

## ORIGINAL ARTICLE

# Navicular tenosuspension with anterior tibialis tendon (Young procedure) associated to calcaneo-stop for the treatment of paediatric flexible flatfoot: clinical and ultrasound study

Elena Samaila, Ingrid Bonetti, Costanza Bruno, Emanuele Argentini, Bruno Magnan

Department of Orthopaedic Surgery, Azienda Ospedaliera Universitaria Integrata, Polo Chirurgico P. Confortini, Verona, Italy

**Summary.** *Background and aim of the work:* Flexible flatfoot is one of the most common deformities in pediatric orthopaedics. Arthroeresis procedures are designed to correct this deformity. Among them, calcaneo-stop is a procedure with both biomechanical and proprioceptive properties. There could be other surgical procedure combined, such as a percutaneous Achilles tendon lengthening and the Gould tibialis posterior retension or Young tibialis anterior navicular tenosuspension. This study analyzed the clinical and sonographic results of 36 patients following flexible flatfoot surgical treatment with a calcaneo-stop arthroeresis combined with Achilles lengthening and a Young procedure. *Methods:* From March 2001 to August 2014, 36 patients (54 feet) were treated with calcaneo-stop arthroeresis, percutaneous Achilles tendon lengthening and Young's tenosuspension. The clinical assessment and a sonography of the anterior tibialis tendon (ATT) were performed in all patients. *Results:* The average follow-up was 7.4 years (range 8 months–14 years) with a satisfactory outcome in 51 feet (94.5%). No major and minor complications were observed. In four cases the calcaneo-stop was removed for pain and low tolerance of the patient. The AOFAS score and the talocalcaneal angle did not have statistically significant in case of ATT was or not still inserted in the navicular at the follow-up. *Conclusions:* The calcaneo-stop procedure is a simple, reliable and minimally invasive procedure for the treatment of pediatric flexible flatfoot. Although the indications for the Young tenosuspension as an isolated procedure is very narrow, it can still be an effective procedure when combined to calcaneo-stop. The key to appropriate utilization is a thorough understanding of the biomechanics of the foot function and a specific appreciation of the function of the ATT. ([www.actabiomedica.it](http://www.actabiomedica.it))

**Key words:** flatfoot, Young's tenosuspension, foot arthroeresis, ultrasound

## Introduction

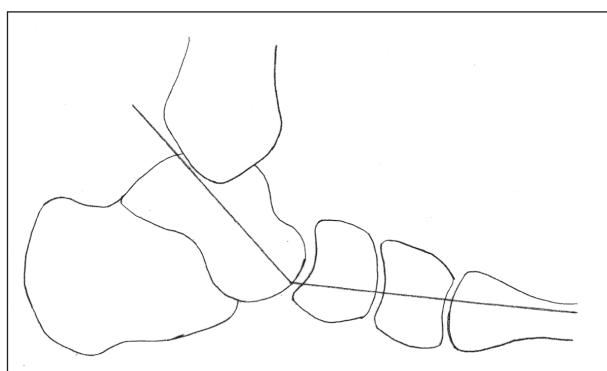
Flexible flatfoot is a one of the most common deformity in pediatric populations (1,2). It is characterized by medial rotation and plantar flexion of the talus, eversion of the calcaneus, collapsed medial arch and abduction of the forefoot with valgus heel position (3,4). Whilst there are differing prevalence estimates for pediatric flatfoot, many studies reports an inverse

relationship between prevalence of flatfeet as children grow older. This is an important consideration in terms of both natural history (5,6). Joint hypermobility and increased weight or obesity may increase flatfoot prevalence, independently of age. The normal findings of flatfoot versus children's age estimates that approximately 45% of children until five years and 15% average age 10 years have flatfeet. Most flexible flatfoot cases resolve spontaneously or remain asymptomatic (7). In

