USE OF A LARGE GAUGE NEEDLE FOR PERCUTANEOUS SECTIONING OF THE ACHILLES TENDON IN CONGENITAL CLUBFOOT

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ABSTRACT

Objective: To evaluate the percutaneous Achilles tendon sectioning technique using a large gauge needle for the correction of residual equinus of congenital clubfoot treated with the Ponseti method. Methods: Fifty-seven Achilles tendon sections were prospectively evaluated in thirty-nine patients with clubfoot, treated with the Ponseti method between July 2005 and December 2008. The tenotomy was performed percutaneously with a large gauge needle. Ultrasound scan was performed immediately after the section, to ascertain whether the tenotomy was complete, as well as stump separation. Results: There was complete tendon section in all cases, but the need to perform the section maneuver more than once was common, due to the persistence of the residual strands between tendon stumps. The Thompson test and dynamic ultrasound evaluation were able to detect incomplete tenotomies. The mean ultrasound measurement of the tendon gap was 5.70 $\pm$ 2.23 mm. Two patients had abnormal bleeding, which was controlled by digital pressure and did not compromise foot perfusion. Conclusion: Percutaneous Achilles tendon sectioning with a needle proved to be efficient and safe to correct residual equinus of clubfoot treated with the Ponseti technique.

Keywords: Clubfoot/ultrasound. Achilles tendon. Foot deformities.

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INTRODUCTION

Idiopathic congenital clubfoot is an important deformity due to frequency and difficulty of treatment. It consists of complex malignment of the foot that involves soft and bony parts which is characterized by equinovarus hindfoot, and midfoot and forefoot cavus and adduction.[1-5]

Advances in knowledge about the possible etiology and pathological anatomy of clubfoot, which in the recent past, sought the correction of deformities by means of extensive surgical releases,[6] and today is geared towards correction with conservative methods that are becoming less and less aggressive.

The Ponseti[1,4,7] method is becoming increasingly widespread today, with many favorable reports in several countries.[5,8-10] Treatment should be started early, in the first days of life, and its principle is to perform serial manipulation and plaster changing with a specific technique for sequential correction of deformities.

Studies proved that the Ponseti technique was able to significantly reduce the need of surgical release,[8,11-14] when compared to previous treatment methods. The wide acceptance of the method extended its use to cases of idiopathic clubfeet in older children;[15-17] complex and resistant feet;[18] recurrent feet,[19] including relapses after extensive surgical release,[20] and also, in non-idiopathic case, such as in myelomeningocele[21] and distal arthrogryposis.[22,23]

However, about 85% of the cases treated with the Ponseti technique require percutaneous sectioning of the Achilles tendon for residual equinus correction.[1,4,8,10,15,24,25] Therefore, percutaneous sectioning of the Achilles tendon may be the only surgical procedure necessary for the correction of the majority of feet affected.

All the authors declare that there is no potential conflict of interest referring to this article.

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The sectioning of the Achilles tendon is simple, effective and involves low risks. However, complications related to the procedure, such as excessive bleeding[24] and the formation of a pseudoaneurysm, were described.[26]
Less invasive procedures are developed with the objective of decreasing surgical aggressiveness, morbidity and costs. Thus in the last few decades there has been considerable progress in microsurgery and in video-assisted surgery. Percutaneous surgery with a needle was described previously, in the orthopedic field, for the treatment of trigger finger.[27-30]
Minkowitz et al.[31] published a modification for the sectioning of the Achilles tendon, performing this procedure percutaneously with a large gauge hypodermic needle. The technique with needle may possibly have advantages when compared to others tendon lengthening techniques, duo to the minimally invasive approach, the simplicity and very low morbidity. simplicity and, Some surgeons perform these procedures the operative room, which raises the cost and exposes the patients to anesthetic risks. Percutaneous tenotomy with a needle is performed in an outpatient setting and under local anesthesia. The surgeon avoids incising the skin. As it is a recent technique, it is a good idea to have it validated by other authors and this is one of the justifications for our present investigation.
The aim of this report is to present the technique and our experience with it, using ultrasonography as an evaluation method. It is not our objective to make a comparison with other techniques.

