E-ISSN: 3068-3726
Journal of Orthopaedic Science and Research

ATHENAEUM SCIENTIFIC PUBLISHERS

Research Article

Innovative Soft Tissue Reconstruction of the Spring–Deltoid Complex in Progressive Collapsing Foot Deformity (Flatfoot): Early Clinical Results

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Citation: Wright A, et al. Innovative Soft Tissue Reconstruction of the Spring–Deltoid Complex in Progressive Collapsing Foot Deformity (Flatfoot): Early Clinical Results. J Ortho Sci Res. 2025;6(3):1-13.

https://doi.org/10.46889/JOSR.2025.6301

Received Date: 21-08-2025

Accepted Date: 08-09-2025

Published Date: 15-09-2025

Abstract

Progressive Collapsing Foot Deformity (PCFD), previously termed Adult Acquired Flatfoot Deformity (AAFD), is a progressive condition characterized by failure of medial soft tissue structures leading to painful biomechanical dysfunction. Traditional reconstructions often rely on nonanatomic osteotomies, such as lateral column lengthening, which carry notable risks. This study evaluates a novel soft tissue reconstruction of the spring-deltoid ligament complex combined with medial column osteotomies for stage II PCFD.

Methods: A retrospective case series was performed on 9 feet in 8 patients (mean age 44.7 years) treated between September 2021 and December 2024. The surgical technique included spring ligament InternalBrace™ augmentation with Flexor Digitorum Longus (FDL) transfer, Cotton osteotomy with titanium wedge and minimally invasive Medial Calcaneal Osteotomy (MICO). Pre- and postoperative radiographs were analyzed for Meary's angle, talocalcaneal angle, calcaneal inclination angle, calcaneocuboid angle and intermetatarsal angle. Functional outcomes were assessed using FAOS and AOFAS hindfoot scores. Paired t-tests determined statistical significance ($p < 0.05$).

Results: All radiographic parameters demonstrated significant improvement: Meary's angle (14.56° → 2.11°), talocalcaneal angle (28.11° → 18.44°), calcaneal inclination (11.67° → 15.89°), calcaneocuboid angle (21.11° → 12.11°) and intermetatarsal angle (11.11° → 6.67°) (all $p < 0.05$). Functional outcomes also improved, with mean FAOS of 79.1 ± 10.5 and mean AOFAS of 84.3 ± 3.8 at an average of 21 month follow-up. No patients required adjunctive lateral column lengthening and no construct failures or major complications were observed.

Conclusion: Spring-deltoid ligament reconstruction with InternalBrace™ augmentation, combined with MICO and Cotton osteotomy, achieved significant radiographic and functional correction in stage II PCFD without the need for nonanatomic lateral column lengthening. This technique may provide a safer, anatomic alternative to traditional reconstructions, offering reliable restoration of medial column stability and improved patient-reported outcomes.

Level of Evidence: IV (Retrospective case series).

Keywords: Progressive Collapsing Foot Deformity (PCFD); Adult Acquired Flatfoot Deformity (AAFD); Flatfoot; Spring Ligament; Deltoid Ligament; InternalBrace™ Augmentation; Medial Calcaneal Osteotomy (MICO); Cotton Osteotomy; Flexor Digitorum Longus (FDL) Transfer; Soft Tissue Reconstruction; Foot and Ankle Surgery

Introduction

Progressive Collapsing Foot Deformity (PCFD) arises from multiple anatomic and biomechanical factors, with aspects of both its origin and techniques remain controversial. The incidence of flatfoot is often underreported, but recent studies suggest that Adult Acquired Flatfoot Deformity (AAFD) occurs in approximately 3.3% of women over the age of 40 [1]. AAFD can be life-changing, ranking second only to ankle arthritis in terms of preoperative pain and limitation of function based on long term outcome scores [1]. The deformity is progressive, accentuated by the loss of the integrity of tendons and ligaments that support the talus, allowing the deformity to worsen [2]. AAFD has been applied to previously described classification systems that were originally designed for Posterior Tibial Tendon Dysfunction (PTTD). Further revisions have been developed to aid surgeons in addressing patient specific deformities, as there is not a “one size fits all” flatfoot deformity. However, core tenants can be addressed to improve long term outcomes [1]. Multiple updates have been made to the accepted classification of PTTD, ranging from 1-IV, now called Progressive Collapsing Foot Deformity (PCFD). This paper will focus on the flexible aspect of the classification and describe a novel technique to address both the soft tissue as well as osseous sequelae of stage II PCFD [3].