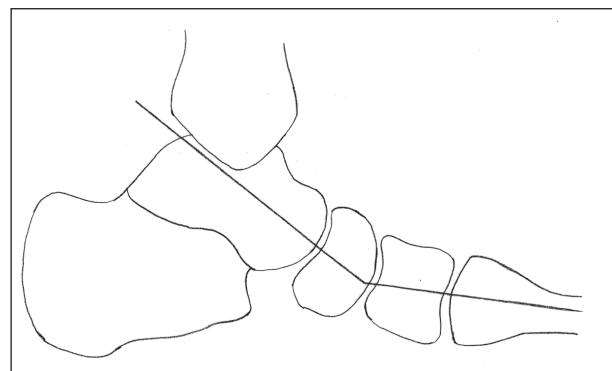
children with symptomatic or pathological flatfeet the surgical treatment is indicated and numerous surgical procedures to correct flatfoot have been proposed during the last century (8-10). Surgical treatment offers three possibilities: arthroeresis, arthrodesis and osteotomy. Nowadays the gold standard of treatment of flatfoot in childhood is arthroeresis. Among them, the calcaneo-stop is a procedure with both biomechanical limitation of the subtalar joint pronation and proprioceptive properties (11,12). It is designed for pediatric treatment and despite many different implants have been proposed for arthroeresis, including bone graft, polyethylene, silicone, reabsorbable, and metallic implants (13), the calcaneo-stop procedure is generally performed by a metal screw implant into the calcaneal "notch" in the sinus tarsi. There are other surgical procedures that can be performed in association with an arthroeresis: a percutaneous Achilles tendon lengthening and/or medial surgical procedure such as capsule-tendon retentions of the medial arch that are used as combined procedures for TP insufficiency/laxity (14). The main goal of the treatment is the restoration of the talo-calcaneal alignment and arthroeresis represents today the golden standard procedure for this.

Our algorithm for treatment of the flatfoot in childhood is an arthroeresis associated to:

1. a navicular resection and retention of the tibialis posterior tendon (Kidner-Gould) (15) in presence of a talo-navicular sub-luxation (the Meary line is broken at the talo-navicular joint) (Fig. 1);



**Figure 1.** The Meary line is broken at the talo-navicular joint: a navicular resection and retention of the tibialis posterior tendon (Kidner-Gould) is indicated



**Figure 2.** The Meary line is broken at the navicular-cuneiform joint: a navicular tenosuspension with the anterior tibialis tendon (ATT) (Young procedure) is indicated

2. a navicular tenosuspension with the anterior tibialis tendon (ATT) (Young procedure) (16) when there is a navicular-cuneiform sub-luxation (the Meary line is broken at the navicular-cuneiform joint) (Fig. 2).

## Objectives

Ultrasound of the anterior tibialis tendon after surgery: does it remain in the navicular after surgery?

## Methods

From March 2001 to August 2014, 36 patients (54 feet) were treated with calcaneo-stop arthroeresis, percutaneous Achilles tendon lengthening and Young's tenosuspension. For arthroeresis a steel or titanium screw device (TECRES S.p.A, Sommacampagna - Italy) was employed. There were twenty-two males and fourteen females, with a mean age  $11.8 \pm 2.9$  years (range 8.1-16.4 years) at the time of surgery and thirty-three feet were symptomatic. The procedure was performed bilaterally, in another surgical session, in eighteen cases.

Weight-bearing radiographs in an anteroposterior and lateral views of the foot were taken preoperatively and in all cases there was a navicular-cuneiform sub-luxation (the Meary line was broken at the navicular-cuneiform joint).

The clinical evaluation found out that all feet presented a calcaneus valgus up to  $15^\circ$  without correction

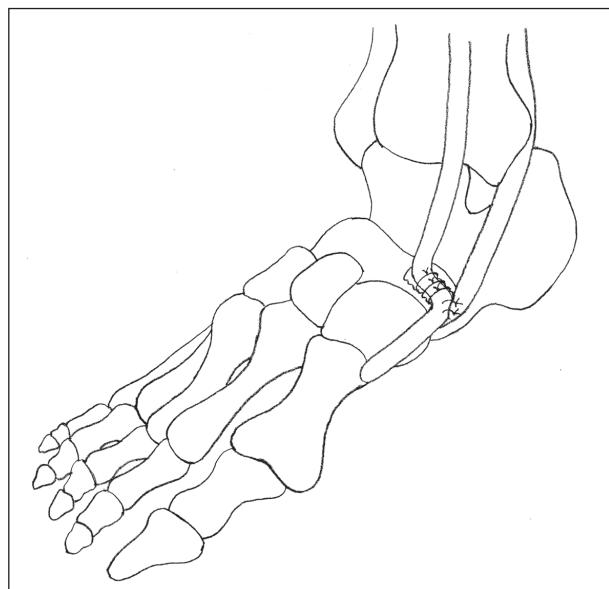
during the functional tests (Jack's test and digitigrade walking) and a short Achilles tendon.

