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Isolated Talonavicular Arthrodesis as Treatment for Flexible Progressive Collapsing Foot Deformity: A Case Series

Christopher J. Traynor, MD[1], Hui Zhang, MD[2], Bryan D. Den Hartog, MD[1], Jeffrey D. Seybold, MD[1], William M. Engasser, MD[1], Rebecca Stone McGaver, MS, ATC[1], Jacquelyn E. Fritz, BS[1], Kayla J. Seiffert, BA[1], Carissa C. Dock, BS[3], and J. Chris Coetzee, MD[1]

Abstract

Background: For the younger, more active patient with flexible symptomatic progressive collapsing foot deformity (PCFD), joint-sparing procedures may be preferred to preserve functional motion. Isolated talonavicular (TN) arthrodesis has been described for treatment of rigid and flexible PCFD for patients that are older and less active whose deformity is still correctable through the TN joint. The purpose of this study was to evaluate radiographic and clinical outcomes in patients with PCFD treated with isolated triplanar correction with a TN joint arthrodesis.

Methods: Forty-nine patients (53 feet) with flexible PCFD underwent isolated TN arthrodesis. Weightbearing radiographs were performed pre- and postoperatively, and measurements included lateral talar–first metatarsal angle, calcaneal pitch, TN coverage angle, and the anteroposterior (AP) talar–first metatarsal angle. The Foot and Ankle Ability Measure (FAAM) and Veterans-Rand 12-Item Health Survey (VR-12) scores were also collected.

Results: Thirty-five females and 14 males were evaluated with a mean age of 63 years, at an average follow-up of 41.3 months. Significant improvements were found radiographically. Lateral radiographs demonstrated improvements in lateral talar–first metatarsal angle from 25.2 degrees preoperatively to 9.5 degrees postoperatively ($P < .001$) and calcaneal pitch from 14.9 degrees preoperatively to 17.5 degrees postoperatively ($P < .001$). AP radiographs showed the TN coverage angle improving from 35.0 degrees to 4.9 degrees postoperatively ($P < .001$) and AP talar–first metatarsal angle improving from 17.3 degrees to 5.9 degrees postoperatively ($P < .001$). Clinical outcomes were improved in the FAAM pain score (48.6 to 39.2, $P = .130$), FAAM ADL score (53.8 to 69.2, $P = .002$), FAAM Sport score (29.5 to 40.7, $P = .099$), and the overall FAAM score (47.7 to 63.1, $P = .006$). Patient satisfaction with medical care was 85.2/100 postoperatively.

Conclusion: Isolated TN arthrodesis is a viable surgical option for older, lower-demand patients with flexible PCFD. This study demonstrated significant improvements in radiographic alignment and FAAM scores. Comparative studies with other surgical procedures should be performed to determine which is the best technique for older, lower-demand patients with flexible PCFD.

Level of Evidence: Level III, retrospective cohort study.

Keywords: flatfoot, progressive collapsing foot deformity, talonavicular fusion

Introduction

Progressive collapsing foot deformity (PCFD) formerly known as adult acquired flatfoot deformity (AAFD) or posterior tibial tendon insufficiency, remains a challenging condition for foot and ankle surgeons to treat. Although there exists more clarity on the treatment for early and mild cases of PCFD as well as end-stage rigid deformities involving PCFD, there is still significant debate over different surgical treatment options for the moderate to severe flexible