MATERIAL AND METHODS

It is prospective study that was approved by the Institutional Review Board of Hospital das Clínicas of the School of Medicine of Ribeirão Preto of the University of São Paulo and the parents or guardians authorized the participation of their children or wards in the study with means of a written consent form.
The following inclusion criteria were established: (1) children with idiopathic or syndromic congenital clubfoot, treated by the Ponseti technique and submitted to percutaneous sectioning with a needle of the Achilles tendon for correction of residual equinus; (2) primary treatment and follow-up performed completely at our institution, (3) performance of tenotomy under ultrasonographic control, to confirm whether it was complete.
No upper age limit was established, but the patients should not yet have started to walk.
The exclusion criteria included the non-acceptance of the parents in participation in the study and performance of the procedure in a operative room, without ultrasonographic control.
Thirty-seven patients with idiopathic congenital clubfoot, one patient with myelomeningocele and one with urinary system malformation were submitted to treatment with the Ponseti technique and percutaneous tenotomy with a needle, totaling 57 feet affected and submitted to tenotomy (two cases with bilateral involvement did not require tenotomy on one of the feet, due to equinus correction with plaster changes), between July 2005 and December 2008.
The ultrasonographic exams were performed by two radiologists specialized in musculoskeletal evaluation (M.H.N.B. and M.N.S.), with Aspen™ Siemens Medical Solutions (Mountain View, California, USA) and HD 11 Ultrasound System Philips Medical Systems, Ltda. (Bothell, Washington, USA) equipment, with linear transducer from 7 to 10 MHz (L7). The images were viewed in real time, on the longitudinal and transversal planes in relation to the tendon. The following tendon characteristics were evaluated: thickness, echogenicity, echotexture, peritendineal structures and the best site for the sectioning, which corresponded to the thinner portion of the tendon body. Figure 1 shows the Achilles tendon viewed in the ultrasonography, prior to the tenotomy. The tendon (arrow) is the structure with homogeneously echoic fibrillar texture surrounded by a hyperechoic peritendon (arrowhead). The Achilles tendon bursa (B), the musculotendinous junction of the flexor hallucis longus (FHL), the tibia (T), the cartilaginous (C) and bony (B) portion of the calcaneus are identified.

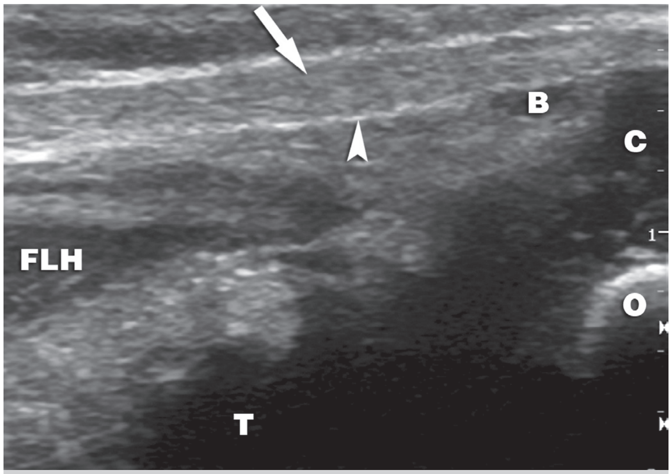

Figure 1 – *Ultrasonographic aspect of the Achilles tendon in a patient with idiopathic clubfoot at the age of two months, before the tenotomy. Median longitudinal scan at the level of the ankle.*

(Source: material obtained by the author).

The percutaneous Achilles tendon sectioning with a needle was performed in an outpatient setting, by residents in training in pediatric orthopedics, under the supervision of a trained pediatric orthopedic surgeon (D.A.C.M.). The procedure followed the technique recommended by Minkowitz et al.,[31] with the use of a large gauge hypodermic needle with regular bevel (caliber 1.6 mm and length 40 mm - BD PrecisionGlide®, Becton Dickinson,).
Thirty minutes before the procedure, a solution of 6% chloral hydrate (1 ml / 2 kg of weight) was administered orally for sedation purposes, and anesthetic cream was applied on the skin over the region of the Achilles tendon (lidocaine 2.5% and prilocaine 2.5%; cream). (Figure 2A)
The patient was placed in supine position, was the knee flexed ~90º and the hip was abducted to allow access to the posterior portion of the leg and foot. An assistant maintained the positioning of the limb. Antisepsis was performed with a solution of 2% degerming chlorhexidine, followed by the were positioned a solution of 0.5% alcoholic chlorhexidine, then preparation of sterile fields. Local anesthesia was used with a solution of 1% lidocaine (~0.2 mL) injected with an insulin needle in the dermis and subcutaneous tissue, at the region of the entrance of the needle for performance of the tenotomy. (Figure 2B)