Failure of soft tissue structures including ligaments, tendons and support structures allows osseous structures to become misaligned and over time lead to painful biomechanics [1]. Recent ligament mapping using attachment-based dissection has further clarified the functional roles of the medial collateral and spring ligaments [2]. There is ongoing debate regarding whether the medial collateral ligament complex is part of the medial deltoid ligament apparatus or the spring ligament. Two components of the medial collateral complex are widely accepted: the superficial and the deep portions. The superficial portion consists of the tibionavicular, tibiospring, superficial posterior tibiotalar and talocalcaneal ligaments, while the deep portion consists of the deep posterior and deep anterior tibiotalar ligaments.

The spring ligament complex consists of both the superioromedial calcaneonavicular ligament, which provides longitudinal arch support and is frequently attenuated or injured in patients with PCFD, as well as the inferior calcaneonavicular ligament whose precise role remains unclear. Although the medial collateral complex and the spring ligament serve distinct functions, they are interconnected via the superomedial calcaneonavicular ligament [2]. This anatomic relationship forms the foundation of the core tenet underlying the novel technique described in this paper.

A common presentation of PCFD includes a patient with flexible hindfoot valgus, forefoot abduction, a painful Posterior Tibial (PT) tendon, medial column sag and talonavicular uncovering consistent with a stage II deformity. Such cases have been shown to respond more favorably to surgical treatment than to conservative measures. Houck, et al., performed a Randomized Control Trial (RCT) comparing orthotics alone with orthotics plus stretching finding only mild improvement in activity and pain at 12 weeks [4].

In 2019, Aynardi, et al., performed a cadaveric study to evaluate the biomechanical impact of spring ligament augmentation using FiberTape™ in a flatfoot model. They demonstrated the FiberTape™ augmentation was safe and effective under cyclic loading. In contrast, 8/8 suture only repairs failed due to suture cut-through (n=5), structure fatigue (n=2) or knot failure (n=1). Only one of the Fiber Tape™ augmented repairs failed after cyclic loading (P=0.0014). At forces of 1600 N (P=0.03) and 1700 N (P= 0.02), there were statistically significant differences favoring Fiber Tape™ augmentation compared to suture-only techniques, with greater collapse of the lateral Meary's talo-first metatarsal angles in the control group [5].

The goals of radiographic restoration in PCFD reconstruction include improvement of the calcaneocuboid angle, reduction of talar head uncovering, correction of Kite’s angle, correction of calcaneal valgus on axial radiographs and resolution of the medial column “sag.” Surgeons must address both rearfoot valgus and forefoot alignment, which may present in supinatus or varus [1]. The role of forefoot abduction relative to the rearfoot remains controversial. Previous principles of flatfoot reconstruction recommended an Evans osteotomy to achieve triplanar correction and directly address the abduction deformity.

Valgus malposition of the heel, due to loss of integrity of the medial column soft tissue apparatus, produces the “too many toes sign.” This transverse deformity can be addressed without lateral column lengthening, despite the historical popularity of the Evans osteotomy since 1975. However, recent studies have shown that while the Evans osteotomy can reliably correct the transverse radiographic deformity, it carries notable sequelae, including calcaneocuboid degeneration (30%), subtalar degeneration (25%), sural neuritis (11%) and lateral column overload (4%), with an overall complication rate of 15.2% [6-8]. Given these complication rates, there is a growing need for less extensive, procedures. Soft tissue balancing techniques may achieve adequate correction while avoiding the risks of aggressive non anatomic structural procedures.

Multiple considerations should be made regarding whether to address the medial column alone or to include the lateral column. These include obesity, osteoarthritis, degenerative joint disease, joint preservation and ankle involvement. For ease of use, this authors' algorithm was simplified to address four core deformities: equinus, valgus hindfoot, soft tissue insufficiency and osseous deficiency.

Equinus correction: Taloachilles Lengthening (TAL), Endoscopic Gastrocnemius Recession (EGR)
Valgus correction: Medializing Calcaneal Osteotomy (MCO), Minimally Invasive Calcaneal Osteotomy (MICO)
Soft tissue correction: Flexor Digitorum Longus (FDL) transfer, Spring Ligament with deltoid repair
Osseous supplementation: Cotton, Lapidus

For stage II patients with obesity (BMI> 40), treatment consists of soft tissue repair with isolated fusion in the absence of Degenerative Joint Disease (DJD) of the Subtalar Joint (STJ), Talonavicular (TN) or Calcaneocuboid (CC) joints. If DJD is present, soft tissue repair is combined with double or triple arthrodesis. Stage III patients typically undergo soft tissue repair with isolated fusion, including double or triple arthrodesis, to address hindfoot valgus. Stage IV patients with ankle involvement may benefit from staged reconstruction, first addressing foot alignment to restore the mechanical axis, followed by treatment of the ankle. This paper focuses on soft tissue correction, specifically restoration of the spring/deltoid ligament complex to treat stage II flexible flatfoot reconstruction. We aim to demonstrate that the spring ligament Internal brace™ ligament augmentation provides adequate deformity correction without requiring nonanatomic reconstructive procedures, the Fiber Tape™ augmentation of the spring ligament is biomechanically safe and effective under cyclic loading, combined deltoid and spring ligament repair yields superior long term success and that the spring ligament repair with Internal brace™ provides both radiographic and clinical improvement.