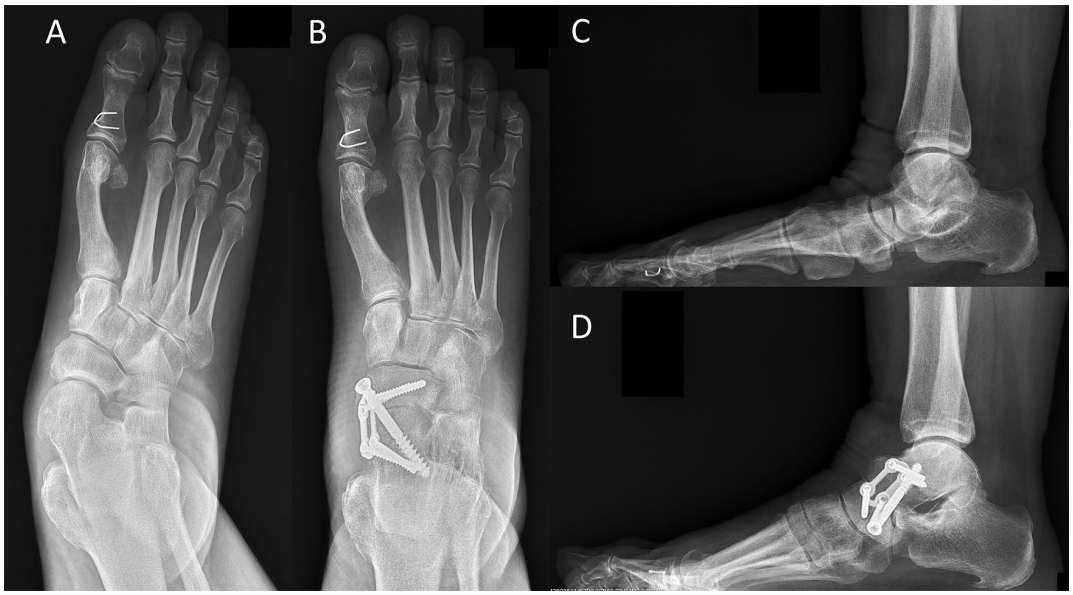

Figure 1. Preoperative (A, C) and postoperative (B, D) anteroposterior (A, B) and lateral (C, D) radiographs of a 58-year-old patient with symptomatic progressive collapsing foot deformity treated with talonavicular arthrodesis.

PCFD. Common surgical corrections for flexible PCFD include the "All-American Procedure" popularized by Manoli in the early 1990s.[5] The described technique often involves some combination of a tendo-Achilles lengthening, medial displacement calcaneal osteotomy, flexor digitorum longus transfer, posterior tibial tendon debridement or excision, lateral column lengthening, and medial column stabilization.

The talonavicular (TN) joint is commonly at the apex of the deformity or the center of rotational angulation (CORA). Stage I class B PCFD describes a flexible midfoot abduction deformity with increased TN subluxation and talar head uncoverage.[12] Because of its position as the CORA, the TN joint is an optimal location for delivering efficient triplane correction to address the deformity associated with PCFD. It is established in foot and ankle deformity correction that realignment is most effective when done at the CORA. Addressing deformities at the CORA allows for correction of the rotational and angular deformity without introducing translational deformities.[13] This concept was applied to our patients with flexible PCFD using a triplanar deformity correction at the TN joint in the form of a TN arthrodesis (Figure 1).

The primary objective of this study was to evaluate radiographic and clinical outcomes in patients with flexible PCFD treated with isolated triplanar corrective TN arthrodesis. It was hypothesized that with an isolated TN arthrodesis, radiographic measures and clinical outcomes of PCFD would improve.

Material and Methods

Institutional review board approval was obtained. A retrospective review of patients who underwent TN arthrodesis for treatment of flexible PCFD from July 2013 to September 2020 was conducted. Inclusion criteria were patients aged >35 years with a lower level of activity, obesity, difficulty being nonweightbearing for an extended period of time, preoperative diagnosis of flexible PCFD with triplane deformity (formerly classified as stage II AAFD), and those who underwent isolated TN arthrodesis. The oblong ball and socket shape of the joint allows movement in three planes. Adjuvant procedures were also performed (see Table 1). The decision to perform an isolated TN arthrodesis was based on surgeon's preference for treating flexible PCFD who met the selection criteria. Excluded were

[1]Twin Cities Orthopedics, Edina, MN, USA
[2]Aurora Orthopedics, Oak Creek, WI, USA
[3]University of Minnesota, Minneapolis, MN, USA

Corresponding Author:
J. Chris Coetzee, MD, Twin Cities Orthopedics, 4010 W 65th St, Edina, MN 55435, USA.
Email: ChrisCoetzee2@TCOMN.com

Table 1. Percentage of Ancillary Procedures.

Ancillary Procedures	Number (%) of all 53 Surgical Procedures
Gastrocnemius/Achilles lengthening	43 (81) / 3 (6)
Bunion/Bunionette	7 (13.2) / 2 (3.7)
Phalanges surgeries	4 (7.5)
Ankle arthrotomy	2 (3.7)
Flexor digitorum longus transfer to navicular	2 (3.7)
Other: peroneus brevis longus transfer, calcaneocuboid joint open debridement, spring ligament repair, accessory navicular removal, tarsometatarsal joint fusion	1 each
None	32 (66)

patients aged <35 years, those with rigid deformities, patients with TN and/or subtalar arthritis that did not have a pes planovalgus deformity, those with prior or concomitant arthrodesis and osteotomies in the midfoot and hindfoot, or those with inadequate follow-up or imaging. Concomitant gastrocnemius lengthening (or PCHCL) was performed if after correction of the PCFD there was limited dorsiflexion <5°. Toe deformity correction procedures were not an exclusion criterion. Patient demographics including sex, age at time of surgery, laterality and comorbidities were documented and recorded.