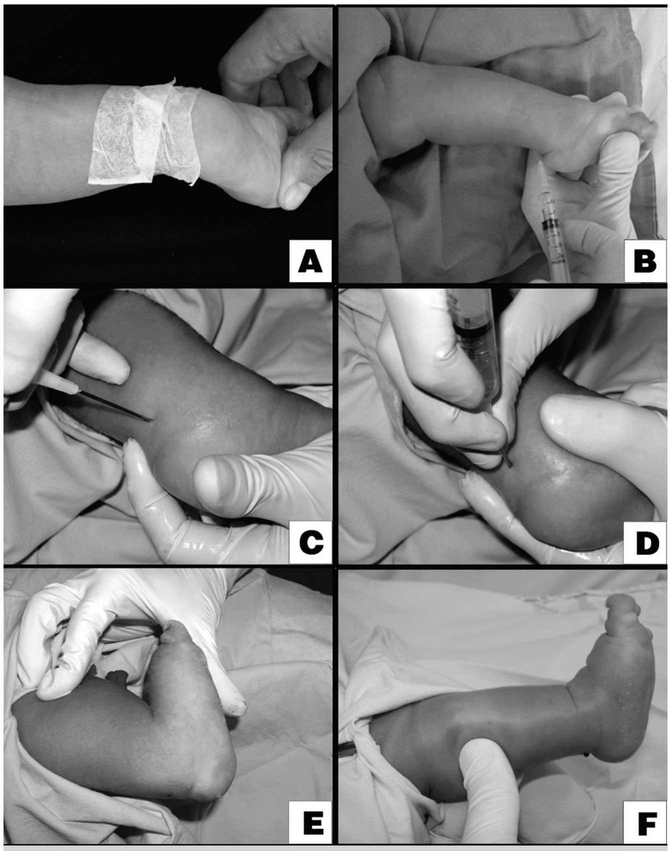

Figure 2 – *A to F – Technical steps of the percutaneous sectioning of the Achilles tendon with a needle.*

The foot was forced in dorsiflexion causing the Achilles tendon to become tense and easily palpable. Care was taken to avoid injuring the posteromedial vasculonervous bundle (posterior tibial). The tendon sectioning was executed with the needle of caliber 16, attached to a 3.0 mL syringe, to facilitate grip and control over the positioning of the needle. In this manner, the needle was inserted shallowly in the medial edge of the Achilles tendon, about 1.0 to 2.0 cm proximal to insertion. (Figure 2C) The needle bevel was used as a blade, sectioning the tendon through lateralization and elevation movements of the cutting end. (Figure 2D) The sectioning was perceived with a click and sudden increase of dorsiflexion. (Figure 2E) The tendon, the entrance point, the section and the continuity solution between the stumps were visualized and recorded by the ultrasonography performed at this time, under aseptic and antiseptic techniques. Finally, a solution of 1.0% lidocaine (0.5 mL) was injected in the space between the stumps.

There was an investigation of the clinical signs of success of the tenotomy, which were increase of dorsiflexion, palpable depression over the tendon in the sectioning region and lack of foot movement, with manual squeezing of the calf, (Figure 2F) which characterizes positive Thompson sign.[32] In the ultrasonograph it was evaluated whether there was complete tendon sectioning with the appearance of distance between the stumps filled by hematoma, and dynamically, absence of transmission of movements between the tendon stumps during flexoextension of the foot and calf compression maneuver (ultrasonographic Thompson).[33,34]

The tendon gap was gauged with the foot in neutral position and measured ultrasonographically. A light pressure on the tenotomized was performed for hemostasis the circulatory conditions of the toes was observed.

The same procedure was then performed on the other foot in cases with bilateral involvement.

Afterwards, plaster cast immobilization was performed with the knee flexed ~90 degrees and the foot positioned in maximum dorsiflexion and abduction of ~70 degrees. The patient remained under observation for around half an hour, with attention paid to general state, circulatory conditions of the ankles and signs of bleeding. Postoperative analgesia was performed with sodium dipyrone or paracetamol, administered orally.

RESULTS

Between July 2005 and December 2008, thirty-nine patients completed the inclusion criteria, with 57 feet affected (nineteen cases with unilateral involvement, twenty cases with bilateral involvement, but in two of them, one foot did not require tenotomy for equinus correction).

The mean age at start of treatment was 6.5 weeks, with standard deviation (SD) of seven weeks and ranged from three days to 30 weeks (median of 2.85 weeks). The mean number of plaster changes was nine (SD=3.53). The mean age at the time of the tenotomy was 16.7 weeks (SD=8.7) and ranged from 6.3 to 40.5 weeks (median of 14.3 weeks).