Methodology

A retrospective case series was conducted of patients undergoing surgical correction for progressive collapsing flatfoot deformity using the authors' novel soft tissue balancing technique, which included the spring ligament reconstruction with corresponding Cotton osteotomy with titanium wedge placement and MICO. All patients were provided informed consent for inclusion in this study. Inclusion criteria included diagnosis of stage II adult flatfoot without end stage arthritis that had failed conservative measures. Exclusion criteria included a rigid flatfoot, end stage arthritis, neuromuscular disease, history of charcot or infection. We included 9 feet, composed of 8 patients between September 2021 and December 2024 who met inclusion criteria.

Operative Technique Guide

Setup: Patients were positioned supine with an ipsilateral hip bump.
We developed the current technique to reconstruct both the calcaneonavicular and tibiospring ligaments of the deltoid ligament.

1. Through a standard medial approach over the PTT, the primary insertion of the PTT was reflected off the navicular, leaving the secondary insertion plantarly. The tendon was appropriately debrided and left intact to advance and provide a side-to-side tenodesis with the FDL to the PTT after transfer
2. The spring ligament was approached with a transverse incision and a wedge resection was performed for imbrication after reconstruction
3. The FDL was identified deep and proximal to the PTT, reflecting the PTT inferiorly to locate the FDL
4. The FDL was transected proximal to the knot of Henry
5. Arthrex suture tape FiberLoop™ was used to create a Krackow-type suture through the FDL. The Keith needle was protected with a clamp and set aside for later tendon transfer
6. The sustentaculum tali was identified just distal to the tip of the medial malleolus (approximately one thumb length) and deep to the prepared FDL tendon
7. The cannulated Internal Brace System (Arthrex)™ was used, with a guidewire placed in the sustentaculum (Fig. 1) Fluoroscopy (lateral and calcaneal axial views) confirmed placement
8. A 2.7 mm drill for a 3.5 SwiveLock Anchor™ was used over the guidewire, followed by tapping. The guidewire was then

removed

9. A 3.5 mm anchor double-loaded with Fibertape™ (Fig. 2) was placed into the prepared drill hole in the sustentaculum. Due to the size of the anchor and the double-loaded suture, the resistance and feedback can be tight. The suture was clamped and set aside
10. A MICO was performed to medialize ankle forces and protect the soft tissue reconstruction. The osteotomy was fixated with two screws perpendicular to the osteotomy (Fig. 3,4)
11. A medial cuneiform osteotomy was prepared at this stage but not fixated until later to allow appropriate positioning. This also allows the cut to take place prior to soft tissue repair in order to prevent final malalignment of the osteotomy
12. A guidewire was placed in the medial talus, distal to the ankle joint, and distal to the medial cartilage of the talus and confirmed with fluoroscopy (Fig. 5). A cannulated 3.4 mm drill was used, followed by tapping. One arm of the sustentaculum suture was fixed with an Arthrex 4.75 SwiveLock™ anchor under tension (Fig. 6)
13. A guidewire was then placed into the medial malleolus, confirmed on fluoroscopy (Fig. 7). A cannulated 3.4mm drill and tap were used and one arm from the sustentaculum and the remaining talus suture were fixed with another Arthrex 4.75 SwiveLock™ anchor under neutral ankle positioning (Fig. 8).
14. The remaining two arms from the sustentaculum were used for the FDL transfer. The tendon was pulled through a prepared navicular tunnel using a pull-through technique and fixed with Arthrex bio-tenodesis anchor™ (Fig. 9,10)
15. The medial cuneiform osteotomy was sized and fixed with an Arthrex Biosync™ cotton cage (Fig. 11)
16. The native spring ligament was imbricated in a pants-over-vest fashion using 2-0 vicryl
17. An endoscopic gastrocnemius or Achilles lengthening was then performed if equinus was present. TAL versus EGR was performed in order to eliminate cephalad pull from the Achilles
18. Fig. 12 before and after innovative technique/correction

