Did Failure Occur Because of Medial Column Instability That Was Not Recognized, or Did It Develop After Surgery?

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KEYWORDS

- Medial column instability • Pes planovalgus • Flatfoot
- Posterior tibial tendon dysfunction

KEY POINTS

- Medial column instability is a primary deforming force in the setting of pes planovalgus deformity.
- Consideration for medial column stabilization only after correction of the hindfoot deformity may result in creating a rigid hindfoot, compromising clinical outcomes given the secondary correction of abduction following a medial column fusion.
- Careful analysis of the lateral radiograph to determine whether the deformity is secondary to the medial column (first tarsometatarsal and/or naviculocuneiform joints) may allow superior radiographic and clinical outcomes.
- Iatrogenic creation of an excessively rigid medial column does not seem to be well tolerated and may lead to significant instability of the remaining joints in the short term and arthrosis in the long term.
- Although there is limited literature regarding the appropriate role of medial column fusion for the surgical treatment of flatfoot, it can be concluded that medial column arthrodesis should be used selectively to correct gross instability in order to maintain as much physiologic motion as possible.

INTRODUCTION

Adult acquired flatfoot deformity (AAFD) has been addressed with an algorithmic approach based on classifications that have attempted to isolate this complex deformity into stages. Classifications allow orthopedic surgeons to discuss a pathologic

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entity in an academic setting; however, rigid classification systems are not able to accurately describe the nuances of a complex process and guide treatment in all cases. This statement was made by Miller[1] in 1927: “There can be no dogmatic classification of flatfoot.” Although he was discussing the care of pediatric flatfoot, the concept of avoiding dogmatic treatment of this multifactorial disorder is applicable to all conditions. This difficulty is acutely noted when discussing posterior tibial tendon (PTT) dysfunction because medial column instability does not play a prominent role in the traditional classification schemes; however, it is a significant contributor to the pathologic process.

In 1989, Johnson and Strom[2] developed the first classification system (**Table 1**) for AAFD, which is based on the integrity of the PTT, hindfoot position, and flexibility of the deformity. This classification has since served as a foundation for more current classification systems. The hallmark of AAFD is attenuation of medial hindfoot supporting soft tissue structures leading to collapse of the medial longitudinal arch. Although it is a critical component of the disorder, past classifications do not emphasize medial longitudinal arch involvement or treatment options when in conjunction with AAFD.

Newer classification systems are beginning to shed some light on the medial column involvement in AAFD. In 2007, Bluman and colleagues[4] proposed a more comprehensive classification system that involved a wider spectrum of subgroups that the previous classifications did not address. These subgroups included medial column instability. The RAM (rearfoot, ankle, midfoot) Classification, described by Raikin and colleagues,[5] takes into consideration involvement of the midfoot, as well as, the hindfoot and ankle. The Grand Rapids Arch Collapse Classification, described by Anderson and colleagues,[6] describes how a myriad of problems can contribute to gastrocnemius contracture, including medial arch collapse in the later stages. Despite the detail and subclassifications that have been added to describe AAFD, each classification attempts to categorize the fluid nature of this pathologic process into defined categories. These classifications schemes serve as a guide only and cannot be relied on to dictate the appropriate treatment of each patient. On review of the treatment recommendations for medial column arthrodesis, there is no correlation with severity of the medial column deformity or whether this may substitute for hindfoot correction (**Table 2**). What is clear is that although the medial column is recognized as part of the deformity in each of classifications, the concept of the medial column as the primary deforming force is not fully understood.

The lateral first talometatarsal angle has proved to be the most discriminating radiographic parameter when evaluating patients with a flatfoot deformity.[7] Instability of the medial column is also reliably shown by analyzing the height of the medial cuneiform.[8] Although both of these measurements help to define the presence of a flatfoot deformity, neither measurement accurately defines the location of the instability, which is critical to understand in order to apply the most effective surgical correction. When evaluating lateral weight-bearing radiographs, surgeons must determine whether the medial column collapse is occurring through the talonavicular (TN), naviculocuneiform (NC), first tarsometatarsal, or a combination of joints. Failure to appropriately address the apex of the instability leads to persistent postoperative deformity. A more frustrating scenario for all parties is for all locations of instability to be addressed with excellent intraoperative correction but further medial column collapse occurs in the postoperative period, which compromises the outcome. Although this situation cannot be predicted in all situations, understanding the implications of increasing the rigidity of the hindfoot and the forefoot secondary to arthrodesis may allow surgeons to mitigate the occurrence of this

Table 1
Classification system for adult acquired flatfoot deformity

Johnson & Strom (1989)[2]	Stage I Peritendinitis and/or PTT degeneration, mobile and normal hindfoot alignment, mild to moderate medial hindfoot pain, able to perform single-heel-rise test, no forefoot abduction, PTT synovitis with mild degeneration Stage 2 PTT elongation, mobile and valgus hindfoot alignment, moderate hindfoot pain over PTT, unable to perform single-heel-rise test, forefoot abduction present, marked degeneration of PTT Stage 3 PTT elongation, fixed and valgus hindfoot alignment, moderate media hindfoot pain over PTT along with lateral subfibular pain, unable to perform single-heel-rise test, forefoot abduction present, marked degeneration of PTT
Myerson (1996)[3]: modification of Johnson & Strom[2] classification	Stage 4 Rigid hindfoot with valgus talus angulation and lateral compartment ankle arthritis caused by deltoid attenuation
Bluman et al (2007)[4]: addition of subtypes to Johnson & Strom[2] and Myerson[3] classification	Stage 1A Tenderness along PTT with normal anatomy and normal radiographic findings: secondary to systemic inflammatory disease Stage 1B Tenderness along PTT with normal anatomy and normal radiographic findings Stage 1C Slight hindfoot valgus clinically and radiographically Stage 2A1 Supple hindfoot valgus, flexible forefoot varus; radiographic changes include hindfoot valgus, loss of calcanea pitch, Meary line disruption Stage 2A2 Supple hindfoot valgus, fixed forefoot varus; radiographic changes include hindfoot valgus, loss of calcanea pitch, Meary line disruption Stage 2B Same as stage 2 A2 with addition of forefoot abduction; radiographic changes include talar head uncovering and forefoot abduction Stage 2C Same as stage 2 B with addition of medial column instability, first ray dorsiflexion with hindfoot correction, sinus tarsi pain, radiographic presence of first tarsometatarsal joint plantar gapping Stage 3A Rigid hindfoot valgus, pain in sinus tarsi; radiographically there is loss of subtalar joint space, angle of Gissane sclerosis, hindfoot valgus Stage 3B Same as stage 3 A with addition of forefoot abduction Stage 4A Supple tibiotalar valgus Stage 4B Rigid tibiotalar valgus

