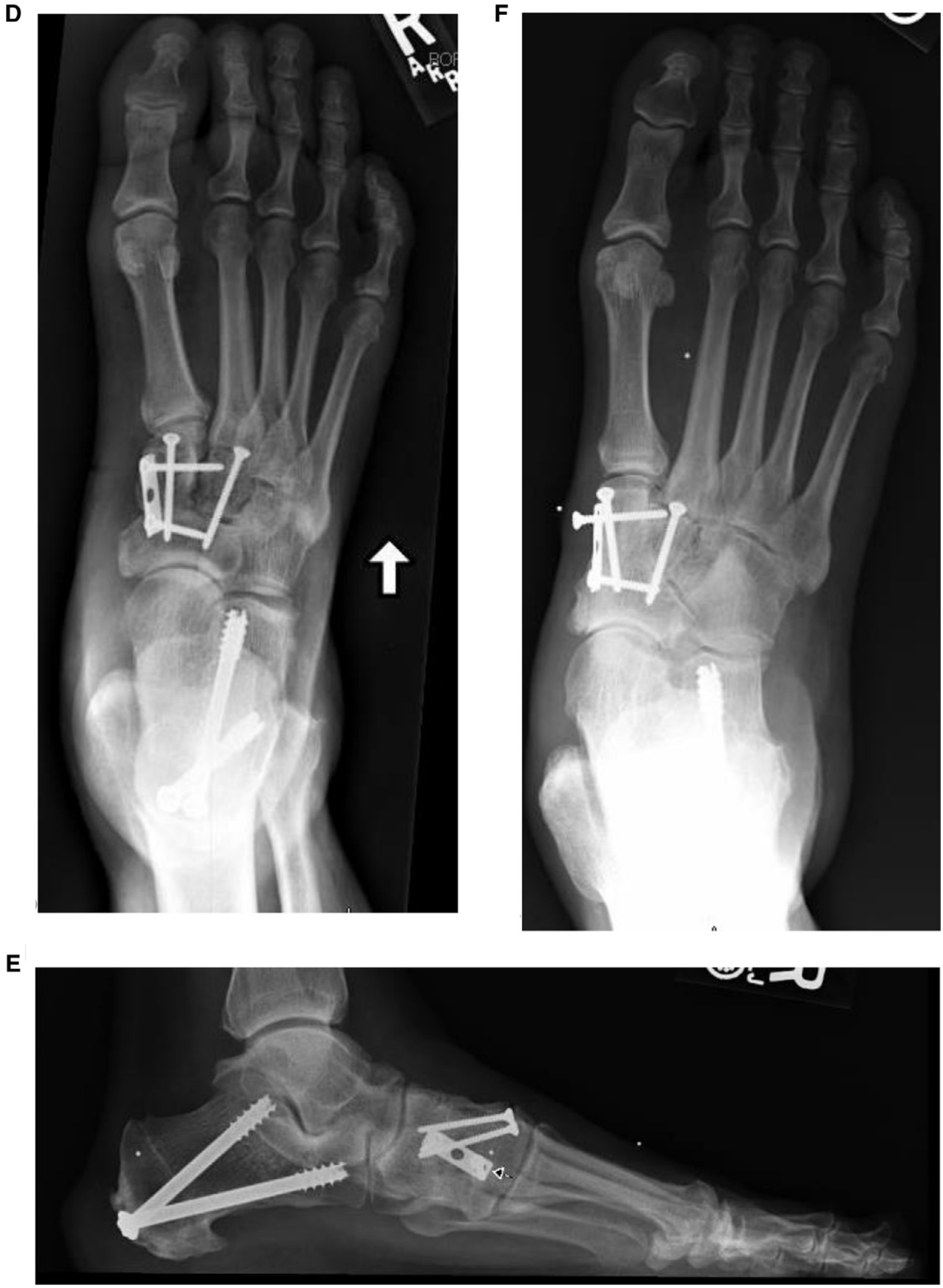

Fig. 2. (Continued)

nonunion occurred when using crossed screws alone, although the isolated TMT nonunion was a combination plate and screw construct, both of which had broken.

The limitations of this study include a small sample size that was retrospectively reviewed. In addition, it is important to note that we had incomplete radiographic imaging for measuring correction in 2 of 11 feet, impacting only the correction measurements. Five of the feet had radiographs that were obtained <6 months from the index operation, so the longevity of repair cannot be certain.

In conclusion, this study found NC fusion to be a safe and predictable procedure, with arthrodesis rates similar to other joints in the foot. Radiographic fusion was shown to take somewhat longer to occur (3 months) than would be typically expected for other foot joints; however, patients with flexible planovalgus deformity achieved durable deformity correction in multiple planes.

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