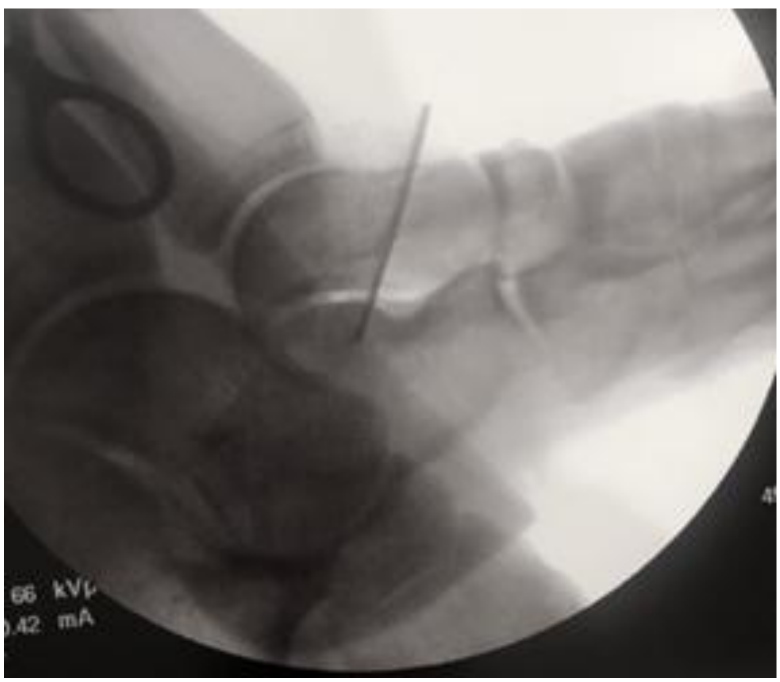

Figure 1: The cannulated Internal Brace System (Arthrex)™.

Figure 2: A 3.5 mm anchor double-loaded with Fibertape™.

Figure 3: A MICO was performed to medialize ankle forces.

Figure 4: Osteotomy was fixated with two screws perpendicular to the Osteotomy.

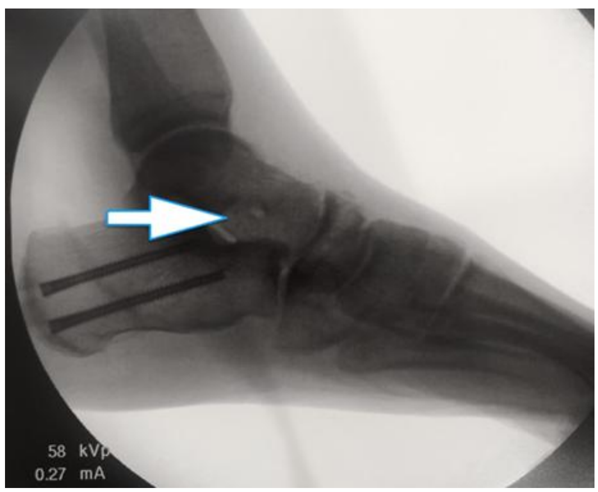

Figure 5: A guidewire was placed in the medial talus, distal to the ankle joint and distal to the medial cartilage of the talus.

Figure 6: One arm of the sustentaculum suture was fixed with an Arthrex 4.75 SwiveLock™ anchor under tension.

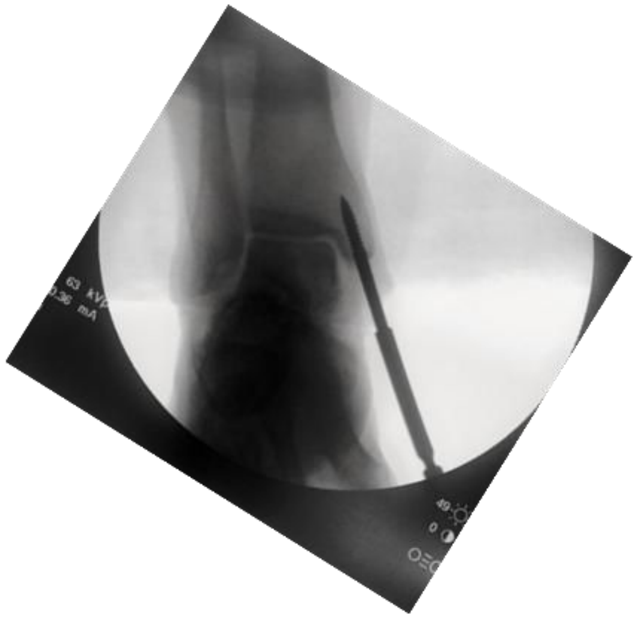

Figure 7: Confirm anchor placement is not within the ankle joint under fluoroscopy.

Figure 8: Neutral ankle positioning, place anchor into the medial malleolus.

Figure 9: Used the remaining two arms from the sustentaculum for FDL transfer. The tendon was pulled through a prepared navicular tunnel using a pull-through technique and fixed with Arthrex bio-tenodesis anchor™.