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Table 1
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RAM Classification by Raikin et al (2012)[5]	Stage 1A Rearfoot: tenosynovitis of PTT Ankle: neutral alignment Midfoot: Neutral alignment Stage 1B Rearfoot: PTT tendonitis without deformity Ankle: <5° valgus Midfoot: mild flexible midfoot supination Stage 2A Rearfoot: flexible planovalgus (<40% talar uncoverage, <30° Meary angle, incongruence angle 20°–45°) Ankle: valgus with deltoid insufficiency (no arthritis) Midfoot: midfoot supination without radiographic instability Stage 2B Rearfoot: flexible planovalgus (>40% talar uncoverage, >30° Meary angle, incongruence angle 20°–45°) Ankle: valgus with deltoid insufficiency with tibiotalar arthritis Midfoot: midfoot supination with midfoot instability and no arthritis Stage 3A Rearfoot: fixed/arthritic planovalgus (<40% talar uncoverage, <30° Meary angle, incongruence angle 20°–45°) Ankle: valgus secondary to bone loss in lateral tibial plafond (deltoid normal) Midfoot: arthritis isolated to medial column (navicular–medial cuneiform or first tarsometatarsal joints) Stage 3B Rearfoot: fixed/arthritic planovalgus (>40% talar uncoverage, >30° Meary angle, incongruence angle 20°–45°); not correctable through triple arthrodesis Ankle: valgus secondary to bone loss in lateral tibial plafond with deltoid normal insufficiency Midfoot: medial and middle column midfoot arthritic changes (usually with supination and/or abduction of the midfoot)
GRACC (2014)[6]	Type 1 Affects gastrocnemius: presents with gastrocnemius equinus, plantar fasciitis, metatarsalgia, Achilles tendon pain; biomechanically there is tensile failure of posterior and plantar soft tissues Type 2 Affects forefoot: presents with hypermobile first ray, hallux valgus, lesser toe deformity, metatarsalgia, metatarsal stress fracture; biomechanically creating medial column incompetency with weight-bearing transfer to lesser rays Type 3 Affects midfoot: presents with midfoot arthritis especially at navicular–medial cuneiform, second, and third tarsometatarsal joints; biomechanically creating a transverse arch collapse Type 4 Affects hindfoot: presents with hindfoot valgus, peritalar subluxation, PTT disorder, lateral hindfoot/subtalar arthritis, sinus tarsi impingement; biomechanically there is medial arch collapse with spring ligament attenuation Type 5 Affects ankle: presents with valgus ankle arthritis; biomechanically there is deltoid ligament attenuation

Abbreviations: GRACC, Grand Rapids Arch Collapse Classification; RAM, rearfoot, ankle, midfoot.

Table 2
Treatment recommendations for medial column arthrodesis

Classification	Stage with Medial Column Involvement	Surgical Treatment Addressing Medial Column Instability
Bluman et al (2007) [4]	Stage 2C Medial column instability with radiographic presence of first TMT joint plantar gapping	Stage 2C Mild instability: Cotton procedure Moderate/severe instability/ arthritis: talonavicular, navicular-cuneiform, or first TMT joint arthrodesis depending on involvement
RAM classification (2012)	Stage 2B Midfoot supination with midfoot instability and no arthritis Stage 3A Arthritis isolated to medial column (navicular–medial cuneiform or first tarsometatarsal joints) Stage 3B Medial and middle column midfoot arthritic changes (usually with supination and/or abduction of the midfoot)	Stage 2B Mild instability: Cotton procedure Moderate/severe instability: navicular-cuneiform or first tarsometatarsal joint arthrodesis Stage 3A Navicular-cuneiform or first tarsometatarsal joint arthrodesis Stage 3B First, second, and third TMT realignment arthrodesis in order to stabilize the medial and middle column
GRACC (2014)	Stage 2 Medial column incompetence Stage 4 Medial arch collapse	Stage 2 First TMT arthrodesis Stage 4 Flexible deformity: first TMT arthrodesis Rigid deformity: talonavicular arthrodesis

difficult complication. This article focuses on both of these aspects of medial column instability.

MEDIAL COLUMN ARTHRODESIS FOR CORRECTION OF PES PLANOVALGUS

The primary difficulty with all reviews regarding flatfoot reconstruction is that there are no outcome scores to determine what procedures are required to improve the functional outcome. Orthopedic surgeons have focused on the improvement in radiographic angles with less attention paid to what aspects of deformity correction are associated with clinical improvement. The following discussion therefore must be approached with this critique in mind. There are 2 aspects of medial column contribution to flatfoot deformity that must be understood in order to discuss the role of surgical stabilization as an integral component of surgical reconstruction. First, the belief that the static medial restraints and stability of the medial column are components of flatfoot deformity. Many surgical algorithms place the medial column almost as an afterthought that needs to be addressed only if residual forefoot supination remains after correction of the hindfoot. However, the contribution of the medial column was initially recognized by Miller[1] in 1927. He described a surgical procedure that included an arthrodesis of the NC and first tarsometatarsal (TMT) joint, Achilles lengthening, and tightening of an osteoperiosteal flap of the medial navicular/cuneiform/first metatarsal without addressing the hindfoot. At 2.5 years of follow-up, no loss of the medial arch correction was noted; however, there is no radiographic analysis given in the article. Hoke[9] presented the first published