Weightbearing radiographs were reviewed preoperatively and postoperatively. Radiographic measurements obtained included lateral talar–first metatarsal angle and calcaneal pitch measured on lateral view and TN coverage angle and AP talar–first metatarsal angle measured on AP radiographs. All measurements were performed by an orthopaedic foot and ankle fellow.

Clinical outcomes measures included the Foot and Ankle Ability Measure (FAAM)[7,11] and Veterans-Rand 12 Item Health Survey (VR-12)[16] collected prospectively prior to surgery and the patient satisfaction collected postoperatively. Patient satisfaction surveys included the question "How satisfied are you with your medical care?" with "least satisfied" being a score of 0 and "most satisfied" being 100.

Operative Technique

The talonavicular arthrodesis was done through a dorsomedial approach, between the tibialis anterior and posterior tibial tendons. The posterior tibial tendon was excised only when palpably large and symptomatic on preoperative evaluations. The talonavicular joint was prepared in usual fashion, reduced, and preliminarily fixated with wire(s) to confirm satisfactory alignment fluoroscopically. Final constructs typically entailed a 4.5-mm lag screw with a dorsal 4-hole plate, depending on surgeon preference. A gastrocnemius recession or percutaneous tendo-Achilles lengthening was completed as needed for gastrocnemius or Achilles contractures, respectively. Postoperatively patients were placed into a short-leg splint or cast and kept nonweightbearing for 2 weeks. At 2 weeks postoperatively, patients were transitioned to a CAM boot and allowed to partially weightbear 50% as tolerated until their 6-week postoperative appointment. The patient was encouraged to continue with their knee scooter for long distances. At 6 weeks postoperatively, patients were allowed to progress to full weightbearing and transition out of the CAM boot to their tolerance. Formal physical therapy was typically started at the 6-week postoperative timepoint.

Statistical Analysis

Two-sample *t* tests were used to determine significant differences between pre- and postoperative measures. Significance was set at $P < .05$. Post hoc sample size calculation was performed to verify that the study was adequately powered. Using the mean ± SD from talar–first metatarsal angle pre- and postoperatively, a sample size of 31 was required to achieve a power of 0.8 (significance level $\alpha = .05$). Statistical analyses were performed using JMP, version 17 (SAS Institute Inc, Cary, NC).

Results

Thirty-five females and 14 males were evaluated with a mean age 63 (range, 38.6-81.9) years at the time of surgery and an average length of follow-up of 41.3 (range, 12-117.2) months. There were significant improvements in deformity correction found in this study. Radiographically, the lateral radiographs demonstrated lateral talar–first metatarsal angle correction from 25.2 degrees preoperatively to 9.5 degrees postoperatively ($P < .001$) and calcaneal pitch improving from 14.9 degrees preoperatively to 17.5 degrees postoperatively ($P < .001$). AP radiographic analysis demonstrated TN coverage angle improving from 35.0 degrees preoperatively to 4.91 degrees postoperatively ($P < .001$) and AP talar–first metatarsal angle improving from 17.3 degrees preoperatively to 5.6 degrees postoperatively ($P < .001$) (Table 2). When comparing preoperative and postoperative measurements, clinical outcomes were significantly improved in the FAAM activities of daily living (ADL) score (53.8 to 69.2, $P = .002$) and the overall FAAM score (47.7 to 63.1, $P = .006$) and improved in the FAAM visual analog scale (VAS) score (48.6 to 39.2, $P = .130$) and the FAAM sport score (29.5 to 40.7, $P = .099$). VR-12 did not

Table 2. Radiographic Measures.

Radiograph	Preoperation, Mean (Range) ± SD	Latest Follow-up, Mean (Range) ± SD	*P* Value
Talar navicular coverage	35 (10-62) ± 10.8	4.9 (0-26) ± 5.5	<.001
AP talar–first metatarsal angle	17.3 (4-40) ± 9.5	5.6 (0-27) ± 5.4	<.001
Lateral talar–first metatarsal angle	25.2 (5-51) ± 9.2	9.5 (0-35) ± 8.4	<.001
Calcaneal pitch	14.9 (6-30) ± 5.2	17.5 (7-27) ± 4.5	<.001

Abbreviation: AP, anteroposterior.

Table 3. Patient Report Outcome Measures.

