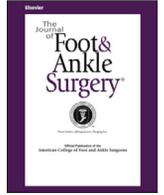


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ACFAS Clinical Consensus Statement

American College of Foot and Ankle Surgeons Clinical Consensus Statement: Appropriate Clinical Management of Adult-Acquired Flatfoot Deformity



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Adult-Acquired Flatfoot Deformity Clinical Consensus Statement Panel of the American College of Foot and Ankle Surgeons, Chicago, IL

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ABSTRACT

This clinical consensus statement of the American College of Foot and Ankle Surgeons focuses on the highly debated subject of the management of adult flatfoot (AAFD). In developing this statement, the AAFD consensus statement panel attempted to address the most relevant issues facing the foot and ankle surgeon today, using the best evidence-based literature available. The panel created and researched 16 statements and generated opinions on the appropriateness of the statements. The results of the research on this topic and the opinions of the panel are presented here.

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Executive Summary

The American College of Foot and Ankle Surgeons (ACFAS) has developed a clinical consensus statement (CCS) on the appropriate clinical management of adult-acquired flatfoot deformity (AAFD), also referred to as posterior tibial tendon dysfunction (PTTD) in this document and in other articles. The CCS was developed through the efforts of the AAFD consensus statement panel, a group of experts consisting of clinicians with recognized credentials and clinical experience in the management of adult flatfoot deformity. The steps used to develop the CCS are described in *The RAND-UCLA Appropriateness Method User's Manual* (1), with the panel using a modified version of this method. The panel met initially to formulate a comprehensive set of consensus statements relevant to the management of AAFD. The panel's first task was to compile a list of all available published and unpublished evidence pertaining to adult flatfoot. The members of the panel chose to use only published literature from the past 25 years. Based on their understanding of the existing evidence, the panel generated 16 statements and addressed these in depth to formulate summary consensus statements that described their agreements, disagreements, and points that

remained equivocal because of insufficient evidence. The 16 statements shown below were provided to the panel, along with all of the available published evidence (1–74), to consider the appropriateness of each statement.

The panel reached consensus that the following statements pertaining to adult flatfoot deformity were “appropriate”:

- Obesity (elevated body mass index [BMI]) may contribute to the development of flatfoot but is unlikely a sole cause of the deformity.
- Equinus deformity may be a factor in the development of flatfoot; however, equinus is unlikely a sole cause of flatfoot deformity.
- Spring ligament damage is an important component of the flatfoot deformity.
- Triplane correction should be considered when addressing the flexible AAFD.
- Medial incision approach does not increase risk of complication when performing hindfoot fusion.

The panel reached consensus that the following statements were “neither appropriate nor inappropriate”:

- Single heel raise is not pathognomonic for the diagnosis of symptomatic adult-acquired flatfoot resulting from posterior tibial tendon insufficiency.
- Intrinsic valgus deformity of the talus may be a predisposing factor in the development of symptomatic adult-acquired flatfoot.

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Conflict of Interest: None reported.

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- Symptomatic adult-acquired flatfoot may be adequately managed with an ankle-foot orthosis.
- Patient satisfaction can be found with foot orthoses in symptomatic adult-acquired flatfoot.
- Eccentric strengthening exercises of the posterior tibial tendon can reduce symptoms in early management of symptomatic adult-acquired flatfoot with the use of an orthotic.
- Congenital factors play an important role in the development of a flatfoot deformity.
- Radiographs provide adequate information for the evaluation of a flatfoot deformity.
- Subtalar arthroereisis should not be considered as a single corrective procedure for stage IIB AAFD.
- Stage IIB AAFD often requires a lateral column lengthening procedure to address forefoot abduction.
- Medial displacement calcaneal osteotomy should be considered in cases of flexible adult-acquired flatfoot correction.
- Rigid flatfoot deformity may be effectively treated by talonavicular and subtalar joint fusion in combination or in isolation.

There were no statements about which the panel did not reach consensus.

Introduction

This clinical consensus statement (CCS) is one in a series of such statements developed by the American College of Foot and Ankle Surgeons (ACFAS). It is important to understand that consensus statements do not represent clinical practice guidelines, formal evidence reviews, recommendations, or evidence-based guidelines. Rather, a CCS reflects information synthesized by an organized panel of experts based on the best available evidence. As such, the CCS contains opinions, uncertainties, and minority viewpoints. The CCS should be used to promote discussion of a topic and is not meant to provide definitive answers.

This CCS focuses on the broad topic of adult-acquired flatfoot deformity (AAFD), a condition about which there are many questions regarding management. The panel has attempted to address the most relevant issues regarding AAFD that face foot and ankle surgeons today using the best evidence-based literature available.

Methods

Creation of the Consensus Statement Panel

The ACFAS Board of Directors determined that the creation of a series of CCSs would be beneficial to all ACFAS members. The CCS initiative evolved as a result of the Board's desire to replace the College's previous clinical practice guidelines (CPGs) with CCSs addressing the appropriateness of management options for various foot and ankle conditions. As a first step in launching this consensus statement, invitations were sent to expert foot and ankle surgeon members of the College to form a 15-member consensus statement panel. According to the criteria for receiving this invitation, the individual clinician was required to be a Fellow of ACFAS and exhibit clinical expertise in the treatment of flatfoot as determined by the ACFAS Board. The panel assumed the role of developing a CCS on adult-acquired flatfoot as well as a future CCS on pediatric flatfoot. The leadership of the panel consisted of 1 chair and 2 co-chairs who were charged with overseeing 2 subgroups of the panel: a pediatric flatfoot subgroup and an adult flatfoot subgroup. Each subgroup consisted of 6 panelists plus the co-chair. ACFAS staff assisted the panel in administrative nonclinical tasks.