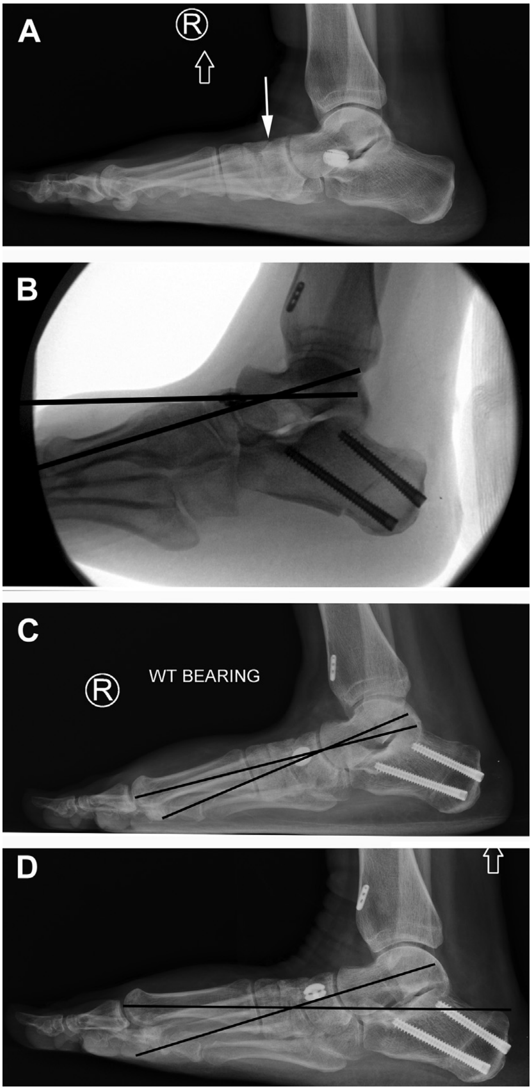

Fig. 1. Preoperative lateral radiograph (*A*) of a patient who failed a prior sinus tarsi implant procedure and who presented with persistent symptomatic complaints with evidence of NC collapse (*white arrow*). Intraoperative correction (*B*) was performed with a medial slide calcaneal osteotomy (medial displacement calcaneal osteotomy [MDCO]), FDL tendon transfer, gastrocnemius recession, and allograft spring ligament reconstruction. Correction was thought to be appropriate with elevation of the talar head. Three-month postoperative (*C*) radiographs note mild loss of correction through the NC joint. However, at 6 months (*D*), note the increasing loss of correction through failure of the NC joint. In hindsight, an isolated NC fusion may have been more appropriate in this patient as opposed to a spring ligament reconstruction.

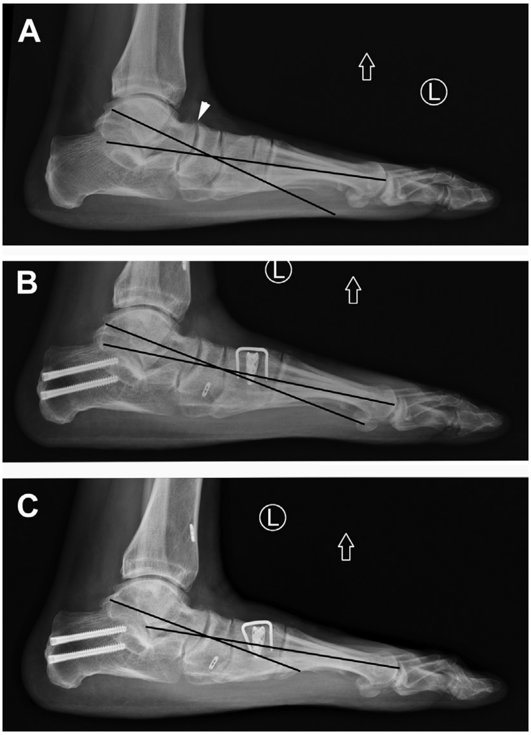

Fig. 2. Preoperative lateral radiograph (*A*) with deformity centered at the level of the NC joint. Note the lack of subluxation of the talonavicular (TN) joint (*white arrowhead*). Three months postoperative (*B*), mild improvement in the deformity is noted following an MDCO, FDL tendon transfer, spring ligament reconstruction, gastrocnemius recession, and Cotton osteotomy. However, near-complete recurrence of the deformity is noted (*C*) 6 months postoperatively secondary to continued collapse through the NC joint.

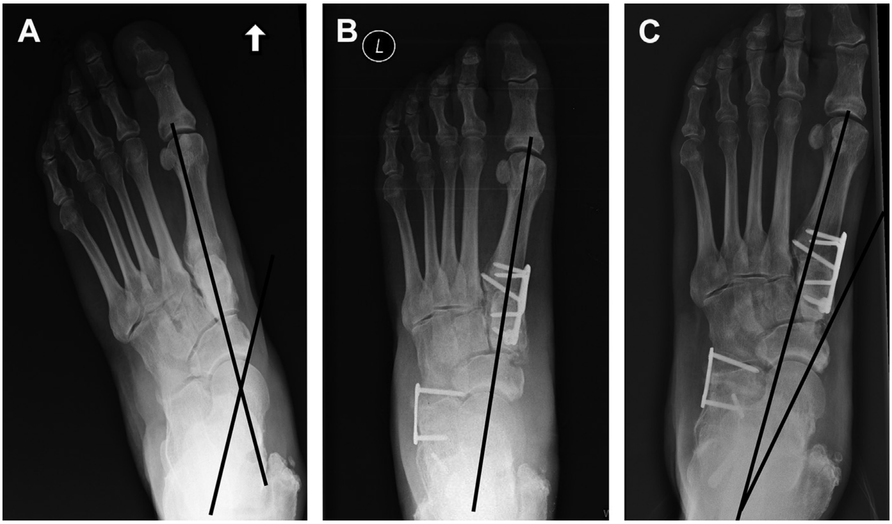

Fig. 3. Preoperative AP radiograph (*A*) with greater than 50% abduction of the TN joint. Excellent coronal plane correction (*B*) was thought to be achieved at 3 months following an MDCO, lateral collateral ligament (LCL), first TMT arthrodesis, spring ligament reconstruction, and FDL tendon transfer. However, at 1 year (*C*), despite bony union, loss of correction occurred, which was thought to be secondary to a failure to address the NC instability (Fig. 4).