Clinically, after the complete tenotomy, there was equinus correction in all the cases, evidenced by the increase of dorsiflexion and by the depression formed between the stumps, with palpation of the tendon gap. Concerning the Thompson maneuver, there was no transmission of movements from the calf muscles to the heel.

The ultrasonographic exam performed immediately after the tenotomy demonstrated section of the Achilles tendon with formation of hypoechoic area with debris and mean distance between the stumps of 5.70 mm (variation: 2.3 to 11.0 mm; SD=2.20 mm; median=5.5 mm). After the tenotomy and equinus correction, the ultrasonography (Figure 3) evidenced distancing between the stumps (arrows) and in the resulting space (arrowheads), an initial reverberating echotexture image ocurred as a result of air penetration in the tenotomy focus. (Figure 3A) Soon afterwards, this space was filled by hematoma (Figure 3B). The bursa of calcaneal tendon (b) and the cartilaginous portion (C) of the calcaneus are identified in Figure 3.

However, in some cases, some residual tendon connection persisted between the stumps, which the ultrasonography was able to identify in the static and dynamic imaging, as well as by means of the Thompson maneuver (clinical and ultrasonographic). These residual bundles were completely sectioned, afterwards, under ultrasonographic view. (Figure 4)

The Thompson maneuver, both clinical and ultrasonographic, seemed to be very sensitive for the residual connections detection on incomplete tenotomy, when it was performed with attention paid to the transmission of movements to the heel.

There were two cases of abnormal bleeding after the tenotomy, which ceased with digital pressure and did not cause implication of perfusion of the feet or interference in the final treatment.

There were no cases of post-tenotomy local infection.

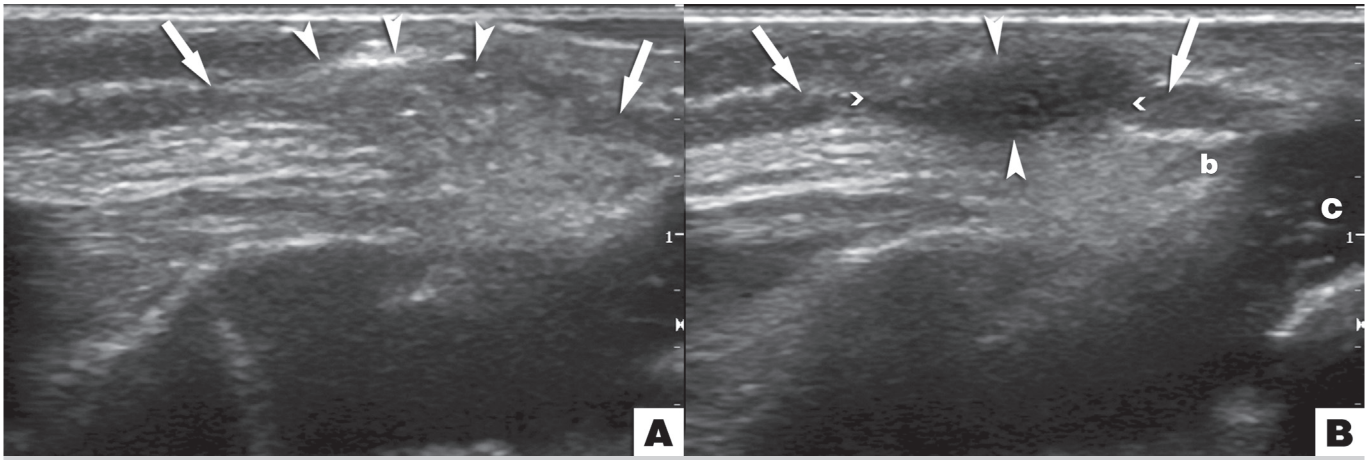

Figure 3 – *Longitudinal ultrasonographic image of the Achilles tendon (arrows) in clubfoot, soon after the tenotomy, with distance between the stumps. The resulting space (arrowheads) is initially filled by air (A) and soon afterwards, hematoma (B).*