Over the course of 11 months (March 2017 to February 2018), the chair, co-chairs, and members of the 2 subgroups engaged in conference calls, e-mail communications, and a final face-to-face meeting to synthesize a set of statements for this CCS based on the current literature in the general topics of adult and pediatric flatfoot. Their aim was to select statements that were likely to benefit foot and ankle surgeons and ACFAS members.

Development of the Questions

The first stage in developing questions involved a conference call to discuss relevant basic topics that would be covered in the consensus statements. The panel members of the

Table 1

Oxford centre for evidence-based medicine grades of recommendations

Grade	Explanation
A	Consistent level 1 studies
B	Consistent level 2 or 3 studies or extrapolations from level 1 studies
C	Level 4 studies or extrapolations from level 2 or 3 studies
D	Level 5 evidence or troubling inconsistent or inconclusive studies of any level

adult flatfoot subgroup, led by the chair and respective co-chair, agreed on the following general topics regarding AAFD: pathophysiology/imaging/physical examination, conservative/nonsurgical treatments, surgical treatment for flexible deformity, and surgical treatment for rigid deformity. They were then assigned topics by the co-chair and asked to perform preliminary data reviews based on agreed-on inclusion criteria. From the general topics, statements were generated based on the evidence that met the inclusion criteria (see "Literature Review"). The panel decided to not limit the number of statements created, allowing for inclusion of all relevant statements to be discussed. At the in-person meeting, the number of statements was reduced to the final set once the evidence was graded according to the criteria of the Oxford Centre for Evidence-Based Medicine (Table 1) (2), and the information was discussed by the panel. Several controversial statements that were discussed during the meeting were omitted because of a lack of convincing evidence.

Literature Review

Panel members performed comprehensive reviews of the published data identified through searches on Medline, EMBASE, Google Scholar, and the Cochrane Database of Systematic Reviews. The following search terms were used: AAFD, flatfoot, pes valgus, pes planovalgus, and posterior tibial tendon dysfunction. To be included for consideration, published articles had to be published within the past 25 years (on or after January 1993), published in the English language, and if a case series, describe a minimum of 20 patients. The recommendations were graded in accordance with the quality of the evidence on which the panel based their decisions, as described by the Oxford Centre for Evidence-Based Medicine grading system (Table 1) (2).

Consensus

The RAND/UCLA Appropriateness Method (RAM) was developed in the mid-1980s, as part of the RAND Corporation/University of California Los Angeles (UCLA) Health Services Utilization Study, primarily as an instrument to enable the measurement of the overuse and underuse of medical and surgical procedures (1). A modified RAM was used by the panel to attain consensus regarding the relevance of the clinical statements that evolved from the clinical questions. This modified RAM provides a method for attaining group consensus using current scientific evidence in conjunction with expert opinion. The RAM process involves 2 interdependent groups: a core panel and an expert panel. In developing this CCS, the adult flatfoot subgroup served as the "core" panel and the pediatric flatfoot subgroup served as the "expert" panel. For the sake of clarity and to prevent confusion, the core panel as referenced in RAM is referred to as the *primary team*, and the expert panel is referred to as the *secondary team* in the remainder of this CCS document.

The primary team guided the secondary team and provided them with synthesized data, which the secondary team used to arrive at a consensus. Before the consensus procedure, the primary team conducted a systematic literature review with evidence synthesized to provide the secondary team with all pertinent information used to guide evidence-based decision-making. The secondary team received the clinical statements electronically through a questionnaire and were asked to rate the appropriateness on a 1 to 9 Likert scale of intervention. In RAM, ratings of 1 to 3 are considered inappropriate (risks outweigh benefits), ratings of 7 to 9 are considered appropriate (benefits outweigh risks), and ratings of 4 to 6 are considered uncertain. Members of the secondary team were asked to rate each statement independently of the other panelists. They were allowed to use the synthesized evidence provided by the primary team overseeing the consensus process. The statements were also rated by the panel chair and the co-chair of the primary team.

Each statement was rated anonymously, and the results were returned to the chair for review. The ratings were reviewed and grouped from 1 to 3 (inappropriate), 4 to 6 (neither inappropriate nor appropriate), and 7 to 9 (appropriate). Using basic descriptive statistics, the results were then summarized.

Results and Discussion

The panel reached consensus for all 16 CCSs. Following are the statements along with the grade of evidence based on the criteria (Table 1) (2); the consensus reached by the panel; and a brief rationale for the recommendation and a synopsis of the pertinent literature. Figs. 1–3 indicate the range of ratings received for each statement.

Pathophysiology / Imaging / Physical Examination

1. Single heel raise is not pathognomonic for the diagnosis of symptomatic adult-acquired flatfoot resulting from posterior tibial tendon insufficiency.

1	2	3	4	5	6	7	8	9	
<i>Extremely inappropriate</i>									<i>Extremely appropriate</i>
2. Intrinsic valgus deformity of the talus may be a predisposing factor in the development of symptomatic adult-acquired flatfoot.

