

## Original Article

# Effects of medializing calcaneal osteotomy associated with posterior tibial tendon re-tensioning in flexible flatfoot treatment in adolescents

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## Abstract

**Objective:** Evaluate the correction of the talonavicular coverage incongruity angles after medializing calcaneal osteotomy associated with talonavicular capsuloplasty and posterior tibial tendon re-tensioning in 12 patients (14 feet) aged between 13 and 16 years.

**Methods:** A retrospective study, using medical records, analyzed radiographs in the anteroposterior incidence pre- and postoperative after six weeks of surgery. Patients submitted to the medializing calcaneal osteotomy associated with talonavicular capsuloplasty and posterior tibial tendon re-tensioning were included.

**Results:** The preoperative talonavicular coverage angle ranged from 15.49 degrees to 31.00 degrees with a mean of 26.02 degrees, and in the postoperative, after six weeks, there was a change in the talonavicular coverage angle ranging from 0.65 degrees to 10.69 degrees, with a mean of 05.56 degrees. In our evaluation, the p-values were < 0.0001, considered extremely significant. The talonavicular incongruity angle in the preoperative ranged from 35.00 degrees to 87.00 degrees, with a mean of 64.00 degrees, and in the postoperative ranged from 0.50 degrees to 19.80 degrees, with a mean of 8.65 degrees. In our evaluation, p-values were < 0.0001, considered statistically significant.

**Conclusion:** The results demonstrated statistically significant improvements in the correction of the talonavicular coverage and incongruity angles following medializing calcaneal osteotomy, associated with talonavicular capsuloplasty and posterior tibial tendon re-tensioning, in adolescents with symptomatic flexible flatfoot.

**Level of evidence II; Prognostic studies - investigating the effect of a patient characteristic on the outcome of disease; Retrospective study.**

**Keywords:** Flatfoot; Osteotomy; Foot deformity.

## Introduction

Flexible flatfoot is a common condition, predominantly affecting children, characterized by the plantar arch collapse when the foot is bearing weight and its restoration when the load is removed. It is often associated with calcaneus valgus and may also involve forefoot abduction and supination relative to the midfoot<sup>(1,2)</sup>. One of the most accepted theories is that the plantar arch, because it is excessively flexible and associated with hypermobility of the subtalar joint, generates

conditions that explain the plantar arch planning and the calcaneus valgus<sup>(3)</sup>.

This foot pathology can occur alone or as part of a broader clinical change, such as neuromuscular diseases, genetic syndromes, collagen, and generalized ligament laxity<sup>(4)</sup>.

Generally, the flexible flatfoot in the adolescent is painless, but in some cases, the pain can be present due to changes in its biomechanics, such as hindfoot valgus, forefoot abduction, and plantar arch collapse, causing the feeling of tiredness and

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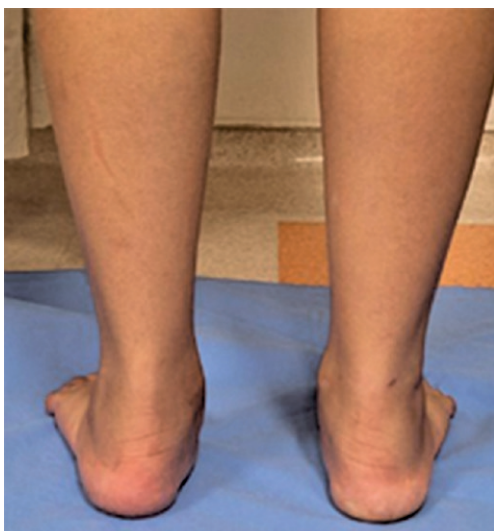
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pain when performing sports activities (Figure 1)<sup>(5)</sup>. It is known that Conservative treatment with orthoses featuring medial arch support, varus wedge, and pronation wedge is indicated when the patient reports pain in the territory of the posterior tibial tendon, despite producing good results regarding the pain, its use is not intended to correct the deformities of the foot<sup>(6)</sup>. Other conservative measures are strengthening the intrinsic and extrinsic foot muscles<sup>(7)</sup>, losing body weight, stretching the calcaneal tendon, and temporarily reducing physical activities.