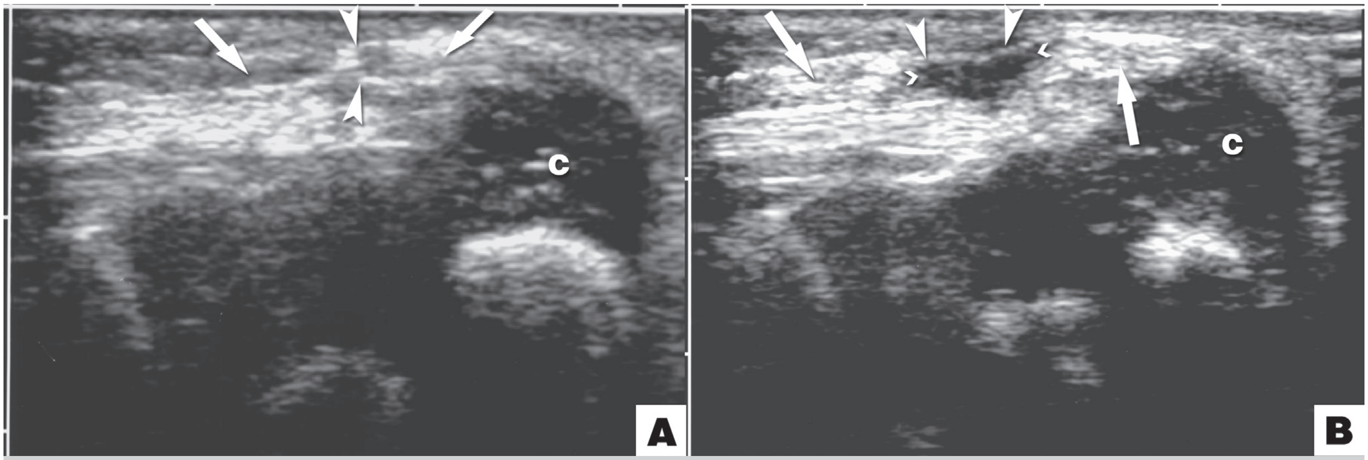

Figure 4 – *Longitudinal ultrasonographic image of the Achilles tendon (arrows) in clubfoot, soon after the tenotomy. A) The arrowheads indentify remaining connection fibers after an incomplete tenotomy. B) After a new maneuver, the tendon was completely sectioned (arrowheads).*

DISCUSSION

Residual equinus in congenital clubfoot treatment with the Ponseti method has been receiving special attention, as it is resistant to manipulations and plaster changes. According to Ippolito and Ponseti,[35] the retraction of the posterior ligaments of the hindfoot produces plantar flexion, but there is associated shortening of the triceps surae, which makes difficult the equinus correction by the manipulative method.[1] In view of this evidence, the Achilles tendon sectioning becomes necessary for the complete normalization of relations among bones and to obtain a plantigrade foot.

However, there have been reports of complications related to percutaneous tenotomy, such as excessive bleeding[24] and appearance of a pseudoaneurysm.[26]

The ophthalmic scalpel blade used by Ponseti is long and has a sharp end, characteristics that would theoretically predispose to the lesion of the structures lateral to the Achilles tendon. Accordingly, the use of a shorter ophthalmic scalpel blade with a rounded extremity was suggested.[24] In the case of the abovementioned pseudoaneurysm, a conventional 15 blade was used. This may[26] be the instrument most widely used in our field for performing the percutaneous tenotomy. To avoid such accidents, some authors suggested the performance of open instead of percutaneous tenotomy, through a small incision.[24,36]

In this investigation, we followed the treatment technique recommended by Ponseti [1,4,7,37,38] However, we performed the tenotomy with a large gauge needle as recommended by Minkowitz et al.,[31] as we consider the technique simple, inexpensive, and theoretically, with lower morbidity. Percutaneous sectioning with a needle has already been practiced for tendon release in trigger finger and is considered safe and efficient.[27-30]

There is a constant search for procedures with increasingly better and less invasive results in Medicine, as besides being less aggressive, they are also less costly and can be performed in an outpatient setting. Therefore, new fields are developed, such as video-assisted surgeries and biological fixations of fractures. However, regardless of the percutaneous tenotomy technique, with the conventional or ophthalmic scalpel or with a needle, there will always be uncertainty about whether the tendon was totally sectioned. Our results with the needle show that some connection between the stumps may persist and not be clinically realized, which could theoretically influence the equinus correction. This feature is probably not exclusively related to the technique with needle, but surgeon-dependent, despite the instruments used in the tenotomy. Obviously, the thicker the instrument and the less experienced the surgeon, the greater the chance of injury of the vessels, represented mainly by the posterior fibular artery posterior and small saphenous vein,[24] as well as by other neighboring structures of the Achilles tendon.