1	2	3	4	5	6	7	8	9	
<i>Extremely inappropriate</i>									<i>Extremely appropriate</i>
3. Obesity (elevated BMI) may contribute to the development of a flatfoot but is unlikely a sole cause of flatfoot deformity.

1	2	3	4	5	6	7	8	9
<i>Extremely inappropriate</i>							<i>Extremely appropriate</i>	
4. Equinus deformity may be a factor in the development of a flatfoot; however, equinus cannot be described as a sole cause of flatfoot deformity.

1	2	3	4	5	6	7	8	9
<i>Extremely inappropriate</i>							<i>Extremely appropriate</i>	
5. Congenital factors play an important role in the development of a flatfoot deformity.

1	2	3	4	5	6	7	8	9
<i>Extremely inappropriate</i>					<i>Extremely appropriate</i>			
6. Radiographs provide adequate information for the evaluation of a flatfoot deformity.

1	2	3	4	5	6	7	8	9
<i>Extremely inappropriate</i>					<i>Extremely appropriate</i>			
7. Spring ligament damage is an important component of the flatfoot deformity.

1	2	3	4	5	6	7	8	9
<i>Extremely inappropriate</i>						<i>Extremely appropriate</i>		

Fig. 1. Questionnaire statements relating to pathophysiology, imaging, and physical examination, with the range of ratings from the consensus panel in bold and highlighted in gray.

Pathophysiology/Imaging/Physical Examination

Statement: Single heel raise is not pathognomonic for the diagnosis of symptomatic adult-acquired flatfoot resulting from posterior tibial tendon insufficiency.

Grade: C

Consensus of the panel: This statement is neither appropriate nor inappropriate.

Rationale: Clinical examination of the AAFD is frequently statically identified as presenting with calcaneal valgus, forefoot abduction, and reduction of the instep vault. Dynamically, there is suggestion of failure based on inability to perform a single heel rise maneuver on the affected side. However, the question arises: Does this dynamic examination provide definitive information regarding the existence of posterior tibial tendon (PTT) insufficiency as a contributing factor to the etiology of the flatfoot deformity? A study by Yeap et al (3) investigated the presence of posterior tibial tendon dysfunction (PTTD) in patients who underwent PTT transfer for acquired drop foot. With a mean follow-up of 64.4 months, the investigators evaluated 17 patients who underwent transfer. They reported that 82% of these patients demonstrated ability to perform a single heel rise even in the absence of the native tendon insertion. Furthermore, of these patients, only 17% exhibited hindfoot valgus and 6% exhibited forefoot abduction. Hintermann and Gachter (4) examined a spectrum of clinical findings used to diagnose PTTD by observing 21 consecutive feet with the disorder. They

found that the clinical signs of “too many toes” and the single heel rise and double heel rise test results were negative in 20% to 35% of the cases. The investigators reported that bringing the heel into varus on the affected side brought the first metatarsal head off the ground in their entire sample size and remained on the ground in their control group. This prompted the development of a new sign referred to as first metatarsal rise.

In a more recent examination of AAFD and age-related differences in the performance of the single heel rise test, a 3-dimensional motion analysis system was used to evaluate 20 participants with stage 2 AAFD and 15 participants without disease (5). The average ages were 58 years for the flatfoot group and 22 years for the control group. Patients with AAFD as well as older controls demonstrated similar loss of achieving appropriate heel height compared with younger controls. However, the study revealed that this failure principally occurred through forefoot and rearfoot kinematics in the sagittal plane and not in the frontal plane that is mainly influenced by the PTT.

Statement: Intrinsic valgus deformity of the talus may be a predisposing factor in the development of symptomatic adult-acquired flatfoot.

Grade: C

Consensus of the panel: This statement is neither appropriate nor inappropriate.

Rationale: To help elucidate the potential factors contributing to the development of AAFD, researchers have become increasingly interested in the intrinsic structural deformities of bone that may predispose a

Conservative / Nonsurgical Treatment

- 8. Symptomatic adult-acquired flatfoot may be adequately managed with ankle-foot orthosis.
 1 **2** 3 4 **5** 6 **7** **8** **9**
Extremely inappropriate *Extremely appropriate*

- 9. Patient satisfaction can be found with foot orthoses in the symptomatic adult-acquired flatfoot.
 1 2 3 4 **5** 6 **7** **8** **9**
Extremely inappropriate *Extremely appropriate*

- 10. Eccentric strengthening exercises of the posterior tibial tendon can reduce patient symptoms in the early management of symptomatic adult-acquired flatfoot with the use of an orthotic.
 1 2 3 **4** **5** **6** **7** 8 **9**
Extremely inappropriate *Extremely appropriate*

Fig. 2. Questionnaire statements relating to conservative/nonsurgical treatment, with the range of ratings from the consensus panel in bold and highlighted in gray.