Surgical treatment may be indicated in painful feet after failure of conservative treatment, especially when there are radiographic changes, including a talonavicular angle exceeding 30%, a talonavicular uncovering angle greater than 7°, and alterations in the talonavicular incongruence angle<sup>(8)</sup>. Other important angles would be the calcaneal valgus angle above 16.00 degrees in the axial incidence, the increase of the Kite angle in the anteroposterior and standing orthostatic profile incidences, the change of the Meary angle in the lateral incidence and the increase of the Mereau Costa Bertani angle above 135.00 degrees<sup>(9)</sup>.

In our study, bone correction was proposed using medializing calcaneal osteotomy, which consists of an oblique osteotomy at 45.00 degrees on the long axis of the calcaneus in profile, medializing the proximal fragment and decreasing the calcaneal valgus. It was also proposed talonavicular capsuloplasty associated with posterior tibial tendon re-tensioning<sup>(10)</sup>.

The objective of the study is to evaluate the correction of the talonavicular coverage incongruency angles through anteroposterior radiographs of the feet after medializing calcaneal osteotomy associated with talonavicular capsuloplasty and posterior tibial tendon re-tensioning in 12 patients (14 feet) aged between 13 and 16 years.



**Figure 1.** Clinical appearance of the patient showing hindfoot valgus.

## Methods

This study was approved by the Institutional Review Board under the number 77477424.5.0000.5415.

This is a retrospective study performed on medical records through radiographs in the anteroposterior and profile incidences in the pre- and postoperative six weeks after the medializing calcaneal osteotomy procedure associated with talonavicular capsuloplasty and posterior tibial tendon re-tensioning. All medical record research was based on ethical values and data confidentiality.

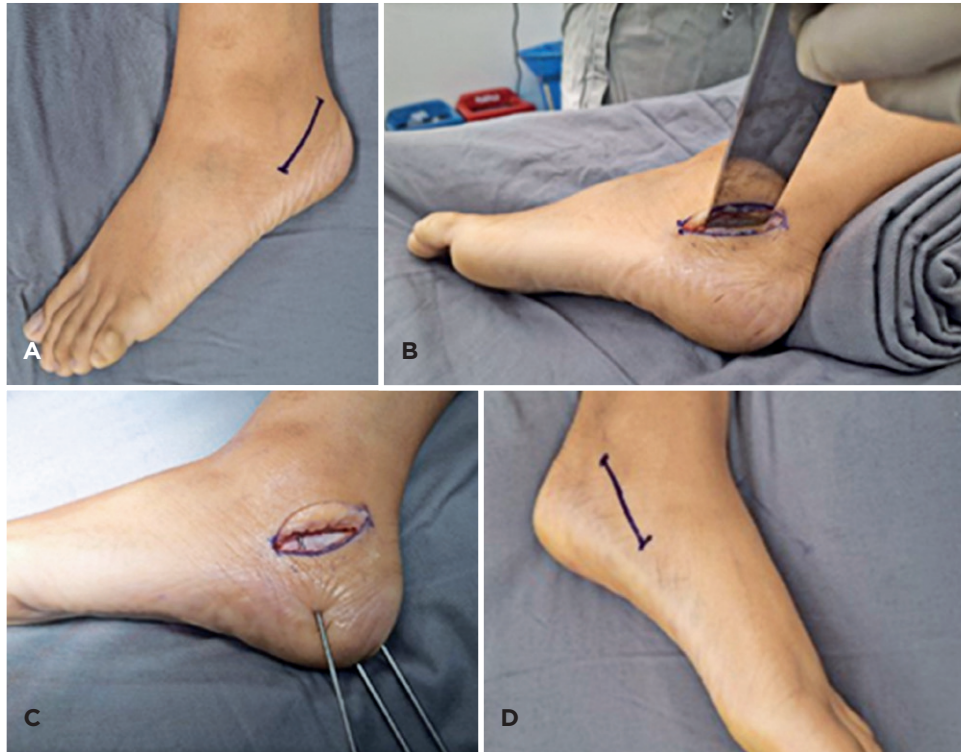
Inclusion criteria were patients submitted to medializing calcaneal osteotomy associated with talonavicular capsuloplasty and posterior tibial tendon re-tensioning. All patients had closed calcaneal epiphyseal plates. Exclusion criteria were patients submitted to medializing calcaneal osteotomy associated with any other bone procedure, such as lateral column lengthening (Evans procedure) or medial cuneiform osteotomy to correct forefoot supination (Cotton procedure). There were no restrictions on sex. Patients with accessory tarsal and navicular coalitions were also excluded.