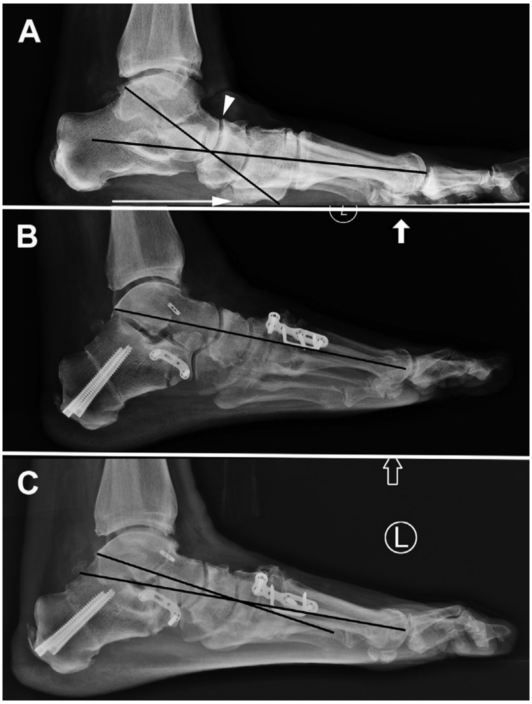

Fig. 4. Lateral preoperative radiograph (*A*) of the same patient in Fig. 3, with complete collapse of the medial column with contact of the cuneiform with the floor (*white arrow*). Note the lack of dorsal subluxation of the navicular relative to the talus (*white arrowhead*). This finding should alert the surgeon to the presence of medial column instability. Excellent sagittal plane correction (*B*) was achieved 3 months postoperatively. However, moderate loss of correction was noted at (*C*) 1 year secondary to persistent instability of the NC joint with associated loss of coronal plane correction (see Fig. 3).

case of the use of an NC fusion to treat AAFD. His technique used a bone block fusion of the NC joint and open Achilles lengthening, with the use of postoperative casting without internal fixation. Although limited in the data that were presented in the article, because only 4 cases (3 pediatric and 1 adult) were presented, radiographs (all 4 cases) and clinical photographs (3 pediatric) were presented showing correction of the sagittal deformity. However, this reliance on a single point of correction for a multiplanar deformity in adolescents did not withstand the test of time. Seymour[10] reviewed 32 feet in 17 patients who underwent an NC fusion for correction of a flexible flatfoot at 16 to 19 years postoperative. He evaluated the same population as was reviewed by Jack[11] (operative surgeon in all cases) at a follow-up of 15 months to 5 years postoperative. Although initial results by Jack[11] were noted to be good to excellent in 82% of patients, this deteriorated to 50% at the final follow-up by Seymour.[10] The 16 feet deemed unsatisfactory by Seymour[10] all had pain that limited activity with restriction of movement at the midtarsal and subtalar joints. The radiographs showed flattening of arch with a negative declination of the talus. Most noteworthy, all of these patients noted arthritic changes in the TN and subtalar joints. However, the review by Seymour[10] is the only article that reviews the long-term complications of an NC arthrodesis. Multiple causal factors may contribute to the hindfoot arthrosis: adjacent joint stress, failure to correct the hindfoot (calcaneal osteotomy), and/or failure relieve dynamic stress (gastrocnemius recession or Achilles lengthening). His data should serve as a warning for readers if the decision is made to proceed with aggressive medial column fusion as a routine part of a treatment algorithm.

In addition, there is evidence that the medial column stabilization not only corrects the sagittal plane deformity but also secondarily corrects the coronal plane deformity. Greisberg and colleagues[12] showed a mean improvement in the anteroposterior (AP) TN coverage of 14° (range 1°–30°) in 19 patients who underwent medial column fusion (first TMT, NC, combined first TMT and NC) with associated augmentation of the PTT and gastrocnemius recession in most patients. The follow-up period was a maximum of 6 months, making it difficult to determine the long-term durability of the correction and risk of adjacent joint disease in their patient population. Ajis and Geary[13] reviewed a series of 20 skeletally mature patients who underwent an NC fusion for pes planovalgus deformity. Of these patients, 8 had a Cobb split anterior tibial tendon transfer, 2 underwent a medial displacement calcaneal osteotomy, and 7 patients had gastrocnemius recessions. Importantly, no patient underwent a lateral column lengthening. Follow-up was noted to be short term