Surgical Treatment

- 1. Subtalar arthroereisis should not be considered as a single corrective procedure for stage IIB adult-acquired flatfoot deformity.
 1 **2** 3 4 5 **6** **7** **8** **9**
Extremely inappropriate *Extremely appropriate*

- 2. Triplane correction should be considered when addressing the flexible adult-acquired flatfoot deformity.
 1 2 3 4 5 **6** 7 **8** **9**

- 3. Stage IIB adult-acquired flatfoot deformity often requires a lateral column lengthening procedure to address forefoot abduction.
 1 **2** 3 **4** **5** **6** 7 **8** **9**
Extremely inappropriate *Extremely appropriate*

- 4. Medial displacement calcaneal osteotomy (MDCO) should be considered in cases of flexible adult-acquired flatfoot correction.
 1 **2** 3 4 5 6 **7** **8** **9**
Extremely inappropriate *Extremely appropriate*

- 5. Rigid flatfoot deformity may be effectively treated by talonavicular and subtalar joint fusion in combination or in isolation.
 1 2 3 4 **5** 6 **7** **8** **9**
Extremely inappropriate *Extremely appropriate*

- 6. Medial incision approach does not increase risk of complication when performing hindfoot fusion.
 1 2 3 4 **5** 6 **7** **8** **9**
Extremely inappropriate *Extremely appropriate*

Fig. 3. Questionnaire statements relating to surgical treatment, with the range of ratings from the consensus panel in bold and highlighted in gray.

valgus orientation of the foot. Through the use of weightbearing computed tomography (CT), investigators have been able to identify increased valgus inclination of the caudal aspect of the talus, which may modify subtalar axis and produce greater valgus orientation of the

foot. Using weightbearing CT, Probasco et al (6) examined 18 normal patients and 36 patients with stage II AAFD who were scheduled to undergo surgical reconstruction. The investigators reviewed 3 angles of the subtalar joint in the coronal view: the angle between the inferior

facet of the talus and the horizontal floor, the angle between inferior and superior facets of the talus, and the angle between the inferior facet of the talus and the superior facet of the calcaneus. They evaluated both intra- and interobserver reliability when reviewing the CT images. The results confirmed that the subtalar joint had an increased valgus orientation in AAFD compared with the controls, suggesting that this may be a risk factor for developing the disorder (6). In a follow-up study, the investigators compared their outcomes using weightbearing CT and attempted to correlate these with standard radiographic measurements (7). They looked at the anterior posterior coverage angle, anterior posterior talar first metatarsal angle, calcaneal pitch, Meary's angle, medial column height, and hindfoot alignment. They appreciated that Meary's angle singularly explained 48% of the variation in the angle between the inferior and superior facets of the talus, and concluded that patients with stage II AAFD had more innate valgus in their talar anatomy as well as more valgus alignment of the subtalar joints compared with controls. In a study that examined subtalar joint configuration using weightbearing CT, Colin et al (8) found that among 59 patients without hindfoot and ankle pathology, the posterior facet of the subtalar joint was concave in 88% and flat in 12%. Moreover, the posterior facet was oriented in valgus in 90% and varus in 10% of patients when measured in the middle coronal plane. These findings define a predisposing factor for medial and plantar subluxation of the talus on the calcaneus.

Statement: *Obesity (elevated BMI) may contribute to the development of flatfoot but cannot be described as a sole cause of the deformity.*

Grade B

Consensus of the panel: This statement is appropriate.

Rationale: Adult-acquired flatfoot may be the result of chronic progressive tendon degeneration. Physiologic degeneration of the PTT can be affected by obesity, steroid exposure, and a variety of systemic diseases, such as collagen vascular disease, gout, and diabetes mellitus (9). The presence of an os naviculare can accelerate the degeneration process or be a focal point of structural failure (10). AAFD is more commonly seen in females during the fourth to sixth decades, and occasionally as the result of an acute trauma in young athletes who participate in high-repetition sports activities (11). For this reason, the panel believes that BMI may be a confounder for the occurrence of flatfoot, rather than a direct causative factor. The confounding aspects of BMI may lie in its significant association with outcomes in AAFD as well as with other variables, thereby masking the causal effects of the other variables.

Statement: *Equinus deformity may be a factor in the development of flatfoot; however, equinus cannot be described as a sole cause of flatfoot deformity.*

Grade: B

Panel consensus: This statement is appropriate.

Rationale: In the setting of AAFD, the combined propulsive forces of the gastrocnemius and soleus muscles act at the metatarsal heads instead of the hindfoot and midfoot, exposing the latter to excessive stress and leading to a loss of stability at the midtarsal joint secondary to attenuation and tearing of the spring ligament. Subsequently, collapse of the medial longitudinal arch occurs, resulting in an uncovering of the talus by a laterally shifting navicular and plantar-medial migration of the talus head along with heel valgus, eversion of the subtalar joint, and abduction of the foot at the talonavicular joint (12,13).

Statement: *Congenital factors play an important role in the development of flatfoot deformity.*

Grade: B

Consensus of panel: This statement is neither appropriate nor inappropriate.

Rationale: PTT dysfunction may be the result of acute trauma or chronic progressive tendon degeneration (14). Physiologic PTT degeneration can be caused by obesity, steroid exposure, and a variety of systemic diseases, such as collagen vascular disease, gout, and diabetes

mellitus. Some patients develop tendonopathy without the aforementioned risk factors or systemic conditions. It is possible that both extrinsic and intrinsic factors including genetics may play a role (17). Godoy-Santos and colleagues in 2 publications (18,19) have shown that genetic variations may lead to changes in the PTT and contribute to the development of a flatfoot. A higher proportion of collagen types III and V may play a role in the decreased resistance and elasticity of the tendon, leading to posterior tendinopathy and flatfoot deformity (20,21). Matrix metalloproteinases (MMPs) are responsible for the degradation and removal of collagen. MMP-1 has been shown to specifically degrade types I and II collagen, which typically are resistant to degradation (22). Inflammatory cytokines, growth factors, and phorbol esters, along with local conditions such as inflammatory processes and mechanical load, are typically responsible for induction of MMP-1 (21). Baroneza et al (22) have shown that MMP-1 haplotypes are directly associated with PT tendinopathy.