## Surgical technique

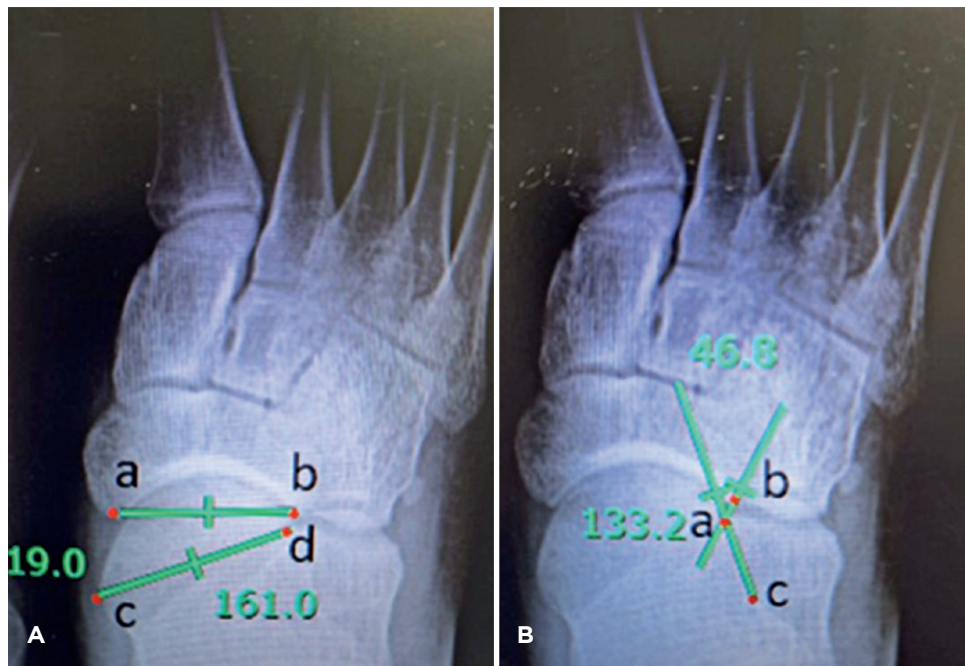
With the patient in dorsal decubitus, a cushion was placed on the buttock ipsilateral to the surgery for elevation and internal rotation of the lower limb. Then, exsanguination and garroting of the limb were performed. To perform the medializing calcaneal osteotomy, an oblique incision was made immediately inferior to the fibular tendons on the lateral face of the calcaneus (Figure 2A), the sural nerve was visualized and removed (Figure 2B). We sought to medialize the calcaneal fragment by approximately 1 cm. After this translation was obtained, the fragments were temporarily fixed with 2 Kirschner wires (Figure 2C) and permanently with two cannulated screws. For the posterior tibial tendon re-tensioning and talonavicular capsuloplasty, an incision was made in the medial surface of the foot (Figure 2D) towards the posterior tibial tendon to the navicular bone, where a number 4 anchor was inserted and assembled with two needles and wires using fiber wire type. A needle was used to advance the posterior tibial tendon, and with a second needle, talonavicular joint re-tensioning in its medial aspect was performed.