Figure 10: Final positioning of all anchors to recreate native anatomy of the deltoid-spring ligament complex.

Figure 11: Cotton cage was then sized and placed after anchors were placed.

Figure 12: Before/After demonstrating flatfoot reconstruction utilizing novel technique.

Postoperative Protocol

Splint immediately post op, transition to CAM boot at 2 weeks. Strict non-weight bearing 4-6 weeks unless its a fusion then 6-8 weeks. Partial weight bearing (50-75%) at 4 weeks. Aggressive physical therapy with gait training, compression and Alter-G treadmill. Transition to shoes at 8 weeks.

Outcome Scores

Outcomes included the Foot and Ankle Outcome Score (FAOS), which has been validated for PCFD, 1,9 and the AOFAS score for comparison with prior literature.

Radiographs

Weightbearing radiographs were obtained pre- and post-operatively. Angles measured included Meary's angle, talocalcaneal angle, calcaneal inclination, calcaneocuboid angle and intermetatarsal angle. Measurements were performed by a single author and averages were recorded.

Statistical Analysis

Paired t-tests compared preoperative and postoperative angular measurements, with significance at $p < 0.05$. Descriptive statistics mean ± standard deviation were calculated for continuous variables. Demographics including age, sex and follow up duration were reported.

Results

Eight patients (9 feet, including one bilateral case) underwent spring ligament InternalBrace™ augmentation with the authors' technique (MICO + Cotton osteotomy).

Radiographic Outcomes

- Calcaneal Inclination Angle increased from 11.67° ± 3.77° to 15.89° ± 2.98°
- Meary's Angle decreased from 14.56° ± 5.36° to 2.11° ± 1.90°
- Talocalcaneal Angle decreased from 28.11° ± 4.73° to 18.44° ± 4.03°
- Calcaneocuboid Angle decreased from 21.11° ± 6.86° to 12.11° ± 5.69°
- Intermetatarsal Angle decreased from 11.1° ± 3.41° to 6.67° ± 1.73°

All changes were statistically significant ($p < 0.05$), supporting meaningful correction of midfoot and hindfoot alignment.

Functional Outcomes

- FAOS: 79.1 ± 10.5, indicating substantial improvement in pain, function and quality of life
- AOFAS: 84.3 ± 3.8, consistent with favorable recovery, although not validated for AAFD

No correlation was found between age and outcomes.

1. A statistical description of the case series (N = 9). Gender, mean age, standard deviation (Table 1)

Characteristic	Value
Total limbs (N)	9
Male	5
Female	4
Mean Age (years)	44.7
Age SD	11.92

Table 1: Statistical description of the case series.

2. A list of concomitant procedures performed (N = 9) on patients with pes planovalgus deformity

All patients received augmented spring ligament repair with suture tape. Abbreviations: FDL, flexor digitorum longus; MICO, medial calcaneal slide osteotomy; PT, posterior tibial; SF, subtalar fusion; TN, talonavicular. EGR, deltoid/spring repair, FDL transfer, Kidner, Brostrum lateral ankle stabilization, MICO, Cottone osteotomy.

3. Angles

Data showing the preoperative mean, postoperative mean and outcome of the radiographic parameters (N = 14). Abbreviations: MC, medial cuneiform; MT, metatarsal; TC, talocalcaneal. All parameters showed radiographic correction. Absolute negative value in Talo-1st MT angle represents sagittal plane concavity. Outcome represents the difference between preoperative and postoperative mean. Abbreviations: MC, medial cuneiform; MT, metatarsal; TC, talocalcaneal. All parameters showed radiographic correction. Absolute negative value in Talo-1st MT angle represents sagittal plane concavity. Outcome represents the difference between preoperative and postoperative mean (Table 2, Fig. 13)

Angle	Mean ± SD (Pre)	Mean ± SD (Post)	Mean Difference	P-Value
Mearys	14.56 ± 5.36	2.11 ± 1.90	-12.44	0.0001
TCA	28.11 ± 4.73	18.44 ± 4.03	-9.67	0.0021
CCA	21.11 ± 6.86	12.11 ± 5.69	-9.00	0.0001
IMA	11.11 ± 3.41	6.67 ± 1.73	-4.44	0.0092
CIA	11.67 ± 3.77	15.89 ± 2.98	4.22	0.0001

Table 2: Data showing the preoperative mean.