Statement: *Radiographs provide adequate information for the evaluation of flatfoot deformity.*

Grade: B

Consensus of panel: This statement is neither appropriate nor inappropriate.

Rationale: Currently, radiography remains the initial imaging study for the evaluation of flatfeet. Several radiographic measurements can help to assess the degree of flatfoot deformity (23,24). Later stages of flatfoot deformity lead to elongation of the PTT, spring ligament, and medial arch structure, leading to an increase in the plantigrade tilt of the head of the talus. This tilt of the head of the talus is best measured on a radiograph using Meary's angle. Abnormal calcaneal inclination or calcaneal pitch and Meary's angle have been shown to strongly correlate with PTT pathology as seen on magnetic resonance imaging (MRI). Lin et al (25) have shown that if both of these angles were within normal limits, there were no diagnostic tears of the PTT. They did conclude that calcaneal pitch angle provided the best assessment of injury to the medial longitudinal arch (25).

Statement: *Spring ligament damage is an important component of the flatfoot deformity.*

Grade: B

Consensus of panel: This statement is appropriate.

Rationale: Patients with PTT tears have a higher incidence of injury to the spring ligament (39% to 92%) (26–29). Adult-acquired flatfoot is frequently defined as PTT insufficiency; however, there are multiple ligaments that are involved in maintaining the structural integrity of the foot's medial column and hindfoot complex. A deeper understanding of the anatomy has led to a greater focus on the spring ligament as a component of the deltoid complex and a contributing factor to this disease process (26,28,29).

Multiple clinical, intraoperative, and radiographic studies demonstrate that spring ligament pathology is associated with AAFD. In an observational study using MRI, Deland et al (30) reviewed a series of 31 consecutive patients diagnosed with PTT insufficiency. They identified increased pathology in the superomedial calcaneal navicular ligament, inferomedial calcaneal navicular ligament, interosseous ligament, anterior component of the superficial deltoid, plantar metatarsal ligaments, and plantar naviculocuneiform ligament, with the most severe involvement in the spring ligament complex (superomedial and inferomedial calcaneal navicular ligaments) (30). Mansour et al (31) assessed the spring ligament complex with sonography and found that spring ligament laxity or tear was characterized by thickening. The study also showed that there was a strong association between posterior tibial tendinopathy and abnormality of the spring ligament (31). In a study assessing whether failure of the spring ligament complex serves as a driving force in the development of the adult flatfoot, Williams et al (32) reviewed 161 images (MRI and plain radiographs) of patients with AAFD. Lateral weightbearing radiographs were analyzed for Meary's angle $\geq 5^\circ$,

calcaneal pitch $\leq 20^\circ$, and talocalcaneal angle $\geq 45^\circ$. Radiographic deformities were then analyzed against MRI and evaluated for evidence of either spring ligament or tibialis posterior tendon pathology. The investigators identified a strong correlation of spring ligament abnormality with planovalgus foot type, reaching high levels of statistical significance in all 3 categories of radiographic deformity. Abnormalities of the tibialis posterior tendon failed to demonstrate any significance unless grade 1 changes were excluded. In a cadaver study performed by Jennings and Christensen (33), a 3-dimensional kinematic system with custom-loaded frame was used to quantify rotation of structures about the talus in 5 cadaveric specimens. The investigators performed mechanical studies before and after sectioning of the spring ligament complex. During simulated mid-stance, they observed that the navicular plantar flexed, abducted, and everted, whereas the talar head plantarflexed, abducted, and inverted with associated calcaneal plantar flexion and abduction as well as eversion after the sectioning of the spring ligament complex. The results of the study suggested that the spring ligament complex was a major stabilizer in the arch during mid-stance and that the PTT was incapable of fully addressing failure of this structure (33).

Conservative/Nonsurgical Treatment

Statement: Symptomatic adult-acquired flatfoot may be adequately managed with an ankle-foot orthosis.

Grade: B

Consensus of panel: This statement is neither appropriate nor inappropriate.

Rationale: AAFD is commonly treated with in-shoe orthoses that do not extend above the ankle. However, more recent reports demonstrate improved outcomes with the use of an ankle-foot orthosis to treat stage II and III AAFD. A study by Augustin et al (34) showed that 90% of patients who used a custom Arizona ankle-foot orthosis had decreased pain and improved function over a 2-year follow-up period. In a retrospective study, Lin et al (35) reported that nearly 70% of patients with an average follow-up of 8.6 years who used a custom double upright brace ankle-foot orthosis for an average of 14.9 months were able to wean from the brace, be brace-free, and avoid surgery. Similarly, Nielsen et al (36) found the incidence of successful nonoperative management with the use of a custom low-articulated ankle-foot orthoses over a 27-month observation period to be 73%, with patients not needing surgical intervention. Chao et al (37) found that 67% of patients who used ankle-foot orthoses or University of California Biomechanics Laboratory (UCBL) shoe inserts to treat AAFD had good to excellent results according to a functional scoring system. Overall, the data support the use of these more restrictive orthoses that extend proximal to the ankle joint to support and restrict the excursion of the PTT.