## Radiographs evaluation

The talonavicular coverage and talonavicular incongruency angles were evaluated in the anteroposterior incidence. The talonavicular coverage angle was obtained through the lines formed by the lateral and medial points of the articular surface of the talus and navicular, with a mean value of 7.00 degrees (Figure 3A). The talonavicular incongruency angle was also obtained through the measurements drawn on the anteroposterior radiograph, using a line that joins the lateral extension of the articular surface of the talus (point a) and the lateral extension of the navicular surface (point c). A second



**Figure 2.** A) Marking of the lateral incision of the calcaneus, B) Calcaneal osteotomy, C) Temporarily fixation, D) Marking of the medial incision.



**Figure 3.** A) Talonavicular coverage angle on orthostatic anteroposterior radiography. B) Talonavicular incongruency angle on orthostatic anteroposterior radiography.

line was drawn between the lateral face of the talus neck in its narrowest segment (point b) and the lateral extension of the articular surface of the talus (point a). The incongruency angle between these two lines has a normality value ranging from 0 to 5.00 degrees, which changes when it exceeds this value (Figure 3B).

### Statistical evaluation

After data collection, the analysis was conducted using an Excel spreadsheet. Descriptive statistical analysis included calculations of central tendency measures, dispersion, and frequency. For the inferential statistical analysis of quantitative variables, the Kolmogorov-Smirnov test was used to verify the data normality, and appropriate tests were applied to compare quantitative data. The Chi-square test and Fisher's exact test were used to compare frequencies.

Correlation analyses were performed using Pearson and Spearman correlation tests, depending on the nature of the data. The correlation coefficients (r) were classified as follows: r = 0.10 to 0.30 (weak), r = 0.40 to 0.60 (moderate), and r = 0.70 to 1 (strong).

In all analyses, p-value ≤ 0.05 was considered statistically significant. The programs used were Statistical Package For Social Sciences (SPSS, IBM, version 24.0), GraphPad Instat 3.10 (2009), and Prisma 6.07 (2015).

### Results

From March 2020 to November 2023, 12 patients submitted to medializing calcaneal osteotomy associated with talonavicular capsuloplasty and posterior tibial tendon re-tensioning were selected, two patients with bilateral approach totaling 14 feet. Among the patients, 12 were male and four

were female, aged between 13 and 16. Talonavicular coverage and incongruency angles were measured before and after six weeks (Table 1).

The XERO® program was used, all images were selected, and the measurement was performed by a single evaluator.

The talonavicular coverage angle before the surgical procedure ranged from 31.00 to 15.49 degrees, and the mean was 26.20 degrees; the talonavicular coverage angle after the procedure ranged from 10.69 to 0.65 degrees, and the mean was 5.56 degrees, in this evaluation the p-values were < 0.0001 considered extremely significant.

### Discussion

The surgical indication for flexible flatfoot in adolescents is primarily based on the presence of symptoms, particularly when angular deformities of the foot are evident in anteroposterior and lateral incidences. The talonavicular coverage angle must be greater than 7.00 degrees per surgical indication criteria. According to Moraleda et al.<sup>(9)</sup> and Yan et al.,<sup>(11)</sup> several surgical techniques for the correction of deformities were reported, including arthroereisis, medializing calcaneal osteotomy, Evans osteotomy, Cotton osteotomy, and the association between osteotomies and soft tissue procedures<sup>(11)</sup>. In our study, the mean talonavicular coverage angle was 26.20 degrees, which is considered abnormal; in addition to pain, it serves as an indication for corrective surgery. After the medializing calcaneal osteotomy (Figures 4 and 5) associated with talonavicular capsuloplasty and posterior tibial re-tensioning, a mean of 5.56 degrees was obtained. Ghaznavi et al.<sup>(3)</sup>, in a 100-foot study, identified a change with a mean of 13.90 degrees with 4.20 degrees of standard deviation in the talonavicular coverage angle before the medializing calcaneal osteotomy associated with