The hindfoot American Orthopaedic Foot and Ankle Society Score (A.O.F.A.S.) (17) was used for the clinical assessment and the sonography study of the anterior tibialis tendon was performed in all patients at final follow-up.

### Surgical technique

In 1939 Young (16) described an "operative treatment of pes planus". This tenosuspension entails rerouting all or one-half of the tibialis anterior tendon through a slot fashioned in the navicular. The tendon is not detached from its insertion at the medial-plantar aspect of the medial cuneiform-first metatarsal base (Fig. 3).

The procedure begins with a medial approach with a horizontal incision made through the periosteum over the medial cuneiform and navicular bones (Fig. 4a). The tibialis posterior is isolated and a resection of the medial prominence of navicular is performed. Then the tibialis anterior tendon is identified under the deep fascia and extensor retinaculum (Fig. 4b) and a tunnel is performed in the navicular from dorsal to plantar and proximal to distal with a micromotorized ball (Fig. 4c) bone-cutter which is then transformed in a groove



**Figure 3.** Outline of Young procedure

(Fig. 4d). The anterior tibialis tendon is pulled into the groove (Fig. 4e) while the foot is held in full supination and transosseous sutures are performed with a tenodesis between anterior and posterior tibialis tendons (Fig. 4f).

In the post-operatively the foot is casted in a natural dorsiflexion position and a below knee walking cast is kept in place for 4 weeks, while weight-bearing is allowed during the fourth week.