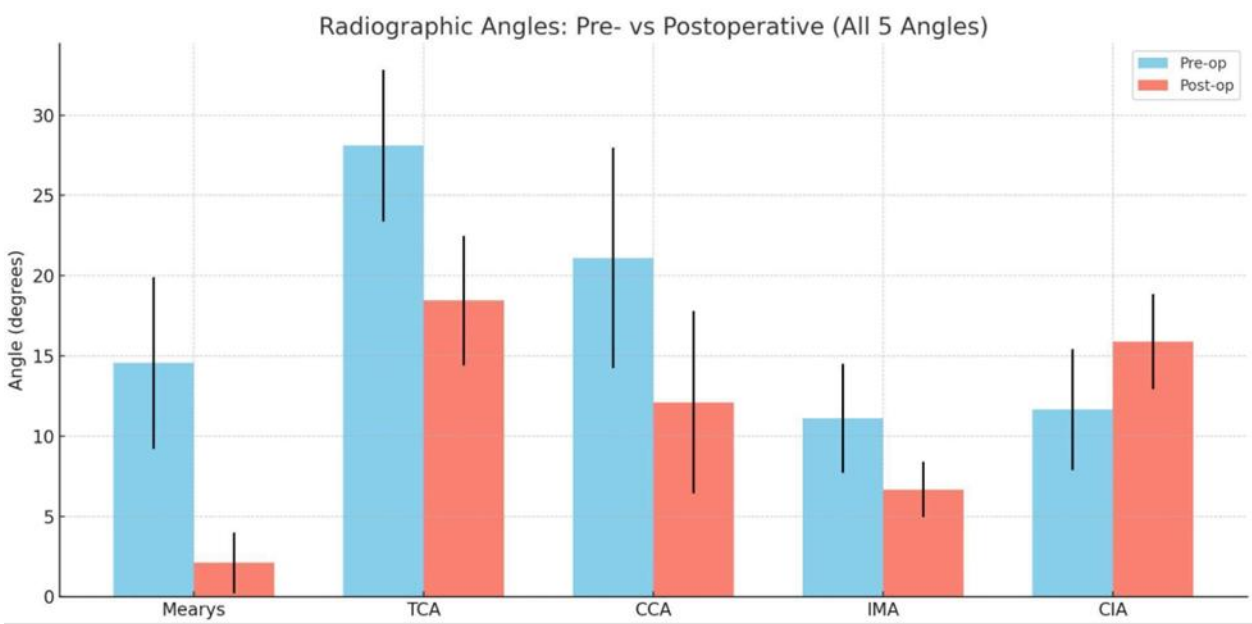

Figure 13: Summary of angle changes pre and post op:
Calcaneal Inclination: Increased-a sign of improved heel position.
Meary's Angle: Decreased-suggesting better medial arch alignment.
Talocalcaneal Angle: Decreased-reflecting corrected hindfoot alignment.
Calcaneocuboid Angle: Decreased-indicating reduced lateral column abduction.
Intermetatarsal Angle: Slight decrease-improved forefoot structure.

4. *FAOS/AOFAS Scores*

Data showing the post operative functional outcomes were then assessed using the FAOS and AOFAS hindfoot scores. A total of 9 limbs had complete outcome score documentation at the time of final follow up. The mean postoperative FAOS score was 79.1 ± 10.5 which indicates a substantial improvement in patient reported pain, function and quality of life with a score of 80 typically indicating a good result. The mean AOFAs score was 84.3 ± 3.8, which although AOFAS scores are not validated in the literature with adult acquired flatfoot, the authors elected to utilize this score as well as a baseline as AOFAS scores had until recently been a standard when reporting outcomes in the foot and ankle. Both scoring systems demonstrated consistent postoperative recovery in the cohort with minimal variance noted. There was no statistically significant correlation between patient age and the FAOS ($r = -0.26$, $p=0.499$)/AOFAS ($r=0.037$, $p=0.924$). This suggests that age was independent and did not affect the subjective or objective postoperative outcomes.

Discussion

This retrospective case series of 9 operative feet demonstrated that flexible stage II flexible flatfoot deformity can be effectively corrected with a combination of osteotomies (MICO, Cotton) and soft tissue augmentation, including the novel spring ligament Internal Brace™ reconstruction described above. The mean age of the patients was 44.7 ± 11.9 years old with 5 males and 4 females. Radiographic angles were compared pre and post operatively including the CIA, Meary's, TCA, CCA and IMA were statistically significant utilizing the novel technique. Functional outcome scores including AOFAS and FAOS scores were favorable showing 84.33 ± 3.84 AOFAS score and 79.09 ± 10.50 FAOS showing improved function and patient satisfaction at an average of 21 months of follow up.