**Table 1.** Preoperative and postoperative angular values (in degrees)

Patient	Sex	Age	Preoperative talonavicular coverage angle	Postoperative talonavicular coverage angle	Preoperative talonavicular incongruency angle	Postoperative talonavicular incongruency angle
1	M	12	31.00 degrees	3.72 degrees	47.60 degrees	15.00 degrees
2*	M	13	25.15 degrees	5.75 degrees	67.00 degrees	11.00 degrees
2*	M	13	28.78 degrees	10.69 degrees	48.00 degrees	10.00 degrees
3*	M	14	15.49 degrees	4.11 degrees	71.00 degrees	20.00 degrees
3*	M	14	26.20 degrees	6.08 degrees	68.00 degrees	13.00 degrees
4	F	13	24.88 degrees	5.20 degrees	87.00 degrees	0.50 degrees
5	M	12	29.35 degrees	3.06 degrees	57.90 degrees	5.40 degrees
6	F	15	16.15 degrees	5.11 degrees	61.80 degrees	5.40 degrees
7	M	12	19.21 degrees	7.77 degrees	67.70 degrees	9.50 degrees
8	F	13	19.65 degrees	5.75 degrees	35.00 degrees	3.30 degrees
9	M	13	30.72 degrees	5.56 degrees	41.70 degrees	3.00 degrees
10	M	13	28.52 degrees	0.65 degrees	85.50 degrees	6.00 degrees
11	M	14	29.30 degrees	5.75 degrees	81.30 degrees	19.80 degrees
12	M	14	21.50 degrees	4.48 degrees	77.70 degrees	12.20 degrees

\*Patients with bilateral approach., n = 14.

posterior tibial re-tensioning, and mean of 5.70 degrees and 1.80 degrees of standard deviation after the procedure (Figure 6). According to the author, the normal angle is below 7.00 degrees; thus, the procedure was sufficient to return the angular normality<sup>(12)</sup>. Another angle analyzed in our study was the talonavicular incongruency angle, with a preoperative mean of 64.00 degrees. After the procedure, the angular mean increased to 8.65 degrees, with a statistically significant improvement; Deland<sup>(13)</sup> demonstrated that the use of the talonavicular congruency angle is a good measurement parameter for forefoot abduction in the adolescent's flexible flatfoot, a statement corroborated in the study by Ellis et al.<sup>(14)</sup>. In our study, 30 patients with flexible flatfoot were evaluated, the angular values ranged from 22.50 to 118.30

degrees with a mean of 70.40 degrees, before the procedure after the angular values ranged from 5.10 to 11.30 degrees, with a mean of 8.30 and 3.00 of standard deviation as the final result<sup>(15)</sup>(Figure 7).

### Conclusion

The results demonstrated statistically significant improvements in the correction of the talonavicular coverage



**Figure 4.** Lateral radiograph after medializing calcaneal osteotomy and posterior tibial tendon re-tensioning with an anchor inserted in the navicular.



**Figure 6.** Talonavicular coverage angle after six weeks of surgery.




**Figure 5.** Anteroposterior radiograph showing an anchor inserted in the navicular.



**Figure 7.** Talonavicular incongruency after six weeks of surgery.

and incongruency angles following medializing calcaneal osteotomy, associated with talonavicular capsuloplasty and posterior tibial tendon re-tensioning in adolescents with symptomatic flexible flatfoot.

**Authors' contributions:** Each author contributed individual and significantly to the development of this article: RMMO \*(<https://orcid.org/0009-0008-9106-9041>), and MSB \*(<https://orcid.org/0009-0004-4119-0653>), and MGCP \*(<https://orcid.org/0000-0001-9061-8063>) Study conception and design, Data acquisition, Analysis and data interpretation, Drafting of the manuscript and Critical revision; RCP \*(<https://orcid.org/0009-0001-1656-7744>), and LBSF \*(<https://orcid.org/0009-0000-5271-8522>), and GC \*(<https://orcid.org/0009-0007-1441-721X>), and MGF \*(<https://orcid.org/0000-0002-5163-1035>) Data acquisition, Analysis and data interpretation, Drafting of the manuscript. All authors read and approved the final manuscript. \*ORCID (Open Researcher and Contributor ID )

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