Statement: Patient satisfaction can be found with foot orthoses in symptomatic adult-acquired flatfoot.

Grade: B

Consensus of panel: This statement is neither appropriate nor inappropriate.

Rationale: The goals of using foot orthotics in AAFD is to allow reduction of the subluxated subtalar and midtarsal joints and to preserve motion at the ankle joint. Low-profile foot orthoses can stabilize the calcaneus and medial arch, providing improved pain relief in patients with AAFD. Initial outcome studies reported good to excellent patient satisfaction with the use of UCBL foot orthoses (37). In another study, the use of a shell brace revealed good and excellent results in 83% of patients (38). Ben et al (39) reported an ~50% decrease in pain and disability levels in patients who used orthotics for AAFD over a 6-week period.

Statement: Eccentric strengthening exercises of the PTT can reduce patient symptoms in the early management of symptomatic adult-acquired flatfoot with the use of an orthotic.

Grade: A

Consensus of panel: This statement is neither appropriate nor inappropriate.

Rationale: In a level 1 study, Kulig et al (40) demonstrated the effectiveness of an eccentric exercise program in patients with stage I and II PTTD. Their results showed that foot function index scores improved and pain decreased in patients who wore an orthotic and underwent stretching with eccentric progressive resistant exercises. However, in another level 1 study, Houck et al (41) found that a home-based exercise program was minimally effective in augmenting treatment with orthoses wear alone in patients with stage II PTTD. They measured self-reported patient outcomes using the Foot Function Index and Short Musculoskeletal Function Assessment in 2 groups: prefabricated orthoses with stretching exercises or prefabricated orthoses with stretching and strengthening exercises. Over a 12-week period, pain and function improved in both groups, but self-reported measures and posterior compartment strength showed minimal differences. A prospective, observational study demonstrated 89% satisfaction and 83% improvement in functional and subjective outcomes in patients who underwent a structured exercise program involving specific strengthening of the PTT, peroneal, anterior tibial, and gastrosoleus tendons along with the use of an orthosis (42). Kulig et al (43) also demonstrated improvements in foot function index, pain, and disability using a 10-week PTT-specific eccentric program with the use of custom orthotics in patients with posterior tibial tendinosis.

Surgical Treatment

Statement: Subtalar arthroereisis should not be considered as a single corrective procedure for stage IIB AAFD.

Grade: B

Consensus of panel: This statement is neither appropriate nor inappropriate.

Rationale: Use of a subtalar implant alone to address pronation of the foot has limited literature demonstrating its use in the flexible deformity without advanced disease of surrounding soft tissues including tendon and ligament. The subtalar implant is designed to be performed with tensioning of the soft tissue structures to allow for their protected healing. The most identified complication is sinus tarsi pain due to presence of the implant; explantation resolves this discomfort. When the severity of deformity has increased with greater heel valgus incapable of resupinating beyond midline, moderate forefoot abduction and increased medial instep collapse adjunct procedures of calcaneal osteotomy must be considered (44).

Arthroereisis developed from the management of the pediatric flexible flatfoot deformity. A study by Koning et al (45) reported that arthroereisis is best performed at age 8 years to allow for the adaptive changes of the immature foot. However, Fernández de Retana et al (46) asserted that it can be done by the age of 12 years with the assumption that foot maturity occurs at age 14 or 15. With this consideration, the adult foot has few adaptive capabilities to withstand sustainability if explantation of the device is required. There is notable intolerance to a subtalar implant, with a relatively high incidence of removal in patients age <60 years with flexible IIA deformity. Saxena et al (47) prospectively studied 100 cases and found an overall 22.1% need for explantation. Cook et al (48) observed increased incidence of implant removal in those cases with incomplete reduction of the talometatarsal angle on anterior posterior imaging or residual transverse planar dominant deformity as appreciated by increased calcaneocuboid abduction angles postoperatively. In a 2018 study by Walley et al (49), the authors demonstrated good/excellent results in short- to mid-term outcomes of arthroereisis in the adult population. It should be noted that the use of this device in the adult is for patients age <60 with flexible type IIA deformity and high explantation rate to protect any soft tissue reconstruction or tensioning done medially.

Statement: *Triplane correction should be considered when addressing the flexible AAFD.*

Grade: B

Consensus of panel: This statement is appropriate.

Rationale: AAFD is appreciated as a multiplanar postural collapse of the foot arch. Frontal plane valgus is noted through the subtalar joint with calcaneal valgus. There is unlocking of the midtarsal complex due to subtalar pronation, and forefoot supination develops at the longitudinal axis of the midtarsal joint. With advancing unlocking of the midfoot, motion across the transverse axis produces increasing abduction of the foot. Correction of deformity at all levels is required to achieve a stable plantigrade foot.