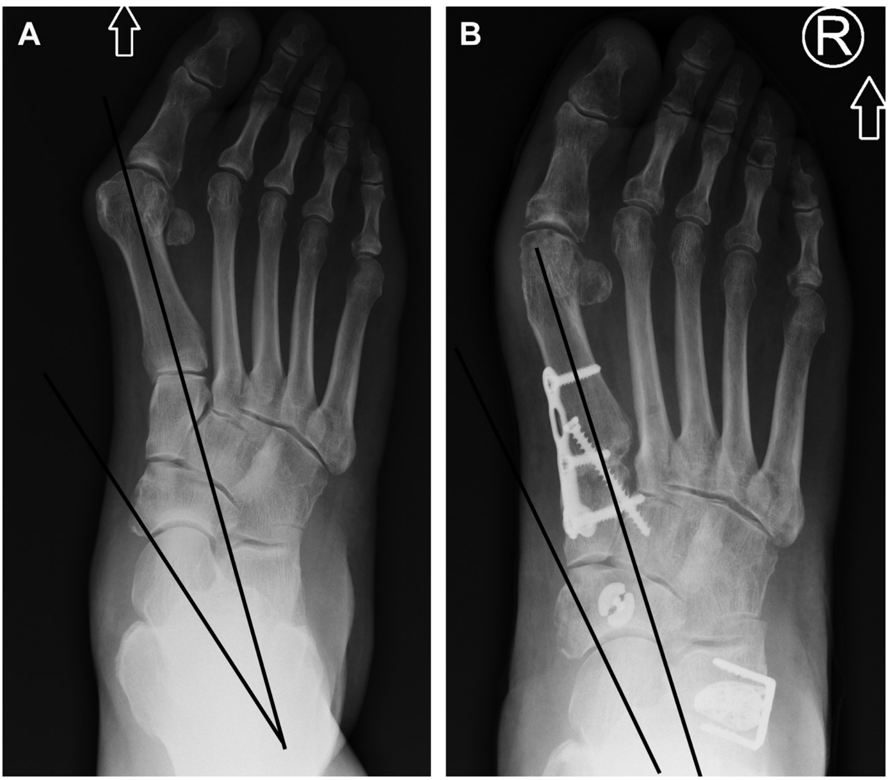

Fig. 5. Preoperative AP radiograph (*A*) with 50% abduction of the TN joint with associated hallux valgus deformity. Improvement in the coronal plane deformity was noted at 1 year postoperative (*B*) following an MDCO, LCL, gastrocnemius recession, spring ligament reconstruction, and Lapidus. Critically, insufficient correction of the hallux deformity is noted, with approximately 20% abduction of the TN joint. The patient is clinically satisfied despite failure to completely correct the abduction.

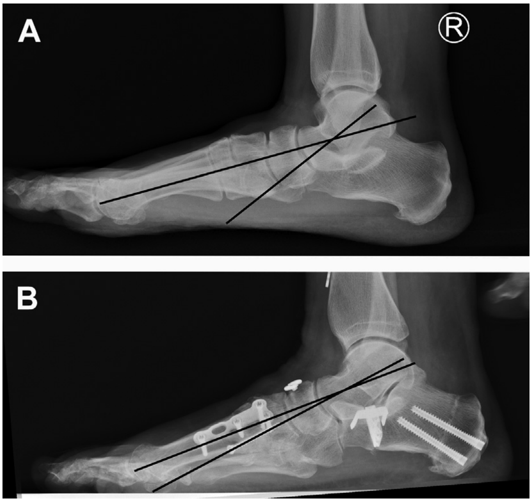

Fig. 6. Lateral preoperative radiograph (*A*) of the patient in Fig. 5 with clear evidence of TN subluxation noted by the incongruence at the TN joint. One-year postoperative correction (*B*) was excellent and maintained because all sites of instability were appropriately addressed.

and patients were followed until they noted clinical and radiographic union, with the longest duration of healing noted to be 60.3 weeks (mean, 21.7 weeks). Investigators noted an improvement of the lateral talo–first metatarsal angle from −12.3° to −5.2°, with concomitant improvement of the AP talo-first metatarsal angle from

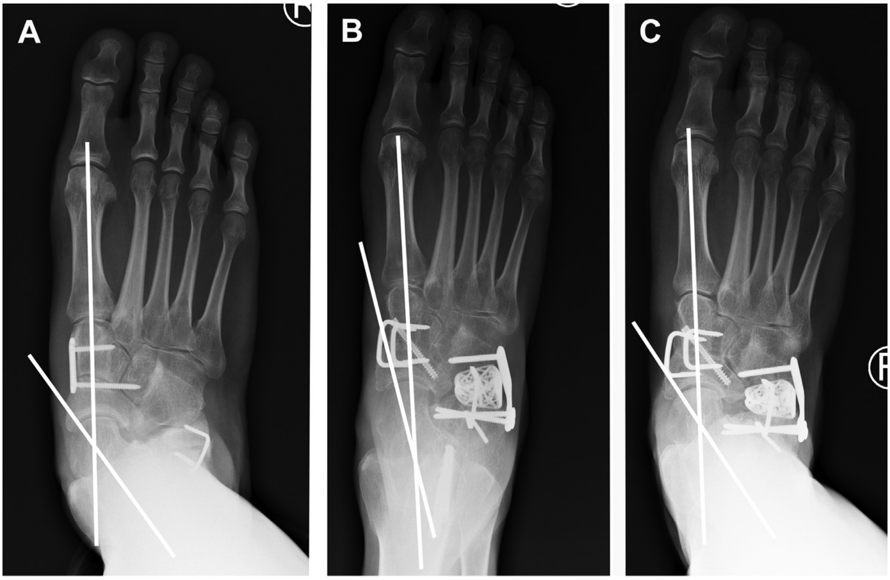

Fig. 7. AP radiograph (*A*) of a patient who presented with a failed NC fusion and LCL. At 3 months (*B*), excellent correction was thought to be achieved following a revision NC fusion, LCL (calcaneocuboid (CC) fusion was required because of prior joint violation), MDCO, FDL transfer, and gastrocnemius recession. However, at 1 year, near-complete recurrence of the deformity (*C*) was noted with collapse through the TN joint.

14.1° to 7.4°. The use of rigid internal fixation along with preparation of all 3 facets of the NC joint was associated with a 97% rate of arthrodesis. The significant limitation in this study is the lack of long-term follow-up and functional outcomes. However, the ability of an isolated medial column fusion to correct both sagittal and coronal plane parameters without the need for a lateral column lengthening has been clearly shown. More credence was given to the concept of medial column instability as a more relevant contributor to flatfoot deformity by Kang and colleagues,[14] whose team showed that the lateral column is not significantly shorter in patients with