### Results

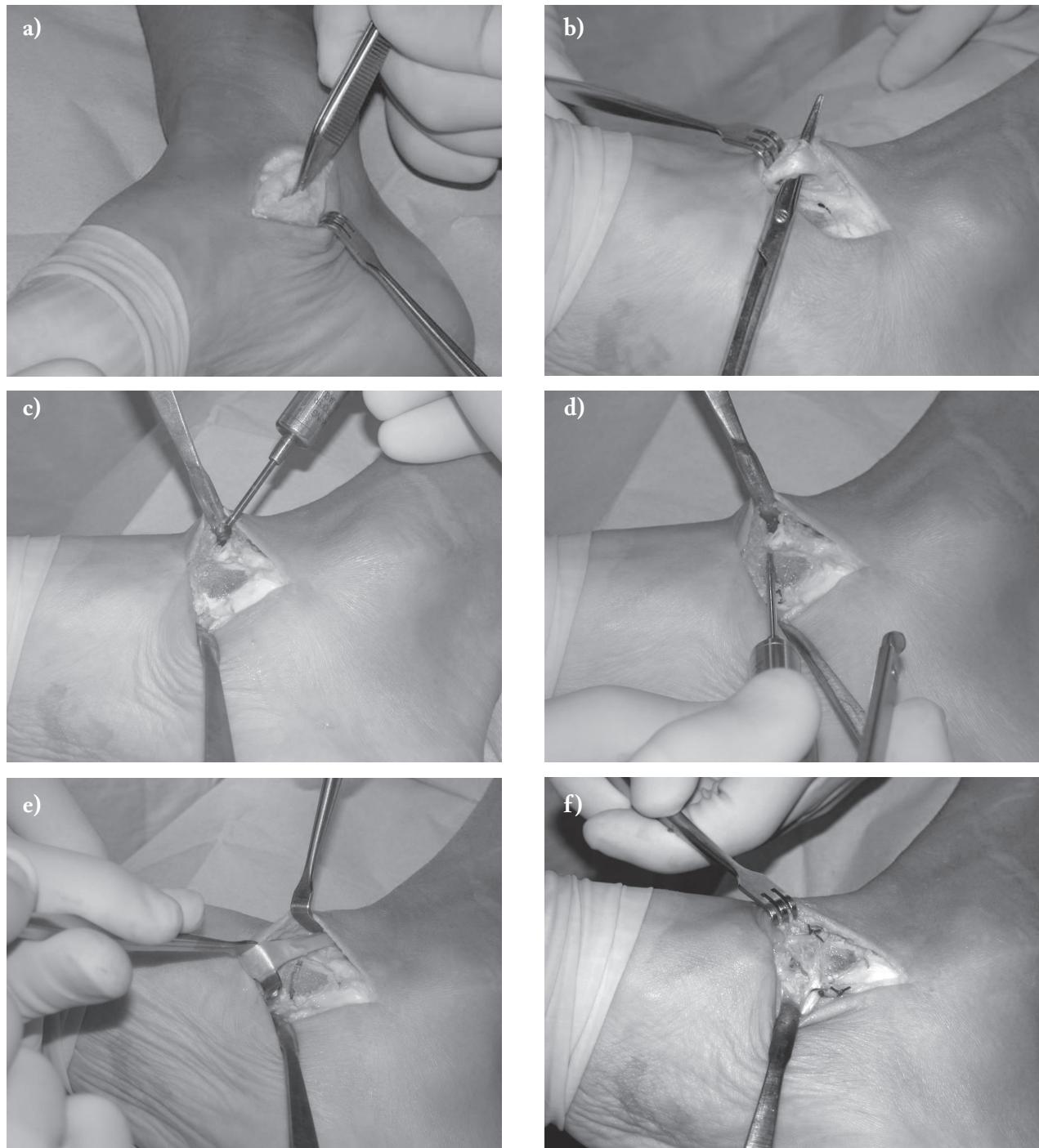
The average follow-up was 7.4 years (range 8 months–14 years). At final follow-up, the outcome was satisfactory in 51 feet (94.5%). The patients were classified into two groups: group A (28 cases, 51.8%) those in which ATT was still found in the keyhole slot in the navicular at the time of follow-up by the ultrasound assessment (Fig. 5) and group B (26 cases, 48.2%) those cases with an ATT disinserted from the groove.

The mean AOFAS score at final follow-up was  $95.3 \pm 4.7$  in group A and  $94.7 \pm 5.3$  in group B. The mean talocalcaneal angle was  $5.39 \pm 2.35$  in group A and  $5.76 \pm 1.84$  in the group B. These results did not have statistically significant in case of ATT was or not inserted on navicular. All the patients were asymptomatic at follow-up. The dorsiflexion was improved to  $10^\circ$ – $15^\circ$  after the percutaneous tendon Achilles lengthening. The mean time of the foot casting was  $30.2 \pm 2.8$  days (range 28–50) and the mean time after weight-bearing with cast was  $21.8 \pm 7.3$  days (range 15–40).

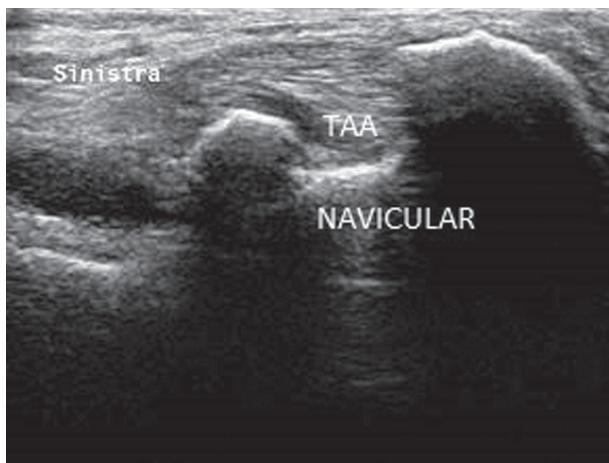
No major complications were observed. In four cases (7.4%) the metal screw device used for calcaneostop was removed for pain and low tolerance by the patient. At the final follow-up the symptoms before surgery were resolved in all patients and in 51 cases (94.5%) there was the correction of calcaneo valgus during walking.