PROMs	Preoperatively	Latest Follow-up	*P* Value
FAAM VAS	48.6 (7.5-95.2) ± 22.0	39.2 (0-100) ± 30.9	.130
FAAM ADL	53.8 (25-90.5) ± 19.0	69.2 (0-100) ± 22.4	.002
FAAM sport	29.5 (0-68.8) ± 20.9	40.7 (0-100) ± 33.4	.099
FAAM	47.7 (18.1-81.0) ± 18.7	63.1 (14.7-100) ± 23.6	.006
VR-12 physical	36.8 (21.4-69.8) ± 9.9	39.1 (15.7-58.3) ± 10.7	.357
VR-12 mental	55.1 (22.5-68) ± 9.2	55.6 (26.6-67.4) ± 9.0	.494
Patient satisfaction		85.2 (5.8-100) ± 18.9	

Abbreviations: ADL, activities of daily living; FAAM, Foot and Ankle Ability Measure; PROMs, Patient Report Outcome Measures; VAS, visual analog scale; VR-12, Veterans-Rand 12 Item Health Survey.

demonstrate significant improvement between preoperative and postoperative scores for both the physical (36.8 to 39.1, $P = .357$) and mental components (55.1 to 56.6, $P = .494$). Patient satisfaction with medical care was 85.2/100 (Table 3).

Ancillary procedures in this cohort are noted in Table 1 with gastrocnemius lengthening occurring in 43 (81%) of the surgical procedures. There were complications in the cohort: 6 cases of symptomatic nonunions, 5 undergoing revision talonavicular fusions, were noted. Another 8 patients developed symptomatic adjacent joint degeneration or collapse, most documented at the naviculocuneiform joint. Two of those patients underwent subsequent arthrodesis at the naviculocuneiform joint. There were 7 documented cases of symptomatic hardware removal. Lastly, 1 patient was taken back for an irrigation and closure of a dehisced wound at 2 weeks postoperation.

Discussion

The current study demonstrates that an isolated TN arthrodesis improves radiographic measures of flatfoot. Additionally, VAS and FAAM scores significantly improved postoperatively but we noted significant rates of nonunion and adjacent joint arthrosis. Many different surgical correction procedures exist to treat different deformity components of PCFD.[1,5] Although these surgical procedures are effective at correcting isolated singular plane deformities, multiple procedures are often needed in combination to fully correct the multiplanar deformity as a part of a full PCFD reconstruction. With each additional procedure, patients are exposed to elevated risk of complications and increased morbidity. There is much debate regarding the advantages or disadvantages of joint-sparing vs limited fusion procedures for the flexible flatfoot deformity. Nonunion of an isolated fusion vs reoperation for a failed joint-sparing procedure are both significant complications.[20] In our clinical experience, a fusion of the TN joint is a less traumatic procedure than multiple osteotomies and tendon transfers typically done for joint-sparing approaches.

First introduced in the 1990s, the concept of isolated TN arthrodesis for the treatment of flexible PCFD has demonstrated reasonable results early on. The first reports of successful results with isolated TN arthrodesis for the treatment of PCFD in 12 consecutive patients was reported by Simmons et al in 1990.[18] Harper and Tisdel published in 1996 their results in 27 patients treated with isolated TN arthrodesis for posterior tibial tendon insufficiency. They found 89% of patients (24 of 27 patients) to have good to excellent results based on their own grading scale created for objective evaluation after a minimum of 1-year follow-up.[6] No radiographic measurements were used in terms other than reporting 1 case of nonunion. They did report 4 cases of adjacent joint arthrosis in either the naviculocuneiform joint or talocalcaneal joint. Camasta et al reviewed 51 cases of isolated TN arthrodesis in 41 patients for the treatment of flexible AAFD in the podiatric literature. In their series, all patients achieved union, with 2 cases considered a delayed

union. They found a significant reduction in patient-reported pain as well as statistically significant improvements of several radiographic markers, including percentage of talonavicular coverage, calcaneocuboid angle, Kite angle, talar dome height, calcaneal inclination angle, and Meary angle.[3]

Fortin and Grant[4] also presented results of TN arthrodesis for the treatment of AAFD in 14 patients, but all patients also had a concomitant medial displacement calcaneal osteotomy due to the severity of valgus deformity in the hindfoot. Although the concomitant medial displacement calcaneal osteotomy does introduce a confounding variable, they did nonetheless demonstrate promising results, with 12 of 14 patients reporting satisfactory results without reservation.