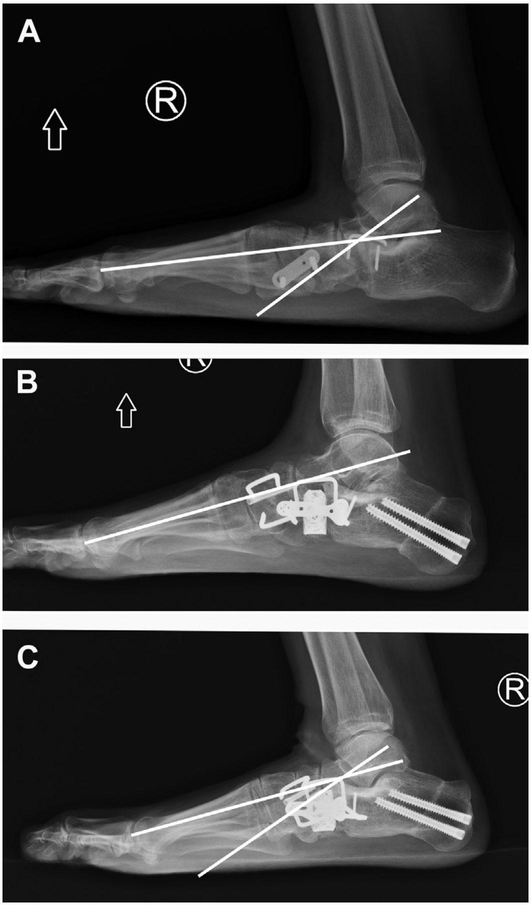

Fig. 8. Lateral preoperative radiograph (*A*) of the same patient in Fig. 7 with clear collapse of the NC joint with a negative talar declination angle. At 3 months postoperative (*B*), complete restoration of sagittal balance was thought to be achieved. Radiographic collapse (*C*) is noted at 1 year with failure through the TN joint because there was union of the both the NC and CC lengthening arthrodesis based on computed tomography (CT) scan. On reexamination of the patient, the right foot was similar in appearance to the left asymptomatic foot, with complete patient satisfaction because she was able to return to all prior activities without pain. This case exemplifies that the goal of surgery is to restore patients to their preinjury/predeformity states, as opposed to theoretic radiographic parameters. Others may argue that this case is a prime example of the saying, "Better lucky than good."

AAFD compared with normal patients. Although lengthening the lateral column can reliably correct the abduction deformity, Deland and colleagues[15] showed that correction of the abduction to adduction (defined as a lateral incongruence angle >5°, a talar uncoverage angle >8°, and a talo-first metatarsal angle >8°) produced worse functional outcomes than slight undercorrection. These findings have led the authors to pursue correction of the abduction through what is thought to be a more physiologic correction by addressing the medial column instability as opposed to routine lateral column lengthening in patients who have less than 50% abduction.

FAILURE TO ADDRESS MEDIAL COLUMN INSTABILITY

Routine use of a medial displacement calcaneal osteotomy and flexor digitorum longus (FDL) tendon transfer is likely insufficient to achieve radiographic correction of most patients with symptomatic flatfoot deformity. Identification of medial column instability on a weight-bearing lateral radiograph is not difficult and allows the surgeon to determine which additional procedures may be required to correct the radiographic deformity. The use of a lateral radiograph with the patient performing a reverse Coleman block test as described by Ajis and Geary[13] may improve the

Fig. 9. Preoperative AP and lateral (*A*) radiographs of a patient who presented for revision correction of his AAFD with clear arthritic changes and collapse of the triple joint complex and NC joint. Successful correction of the deformity was achieved at 1 year (*B*); however, this construct may lead to instability of the first TMT joint or the deltoid ligament secondary the rigidity of the construct.

ability to identify medial column instability. Close inspection of postoperative radiographs shows the subtle changes that occur when the medial column is not addressed. Progressive loss of correction is inevitable, compromising the radiographic parameters; however, again the clinical relevance of subtle loss of correction has yet to be determined (**Fig. 1**). The use of a Cotton osteotomy to plantarflex the medial column has a reliable union rate and has shown clinical and radiographic improvement in sagittal radiographic parameters.[16] In the presence of NC instability, despite what is thought to be excellent intraoperative correction

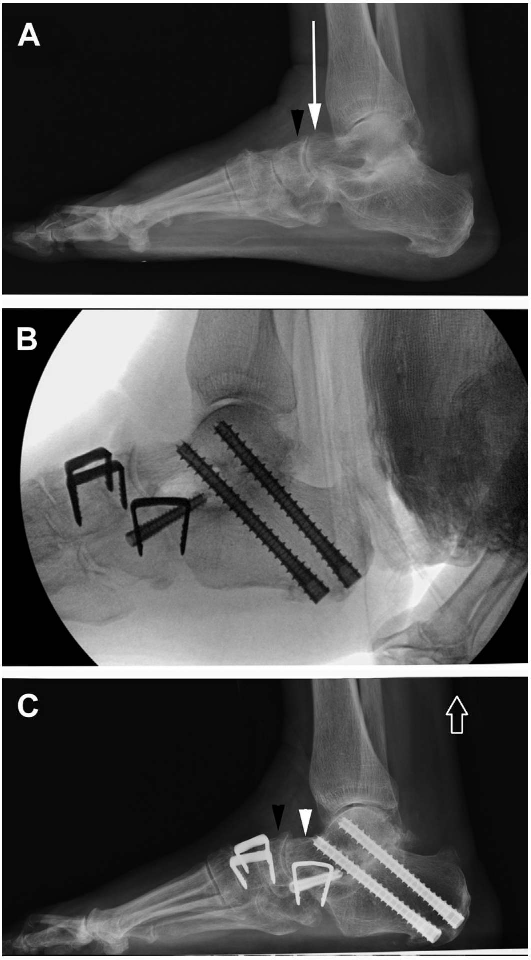

Fig. 10. Lateral radiograph (*A*) showing subtalar, CC, and NC arthritis with mild collapse of the medial column at the NC joint. Note the position of the talus (*white arrow*) relative to the navicular (*black arrowhead*) with no evidence of peritalar subluxation. Intraoperative fluoroscopy (*B*) of a combined subtalar, CC, and NC fusion was thought to achieve appropriate correction without resultant deformity or collapse of the TN joint. Note the change at 1 year in the position of the TN joint (*C*) with a clear alteration of the relationship of the navicular (*black arrowhead*) relative to the now more plantar talus (*white arrowhead*). The rigidity that was created within the NC joint was compensated by reciprocal instability of the TN joint in the postoperative period.

from the osteotomy, recurrence of deformity and disappointment in the clinical appearance occurs in the setting of untreated NC instability (Fig. 2). Although the Cotton osteotomy is simple and can be effective, it cannot substitute for stabilization of the NC or first TMT joint. In many cases, the use of a first TMT arthrodesis has been advocated as a way to improve medial column instability and plantarflex the medial column. However, using the first TMT as a proxy for NC instability does not achieve a long-term solution (Figs. 3 and 4). However, the presence of hallux valgus in conjunction with a pes planovalgus deformity should attune the surgeon