### Discussion

The pediatric flatfoot is a frequent presentation in clinical practice (19). Because of the continuous changes in the musculoskeletal system as growth progresses, it is important to begin conservative treatment



**Figure 4.** (a) Medial approach with a horizontal incision made through the periosteum over the medial cuneiform and navicular bones. The tibialis posterior is isolated and a resection of the medial prominence of navicular is performed. (b) The tibialis anterior tendon is identified under the deep fascia and extensor retinaculum. (c) A tunnel is performed in the navicular from dorsal to plantar and proximal to distal with a micromotorized ball bone-cutter. (d) The tunnel is transformed in a groove. (e) The anterior tibialis tendon is pulled into the groove. (f) While the foot is held in full supination and transosseous sutures are performed with a tenodesis between anterior and posterior tibialis tendons.



**Figure 5.** The sonography at 7.5 years at follow-up evidence that the ATT was still found in the keyhole slot in the navicular

as early as possible to prevent exacerbation of the deformities (20,21). When the conservative approach fails to reduce planovalgus deformity and children present with pain in the foot or the ankle region or fatigue after physical activity, surgical correction must be considered (22). Numerous kinds of implants (re-absorbable devices, titanium or steel screws) for the correction of flexible flatfoot have been proposed in the literature (8,9,23,24). In our study we implanted a steel or titanium calcaneal screw for calcaneo-stop procedure. At a mean follow-up period of 7.4 years this treatment provided good outcomes with a 92.6% good to excellent level of patient satisfaction. We think that an important issue of this treatment is the proprioceptive mechanism than maintained the calcaneus in neutral position(11,12,25).

For the pre-operative planning is very important to evaluate if it is necessary to perform a medial surgical procedure or Achilles tendon lengthening for adequate correction. If the Meary's line is broken at the navicular-cuneiform joint the Young's tenosuspension can be considered to a greater extent correction of the medial arch. In our study the TAA tendon was found in the navicular keyhole in 51.8% of the feet at a mean follow-up of 7.4 years and no difference in function was observed. Also the clinical results (A.O.F.A.S. score and talocalcaneal angle) did not presented statistically significant between the groups. This observation can be due to the fact that in about half of our patients the tibialis anterior tendon was detached from the na-

vicular bone after a certain amount of time that it was not possible to determine in our study, but probably enough to enhance and maintain the correction. On the other hand, it could also be argued that there is some doubt about the real role of this tendon transfer. In a retrospective study the subtalar arthroeresis associated to an Achilles tendon lengthening with or without Young tenosuspension was compared and there was a significant difference in the reduction of forefoot supination; in fact it was greater in patients on which the tenosuspension was performed (26).

The major complications of the arthroeresis include persistent sinus tarsi pain correlated of the implant (biodegradable or not), osteonecrosis, subtalar joint arthrosis, overcorrection, loosened or broken implant (2,27). In our study in four patients (7.4%) there was a sinus tarsi pain and the implant was removed with complete reversal of symptoms to restore complete and painless motion in the subtalar joint.

## Conclusions

The calcaneo-stop procedure is a simple, reliable and minimally invasive procedure for the treatment of pediatric flexible flatfoot. It allows alignment of the talus and calcaneus restoring a proper foot arch. Although the criteria of using the Young's suspension as an isolated procedure is very narrow, it can still be an effective procedure when combined with arthroeresis, as shown in our algorithm. Ultrasound of the ATT demonstrated its presence in the navicular groove at medium-long term ( $86.8 \text{ months} \pm 31.6 \text{ min}$  follow up 8 months) in 51.7% of cases. It was not possible understanding which should be the minimum cut-off period for the ATT permanence in the navicular before it's return to the origin, probably should be the same.

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Correspondence:

Elena Samaila, MD  
Orthopaedic Department  
University of Verona  
Azienda Ospedaliera Universitaria Integrata  
di Verona  
Tel. +39 045 812 7690  
Fax +39 045 812 3578  
E-mail: elenasamaila@yahoo.it