There are many studies demonstrating the need to correct the calcaneal valgus deformity by the medializing osteotomy of the heel. Arangio and Salathe (50) demonstrated through biomechanical models that performing a 10-mm medial displacement of the calcaneus can restore normal loading across the talonavicular joint to levels of a rectus foot posture. Interestingly, they found that the addition of the flexor digitorum longus transfer did little to impact these loading parameters. Chan et al (51) demonstrated that correction of hindfoot valgus alignment was primarily determined by the medial calcaneal osteotomy and not by associated procedures to include lateral column lengthening, midfoot osteotomy, or fusion and soft tissue reconstruction. Conti et al (52) attempted to establish the optimal position of the heel after reconstruction of stage II AAFD. Evaluating 55 feet in 55 patients, they reported that improved (Foot and Ankle Outcome Score) pain scores were better in those corrected to mild hindfoot varus.

Lateral column lengthening is commonly executed as an opening wedge calcaneal osteotomy or distraction arthrodesis of the calcaneocuboid joint for correction of abduction of the foot as noted clinically and radiographically in the presentation of AAFD. Oh et al (53) evaluated plantar pressure and talonavicular alignment when performing lateral column lengthening for flatfoot reconstruction. They reported that 2-mm increment increases consistently reduced talonavicular abduction and demonstrated increasing plantar pressure to the lateral aspect of the forefoot. Interestingly, Kang et al (54) evaluated whether there was true lateral column shortening in the adult flatfoot. Their study involved 75 patients with AAFD and 70 patients without the deformity, and found no statistically significant difference between the 2 groups when measuring, from anterior to posterior on radiograph, the lengths of the medial and lateral columns. They concluded that there is a perceived shortening associated with AAFD due to forefoot abduction and hindfoot valgus deformities, and that surgeons performing a lateral column lengthening are lengthening a “normal”-size calcaneus to correct the forefoot abduction.

Because secondary forefoot supinatus exists in the complex of adult-acquired flatfoot, reduction of this deformity to establish normal forefoot loading parameters is desirable. Hirose and Johnson (55) evaluated the use of the opening wedge medial cuneiform osteotomy for correction of this deformity in 16 feet. Follow-up radiographic studies revealed a notable improvement in mid-medial cuneiform to floor height on lateral radiograph. The investigators concluded that an opening wedge medial cuneiform osteotomy is an important adjunctive procedure to correct the forefoot varus component of a flatfoot deformity. Aiyer et al (56) studied the use of the Cotton osteotomy to correct residual forefoot supination in flexible flatfoot deformity reconstruction. They analyzed the radiographs of 67 patients who underwent this procedure as part of their flatfoot reconstruction. The investigators evaluated 12 radiographic parameters, including a newly defined medial arch sag angle, and compared these findings with those of 28 patients who did not undergo medial cuneiform osteotomy (matched controls). The results showed that the Cotton osteotomy did not improve the talometatarsal angle but did notably improve the medial arch sag angle (56).

Statement: *Stage IIB AAFD often requires a lateral column lengthening procedure to address forefoot abduction.*

Grade: B

Consensus of panel: This statement is neither appropriate nor inappropriate.

Rationale: The pathogenesis of AAFD is known to include lateral column shortening in relation to the medial column, resulting in the clinical abduction of the forefoot at Chopart’s joint. For this statement, lateral column lengthening (LCL) includes any lengthening osteotomy of the anterior process of the calcaneus. While the biomechanics of the LCL have been studied, the clinical indications are certainly ambiguous.

The difficulty in understanding the efficacy of the LCL alone is that when it is studied in vivo, it is almost exclusively performed with ancillary procedures and not in isolation. There have been several cadaveric studies performed to understand the influence of the LCL on the adult-acquired flatfoot, including a study by Baxter et al (57). Creating 12 cadaveric flatfoot models, all had a step-cut LCL performed in isolation to observe the impact on the hindfoot valgus and forefoot abduction. The investigators found that the step-cut LCL corrected 60% of the hindfoot valgus deformity and 100% of the midfoot abduction. They concluded that surgeons may consider performing the LCL before other calcaneal osteotomies, as it can correct the hindfoot valgus and forefoot abduction.

The use of the LCL is thought to be reserved for the later stage II or IIB deformity because of the excessive abduction of the forefoot as the deformity progresses. This has been supported in the literature on several occasions. In a 2018 retrospective review of 102 feet over 10 years, the authors concluded that in patients with forefoot abduction, an LCL procedure should be used to correct the deformity (58). Chan et al in 2015 (59) performed a retrospective review of 41 patients who underwent an LCL. They found that 2 variables significantly changed patients’ lateral incongruity angle: weight and the amount of LCL performed. Each millimeter of LCL performed corresponded to a 6.8° change in the lateral incongruity angle. The investigators concluded that correction of forefoot abduction in adult-acquired flatfoot reconstruction was directly determined by the LCL procedure (59). Interestingly, in a prospective study by Marks et al (60) that compared medial calcaneal displacement osteotomy with LCL in patients with stage II and IIB flatfoot deformity, the investigators found no statistical differences in radiographic measures. It is of interest that 6 of the 20 total patients who underwent the LCL had a significantly higher preoperative talometatarsal angle on the anteroposterior radiograph, indicating a more significant forefoot abduction (60).