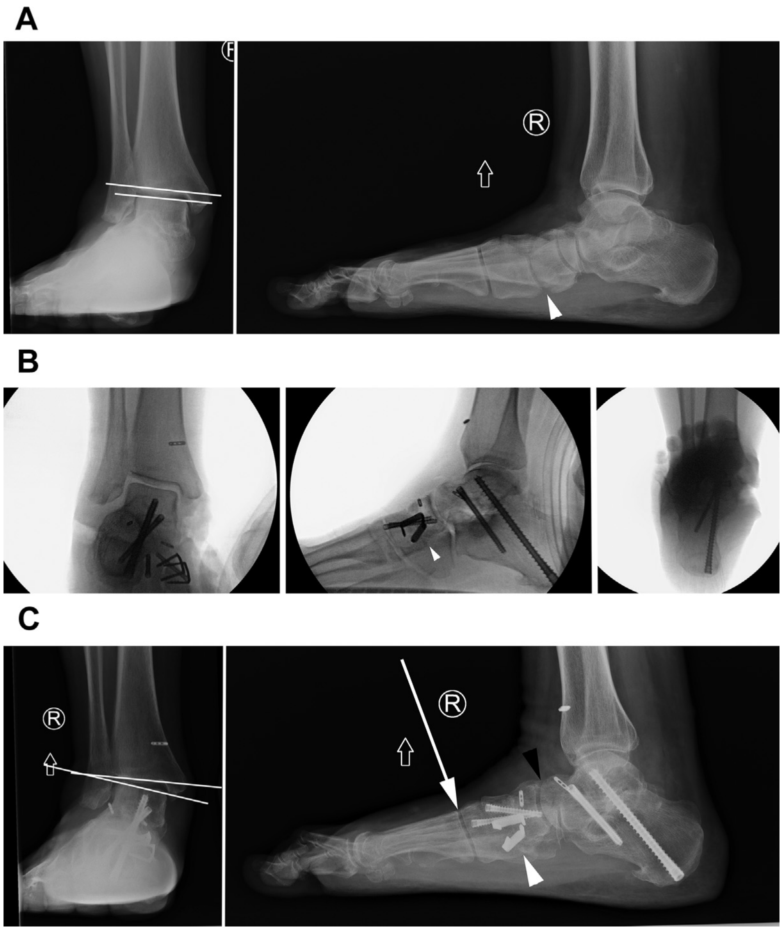

Fig. 11. Preoperative AP and lateral radiographs (*A*) showing a flatfoot deformity with clear collapse at the NC joint with a neutral tibiotalar joint. Intraoperative fluoroscopy (*B*) was performed secondary to the instability of the subtalar joint and obesity with associated NC fusion and allograft spring ligament reconstruction. Appropriate alignment was thought to be achieved with correction of the sagittal plane deformity and restoration of a neutral axis of the hindfoot. Medial column failure occurred in this case through the deltoid ligament with subsequent ankle valgus (*C*). The remaining medial column, including the first TMT joint (*white arrow*), NC arthrodesis (*white arrowhead*), and TN joint (*black arrowhead*) maintained their positions, which may explain why the collapse occurred through the deltoid ligament.