Our study demonstrated significant improvements in clinical outcomes with patient-reported functional FAAM scores after isolated TN arthrodesis. To our knowledge, this is the first study to publish validated patient-reported outcomes (PROs) for a cohort that underwent TN arthrodesis for treatment of flexible PCFD. Prior studies using FAAM scores to assess outcomes of flatfoot deformity correction have shown promising results with a variety of techniques.[2,8,14,17,19] In general, preoperatively our patients had poorer scores. Our preoperative FAAM ADL and sports score were 53.9 and 29.7, respectively. Raikin et al[14] investigated outcomes of joint-sparing flatfoot reconstruction with and without spring ligament tears. Their cohort of 86 patients had mean preoperative scores of 57.6 and 32.4 for the FAAM ADL and sports measures respectively. Similarly, a mean FAAM ADL score of 56 .0 and FAAM sports score of 31.3 were noted preoperatively in Tsai et al's[19] study investigating pes planovalgus deformity correction using metallic wedges. Postoperatively, our FAAM ADL and sports scores were noted to be 68.7 and 40.3, respectively. This fared worse than prior studies as well. Postoperative FAAM ADL and sport scores were measured to be 77.8 and 58.1 in the Raikin et al[14] study and 80.0 and 50.0, respectively, in the Tsai et al[19] study as well. Additionally, given the heterogenicity of patient populations, surgical techniques, and overall study design, it is hard to compare cohorts.

The most concerning and well-documented complications for talonavicular fusions include fusion nonunion and adjacent joint arthrosis.[3,4,6,9,10] The most clinically significant complication in our study was the development of adjacent naviculocuneiform joint arthrosis (16% of the cohort). It is not understood why some of our patients developed pain and joint space narrowing postoperatively that was not present by plain radiographs preoperatively. Perhaps this was from increased mechanical stress from adjacent joint stiffness or present preoperatively but unrecognized. Further investigation is needed to better understand the cause of this progressive collapse and/or arthrosis and how to predict which patients are at risk for this complication. Weightbearing computed tomography scan could be a tool to help identify preoperative instability at the naviculocuneiform and other adjacent joints.[15,21]

We noted a nonunion rate of 11%. This is higher than the Camasta et al[3] and Harper and Tisdel[6] series, which noted a nonunion rate of 0% and 4%, respectively. The reason for this higher rate of nonunion is unclear. There is a heterogenicity between our studies including surgical techniques, choice of fixation, patient cohorts, and rehabilitation protocol. Anyone of these variables could factor into the different nonunion rates.

There are several limitations to our study. The retrospective nature of our analysis is a weakness. With this being a retrospective case series analysis, the assessors of the radiographic markers of correction were not masked to the intervention and thus introduces a possible bias in the assessment of radiographic outcomes. In addition, the lack of a control group for comparison makes it impossible for any comparative conclusion to be made regarding the utilization of isolated talonavicular arthrodesis for the treatment of flexible PCFD to other surgical treatment measures. Moreover, some patients had bilateral procedures done at various times, which may have influenced their functional FAAM score reporting at different time periods during follow-up. Additionally, when looking at our complications, we only evaluated for symptomatic nonunions and adjacent degeneration. It is likely that more patients may have asymptomatic evidence for complications not captured in our study design. Future studies that include a prospective, randomized trial comparing isolated talonavicular arthrodesis vs other surgical procedures for the treatment of flexible PCFD would be helpful in elucidating whether this treatment has benefits or weaknesses over other surgical procedures.

Isolated TN arthrodesis can correct flatfoot deformity on multiple planes providing significant improvement in radiographic alignment. Statistical improvements were also noted in FAAM clinical outcome scores, albeit worse than prior studies investigating alternative flatfoot correction procedures. The selection of this procedure in our practices is the middle age and older, more sedentary, lower-demand, or heavier, higher-risk patient that may not do as well with a multiple procedure surgery. Comparative studies should be performed to determine which is the best technique for patients with flexible PCFD.

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Ethical Approval

Ethical approval for this study was obtained from *Integ Review IRB, now Advarra Institutional Review Board.

Declaration of Conflicting Interests

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ORCID iDs

Christopher J. Traynor, MD, https://orcid.org/0000-0002-8561-4161
Bryan D. Den Hartog, MD, https://orcid.org/0000-0002-5146-3107
William M. Engasser, MD, https://orcid.org/0000-0002-7230-3356
Rebecca Stone McGaver, MS, ATC, https://orcid.org/0000-0001-9614-5383
J. Chris Coetzee, MD, https://orcid.org/0000-0001-6822-9512

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