LCL is not without shortcomings. There has been discussion that increasing lateral column pressures in the adult population potentially leads to pain at the calcaneocuboid joint postoperatively. It is thought that adults may not be able to tolerate as much LCL as juveniles. Complication rates tend to be slightly higher when LCL is used in the adult flatfoot. In a 2013 retrospective chart review by Iossi et al (61), 72 feet that underwent correction of stage II flatfoot were separated into 3 groups: medial displacement calcaneal osteotomy (MDCO) alone, LCL alone, and MDCO and LCL together. Although the investigators found that LCL resulted in a greater radiographic improvement and alignment, MDCO alone had only a 17% complication rate, whereas LCL had a 40% complication rate and the LCL plus MDCO had a 47% complication rate. The LCL is a powerful procedure in the surgeon’s armamentarium for treating AAFD and forefoot abduction, but it should be used judiciously and on a case-by-case basis.

Statement: *Medial displacement calcaneal osteotomy (MDCO) should be considered in cases of flexible adult-acquired flatfoot correction.*

Grade: B

Consensus of panel: This statement is neither appropriate nor inappropriate.

Rationale: Stage II flexible AAFD is characterized by a range of passively correctable deformities including collapse of the medial

longitudinal arch, forefoot abduction, increased talonavicular uncovering, and hindfoot valgus. The results of AAFD can be a combination of dysfunction in the PTT, failure of the supporting ligamentous structures on the medial longitudinal arch, and malposition of the supporting bony architecture of the foot.

Koutsogiannis (62) introduced the concept of medializing calcaneal osteotomies for flatfoot reconstruction in 1971. Later studies quantified the relationship, suggesting that translating the posterior segment approximately 10 mm medially provided adequate correction (50,63). The analysis of Arangio and Slathe (50) showed that 10-mm medial slide calcaneal osteotomy substantially decreased the strain on the talonavicular joint and the load of the medial arch. Displacement of the calcaneus to a position of mild medial position via medial displacement osteotomy during flatfoot reconstruction provides static support to the PTT and supporting ligamentous structures of the medial longitudinal arch while simultaneously causing a medial shift to the force of the Achilles tendon, which in turn blocks the open translation of the tarsal joint during toe-off. Otis et al (64) concluded that use of the MDCO resulted in a decrease in the length of the superomedial portion of the spring ligament. This decrease demonstrated advantageous lessening of the tension of the spring ligament that occurs during stance (64). Resnick et al (65) demonstrated reduction in strain at the proximal attachment of the deltoid ligament after the MDCO, which in turn led to the protection from dysfunction of its attachment to the spring ligament. Resnick et al additionally speculated that the MDCO caused a medial shift of the force of Achilles tendon, leading to correction of the arch in the stance phase (65). Multiple studies have shown that the MDCO can be used to restore foot alignment, decrease load on the medial arch, normalize force of the talonavicular joint, and improve patient outcomes. Findings from a study by Chan et al (59) suggested that the amount of MDCO performed on the flatfoot reconstruction is the primary determinant of the correction to hindfoot alignment achieved postoperatively (59). The authors also concluded that the hindfoot moment arm can be used to help surgeons more precisely achieve the amount of correction obtained intraoperatively and ultimately improve the patient outcomes in a more predictive manner (59).

Statement: Rigid flatfoot deformity may be effectively treated by talonavicular and subtalar joint fusion in combination or in isolation.

Grade: B

Consensus of panel: This statement is neither appropriate nor inappropriate.

Rationale: Triple hindfoot arthrodesis is a primary treatment for end-stage flatfoot deformity. Triple arthrodesis can improve alignment and pain associated with flatfoot deformity. Despite the effectiveness of this procedure, fusion of all 3 joints may not be essential for effective treatment of the rigid flatfoot. The literature raises the question of whether triple arthrodesis is needed. Of the literature reviewed, the most common agreement found was related to the complications of the triple arthrodesis. Known complications of the triple arthrodesis include nonunion, damage to the sural nerve, and wound healing complications (fusion versus compression) (66–72). Other arguments posed include the associated long-term incidence of ankle valgus, the arthrodiastasis effect of the calcaneocuboid joint (CCJ), and increased total cost (72). By avoiding arthrodesis of the CCJ, length is maintained in correcting for the forefoot abduction. In doing so, the surgeon is allowing for an accommodative function to the hindfoot on uneven ground (72). The calcaneal cuboid joint, which is less commonly affected by arthritis and contributes least to hindfoot range of motion, may not always require fusion when treating the flatfoot deformity (73). The decision for isolated or multiple joint fusions should be based on joint symptoms and the magnitude of deformity correction that can be achieved by fusion of any particular joint.

Statement: Medial incision approach does not increase risk of complication when performing hindfoot fusion.

Grade: B

Consensus of panel: This statement is appropriate.

Rationale: The medial incision approach provides adequate visualization and surgical access to hindfoot joints when performing a modified triple arthrodesis. A medial incision is an alternate approach to classic dorsal lateral and dorsal medial incisions traditionally described for surgical access to the subtalar and talonavicular joints when performing a joint fusion (68,70–72). Cadaver studies have verified the safety of the medial incision for access to the talonavicular and subtalar joint with a 2-cm safe distance between the middle facet and the neurovascular bundle (74). Furthermore, the medial approach reduces the potential skin closure complication of a lateral approach because of the contracted lateral soft tissues (73). It also provides adequate visualization and surgical access to hindfoot joints when performing a modified triple arthrodesis. Complication rates including dehiscence and nonunion are comparable to alternate surgical approaches for isolated and triple arthrodesis procedures (67,68,72).

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