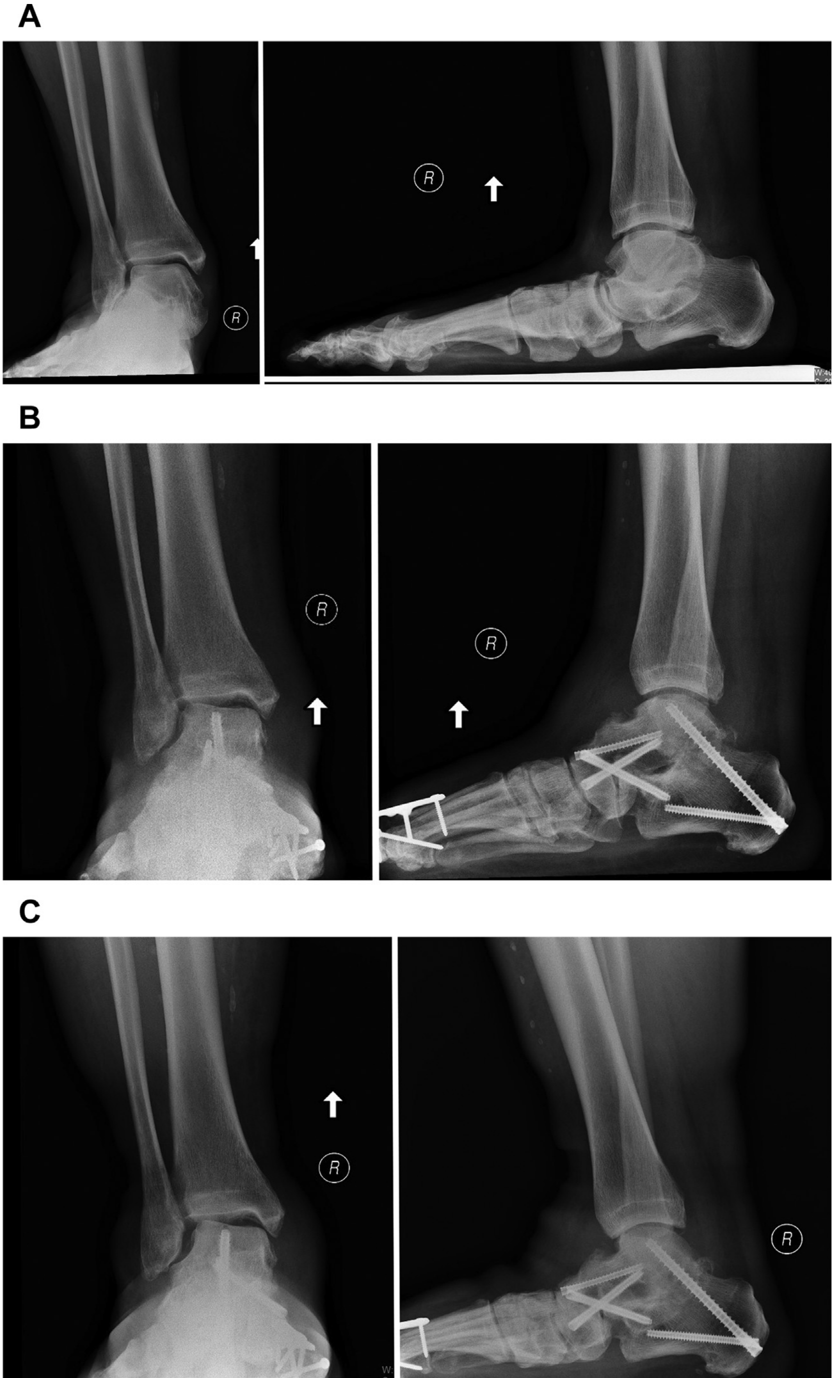

Fig. 12. Preoperative AP ankle and lateral foot radiographs (*A*) of a patient with hallux rigidus combined with a symptomatic severe pes planus deformity. Note the mild ankle valgus on the AP radiograph. Because of the severe hindfoot instability and early arthritic changes noted on CT scan, a triple arthrodesis, first metatarsophalangeal (MTP) arthrodesis, with an Achilles lengthening was performed. In addition, in an attempt to minimize the risk of ankle

to the presence of first TMT instability. In this setting, a first TMT arthrodesis is the appropriate procedure to correct both the coronal and sagittal plane deformity. When reviewing the radiographs, plantarflexion of the talar head relative to the navicular (true dorsolateral peritalar subluxation) denotes that the instability is occurring through the TN joint and not the NC joint. In these situations, addressing the hindfoot disorder primarily (spring ligament reconstruction and/or lateral column lengthening) is more appropriate than adding an NC fusion (**Figs. 5** and **6**). The primary concern for surgeons is how to maintain correction without creating excessive hindfoot rigidity through the use of overlengthening of the lateral column or subtalar arthrodesis. In many cases, despite addressing all observed components of the deformity, correction is not maintained but the patient is completely satisfied (**Figs. 7** and **8**). A primary difficulty for treating surgeons is the lack of understanding of the normal bony anatomic relationship for a particular patient. For example, in the case of a patient whose foot has been mildly flat with subsequent development of posterior tibial tendon dysfunction and worsening collapse, attempting to correct the foot to an idealistic neutral may result in an inappropriately stiff foot or force the stresses to collapse another aspect of the medial column. However, clinicians do not have a complete understanding of the primary pathologic process in flatfoot deformity, as is made clear by the controversies addressed in this publication and the difficulty in creating an accurate biomechanical model.

POSTRECONSTRUCTION MEDIAL COLUMN INSTABILITY

The increased stress imparted on adjacent joints following a triple arthrodesis with subsequent degenerative changes has been well documented.[8–11,17] Barg and colleagues[17] noted that extension of a triple arthrodesis to include the NC joint stiffens the posterior aspect of the medial arch, overloading the distal joints and resulting in medial column collapse. However, in some situations, this cannot be avoided if both joints are clinically symptomatic (**Fig. 9**). They therefore recommend that in cases of severe deformity, without evidence of TN arthritis, an isolated subtalar fusion combined with an NC fusion is preferred to maintain mobility and prevent excessive stress to the remaining joints. The authors have used this concept in our practice; however, we have noted that there is a tendency for the medial column to collapse at the TN joint in the postoperative period (**Fig. 10**). Although this collapse does not seem to compromise function in the small subset of patients who have undergone this procedure, absolute rigidity of the medial column may not be biomechanically appropriate because the foot shows instability through the adjacent joints in the postoperative period in some cases. More critically, and even more difficult to address, is instability through the deltoid ligament (**Fig. 11**A–C). This serious complication may only be avoidable by minimizing the creation of rigidity in the hindfoot and accepting a compromised radiographic correction of the flatfoot deformity.

Although not previously described, the authors have noted that, in patients who have a pes planovalgus deformity in addition to hallux rigidus, arthrodesis of the hallux in conjunction with a hindfoot fusion may result in a significant increase in stress

valgus, an MDCO was performed. Three-month postoperative correction (*B*) was noted to be satisfactory with improvement in the alignment of the first TMT and NC joints. However, the ankle valgus was noted to worsen. At 1 year postoperative (*C*), severe collapse of the NC and first TMT joint was noted with additional worsening of the ankle valgus. The added stiffness imparted from a first MTP arthrodesis was thought to contribute to failure of the residual medial column.

across the medial column, resulting in rapid loss of correction. This concept is akin to what was described by Barg and colleagues,[17] who noted that creating an extended hindfoot fusion results in rapid collapse of the first TMT joint and loss of correction. When the authors encounter this scenario, we now choose to use joint-sparing surgery for the hallux in all cases to minimize this risk (Fig. 12A–C).

SUMMARY

Medial column instability is a primary deforming force in the setting of pes planovalgus deformity. Consideration for medial column stabilization only after correction of the hindfoot deformity may result in creating a rigid hindfoot, compromising clinical outcomes given the secondary correction of abduction following a medial column fusion. Careful analysis of the lateral radiograph to determine whether the deformity is secondary to the medial column (first TMT and/or NC joints), which is best served by a medial column arthrodesis, or true peritalar subluxation that may be superiorly treated with hindfoot stabilization (lateral collateral ligament or spring ligament reconstruction) may allow superior radiographic and clinical outcomes. Iatrogenic creation of an excessively rigid medial column does not seem to be well tolerated and may lead to significant instability of the remaining joints in the short term and arthrosis in the long term. Despite clear evidence that a medial column arthrodesis is effective in correcting the radiographic parameters of a flatfoot deformity, this correction has not been evaluated for long-term clinical outcomes since 1967, when a deterioration of function and increase in pain over time was shown. Although there is limited literature regarding the appropriate role of medial column fusion for the surgical treatment of flatfoot, it can be concluded with some confidence that medial column arthrodesis should be used selectively to correct gross instability in order to maintain as much physiologic motion as possible.

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