Comparison to Current Literature

Nery, et al., showed that combined spring ligament and deltoid repair provided durable correction without failures or stiffness [10]. Krautmann, et al., then postulated that the deltoid and spring ligament are intimately related in both form and function, where incompetence in one causes incompetence in the other requiring combined reconstruction when treating PCFD. They found that failure of the spring ligament is required for the deformity to progress in PCFD. Thus, when the spring ligament fails, the deltoid integrity is compromised leading potential sequela including further worsening of the valgus heel leading to overload of the lateral ankle thus potentiating the need for syndesmotic and lateral ankle stabilization [11]. Fogleman, et al., performed a retrospective review of 57 patients pre and post operative radiographs after augments spring ligament repair utilizing Suture Tape and found that at an average of 62 weeks, there were significant improvements in all radiographic angles. They only had 5 subsequent operations due to deep infection (1), removal of augmentation (2), ankle arthrodesis (1) and triple arthrodesis (1) suggesting further that the spring ligament augmentation was a safe procedure that contributed to the radiographic correction still seen at an average of 62 weeks [12]. Acevedo, et al., then performed a case series of 26 patients who underwent spring ligament reconstruction with Internal Brace ™ ligament augmentation. All patients underwent FDL transfer with resection of diseased portion of the PT tendon. 25 required Medial Calcaneal Osteotomies (MICO), 11 cottons, 4 lapidus and only 2 required lateral column lengthening. They found that the procedure allowed for a more powerful deformity correction and may decrease dependency on other nonanatomic reconstructive procedures. In the author's technique they used anchors to recreate the inferomedial and superomedial bands of the spring ligament via a hammock-like sling of the medial complex. They believe this reduced the talus into anatomic position relative to the foot while allowing the native anatomic spring ligament repair to heal under appropriate tension. The Spring ligament was either anatomically repaired when torn or if attenuated or partially torn it was fully transected then repaired, these repairs were done after the Internal Brace™ construct was placed to minimize strain on the anatomic tissue repair. By addressing the spring and deltoid complex, you are able to decrease dependency on other non anatomic reconstructive procedures such as a Lateral Column Lengthening (LCL) [13].

Initial surgical techniques included a Medializing Calcaneal Osteotomy (MICO) in conjunction with an Flexor Digitorum Longus (FDL) of Flexor Hallucis Longus (FHL) tendon transfer with early outcomes showing improvement in AOFAS scores at 30 months [14-17]. Both Myerson, et al., and Guyton, et al., found significant improvements in midfoot abduction radiographic parameters, while Sammarco, et al., found no significant differences with a MICO [14-16]. However, these did not include any other soft tissue augmentation. Further investigation by Niki, et al., found that only Mearys angle and tibiocalcaneal angle were statistically significant and maintained at a 1 year follow up after having MICO with FDL transfer, as well as no statistical differences noted after the 3 month postoperative mark [18].

Although *in-vivo* loading conditions were not directly measured, clinical outcomes, radiographic maintenance of correction and absence of recurrent deformity at short-term follow-up suggest that the FiberTape spring ligament augmentation remains stable under physiologic cyclic loading. No evidence of attenuation or failure of the construct was observed radiographically or clinically. Collectively, the observed improvements in alignment and function support the hypothesis that spring ligament repair with Internal Brace™ augmentation leads to measurable radiographic correction and clinical benefit.

Discuss Clinical Applications

This novel technique allows providers to perform anatomic restoration of defects allowing adequate correction of the angular deformities seen in stage II flatfoot deformity. No patients required adjunctive lateral column lengthening suggesting the Internal Brace™ was effective in achieving significant correction without non-anatomic procedures. Our results align with recent data supporting spring ligament augmentation as safe and biomechanically stable, avoiding the long-term sequelae of Evans osteotomy such as lateral column overload, sural neuritis and joint degeneration.

Limitations

This study is limited due to its retrospective nature, as well as not comparing pre versus post operative FAOS/AOFAS scores. Our small sample size limits the statistical power of our study increasing the risk of Type II errors, thus reducing the generalizability to broader populations. We also acknowledge follow up bias, as the follow up range of each patient varied from 1-3 years leaving the possibility of late complications, recurrence or biomechanical complications. Finally, we acknowledge that this is a single surgeon, single center designed study and should be treated as such.

Future Directions

Future studies should include larger cohorts, prospective designs and long-term follow-up to assess durability. Broader use of validated functional outcomes would also strengthen our conclusions.

Conclusion

This study demonstrates that spring ligament InternalBrace™ augmentation, combined with MICO, Cotton and soft tissue reconstruction, can achieve significant radiographic and functional correction of stage II PCFD. Importantly, this technique avoided the need for nonanatomic lateral column lengthening, reducing potential complications while restoring medial column stability.

Conflict of Interests

The author declares no conflict of interest.

Funding/Sponsorship

This research did not receive any specific grant from funding agencies in the public, commercial or not-for-profit sectors.

Acknowledgments

None.

Author Contributions

The senior author Dr. Michael W. Downey is a paid Consultant for Arthrex, Inc™. Arthrex had no involvement in the design, conduct, data collection, analysis, or interpretation of this study. Arthrex products were used in surgical procedures as part of standard practice, but the company had no role in the preparation or review of the manuscript.

Ethical Approval

Not applicable.

Informed Consent Statements

Written informed consent was obtained from all the patients.

Data Availability Statement

Not applicable.

References

1. Conti MS, Garfinkel JH, Ellis SJ. Outcomes of reconstruction of the flexible adult-acquired flatfoot deformity. Orthop Clin North Am. 2020;51(1):109-20.

2. Cromeens BP, Kirchhoff CA, Patterson RM. An attachment-based description of the medial collateral and spring ligament complexes. Foot Ankle Int. 2015;36(6):710-21.
3. Henry JK, Shakked R, Ellis SJ. Adult-acquired flatfoot deformity. Foot and Ankle Orthopaedics. 2019;4(1):2473011418820847.
4. Houck J, Neville C, Tome J, Flemister A. Randomized controlled trial comparing orthosis augmented by either stretching or stretching and strengthening for stage II tibialis posterior tendon dysfunction. Foot Ankle Int. 2015;36(9):1006-16.
5. Aynardi MC, Saloky K, Roush EP, Juliano P, Lewis GS. Biomechanical evaluation of spring ligament augmentation with the FiberTape device in a cadaveric flatfoot model. Foot Ankle Int. 2019;40(5):596-602.
6. Hao C, Li Z, Xu C. Comparative effects of two calcaneal lengthening osteotomies (Hintermann vs Evans) in stage II adult-acquired flatfoot. BMC Musculoskelet Disord. 2025;26(1):434.
7. Zachary PH, Joseph RB, Ross TG, Alex B, Alexa TB, Robert WM. Outcomes and complications associated with lateral column lengthening using porous titanium wedges for flexible flatfoot deformity correction: A systematic review. Int J Foot Ankle. 2024;8(1).
8. Obey MR, Johnson JE, Backus JD. Managing complications of foot and ankle surgery. Foot Ankle Clin. 2022;27(2):303-25.
9. Mani SB, Brown HC, Nair P. Validation of the foot and ankle outcome score in adult acquired flatfoot deformity. Foot Ankle Int. 2013;34(8):1140-6.
10. Nery C, Lemos AVKC, Raduan F, Mansur NSB, Baumfeld D. Combined spring and deltoid ligament repair in adult-acquired flatfoot. Foot Ankle Int. 2018;39(8):903-7.
11. Krautmann K, Kadakia A. Spring and deltoid ligament insufficiency in the setting of progressive collapsing foot deformity: an update on diagnosis and management. Foot Ankle Clin. 2021;26(3):577-90.
12. Fogleman JA, Kreulen CD, Sarcon AK, Michelier PV, Giza E, Doty JF. Augmented spring ligament repair in pes planovalgus reconstruction. J Foot Ankle Surg. 2021;60(6):1212-6.
13. Acevedo J, Vora A. Anatomical reconstruction of the spring ligament complex: “internal brace” augmentation. Foot Ankle Spec. 2013;6(6):441-5.
14. Myerson MS, Badekas A, Schon LC. Treatment of stage II posterior tibial tendon deficiency with flexor digitorum longus tendon transfer and calcaneal osteotomy. Foot Ankle Int. 2004;25(7):445-50.
15. Wacker JT, Hennessy MS, Saxby TS. Calcaneal osteotomy and transfer of the tendon of flexor digitorum longus for stage II dysfunction of tibialis posterior. J Bone Joint Surg Br. 2002;84(1):54-60.
16. Guyton GP, Jeng C, Krieger LE, Mann RA. Flexor digitorum longus transfer and medial displacement calcaneal osteotomy for posterior tibial tendon dysfunction: A middle-term clinical follow-up. Foot Ankle Int. 2001;22(8):627-32.
17. Sammarco GJ, Hockenbury RT. Treatment of stage II posterior tibial tendon dysfunction with flexor hallucis longus transfer and medial displacement calcaneal osteotomy. Foot Ankle Int. 2001;22(4):305-12.
18. Niki H, Hirano T, Okada H, Beppu M. Outcome of medial displacement calcaneal osteotomy for correction of adult-acquired flatfoot. Foot Ankle Int. 2012;33(11):940-6.
19. Wills B, Lee SR, Hudson PW. Calcaneal osteotomy safe zone to prevent neurological damage: fact or fiction? Foot Ankle Spec. 2019;12(1):34-8.
20. Conti MS, Ellis SJ, Chan JY, Do HT, Deland JT. Optimal position of the heel following reconstruction of the stage II adult-acquired flatfoot deformity. Foot Ankle Int. 2015;36(8):919-27.