The care with the tenotomy is also justified in view of the vascular anatomical variations that are frequently found in clubfoot. In the report of the case of pseudoaneurysm, referred above, the authors described close proximity of the Achilles tendon with the posterior tibial vasculonervous bundle, in a "Z"-shaped Achilles tendon lengthening surgery, for correction of recurrent equinus in the contralateral foot.[26] The patient had undergone magnetic nuclear angioresonance, prior to surgery, and there was evidence of single blood supply through the posterior tibial artery, which was the reason why the authors contraindicated percutaneous tenotomy and performed it through a small access.

Another vascular anomaly in clubfoot is the absence or insufficiency of the anterior tibial artery, which may present frequency of up to 85%, in some studies.[24,39-47] In these cases, the blood supply is provided by the posterior tibial artery, which is anatomically close to the Achilles tendon and potentially at risk during the tenotomy.

There was also a description of the absence or insufficiency of the posterior tibial artery in clubfoot.[43,45,46,48,49] In these uncommon cases, with deficiency of the blood supply through the anterior and posterior tibial arteries, the fibular artery becomes dominant and should be carefully protected in clubfoot release surgeries, as well as in Achilles tendon sectioning procedures.[24,43,49]

clubfoot may have a decreased basal blood supply in relation to the normal foot. If there is only one artery, and if it is injured, there may be vascular suffering, gangrene, partial or complete necrosis of the foot and risk of amputation.[24,26]

Therefore, precautions that increase the safety of this procedure are important,[24] since as the Ponseti method becomes popular, more patients will be treated by different physicians and the possibility of complications increases.

The search for the anterior and posterior tibial pulses, carried out prior to the tenotomy, was described as a supplementary measure for the procedure and, in cases with both pulses absent, the recommendation was to perform a Doppler ultrasonography to locate the nutrient arteries.[24,40] In relation to the distal vascular exam, Sodré et al.[40] considered the Doppler relatively limited as a continuous wave technique, since the method does not discriminate between the smaller and larger vessels and the exam can be positive in places where there is absence of the pedious artery proved by the arteriography. However, the ultrasonography with color Doppler and pulsed waves allows better identification of the contours, caliber, blood flow direction and anatomical relations of the vessels.[47] If the ultrasonography with Doppler is inconclusive, the arteriography or angioresonance can be done to characterize the vascular anatomy.[5,24,41,43]

Another precaution would be the performance of the tenotomy through a small access that visualizes the tendon directly.[36] In our opinion, this option should be used preferentially in cases of a single dominant artery in the blood supply of the foot.

In literature, other safe and non-invasive ways of dealing with residual equinus have been sought, such as the use of botulinum toxin applied in the surae triceps, on the grounds that attenuation of muscle activity in association with manipulations and plaster changes, would facilitate correction.[50] These authors concluded that the method is safe and effective. However, in a later report by Ramachandran and Eastwood[51], with a randomized prospective study, which involved 20 newborns with CCF, there was no benefit in the use of botulinum toxin in association with manipulations and plaster changes.

In our methodology, we introduced the ultrasonographic exam as a means of ensuring that the tenotomy was complete, particularly when using a needle, which is a relatively new technique and without other reports in literature. This precaution was not observed in previous studies, even in the most important ones.

In our experience, the ultrasonographic exam would be very useful for cases in which the tenotomy proves especially difficult (feet with very severe equinus, small and fat) or, also, upon suspicion of vascular anomalies. However, the exam should be carried out by an experienced professional, as a dependent examiner, and under conditions of asepsis and antisepsis, which may represent some difficulty. On the other hand, the routine use of the exam represents a complicating factor and additional cost for the procedure.

A section of the tendon may be diagnosed by the ultrasonographic exam. When it is complete, there is distancing between the stumps due to proximal retraction, with the appearance of a space that is filled acutely by hematoma that is expressed as echographic debris. In the more chronic or late-onset cases, the space is filled by fibrous tissue. In the dynamic evaluation with flexion-extension of the ankle, there is no transmission of movements from the ankle to the proximal stump of the tendon and the Thompson maneuver[32] adapted to the ultrasonography[33,34] is positive. In this maneuver, with the knee flexed 90 degrees, and the foot free of support, the muscular venter of the calf is squeezed manually, aiming to cause retraction and to provoke plantar flexion of the ankle.[32] When there is completes discontinuity of the tendon, the ultrasonography does not show transmission of movements from the proximal to the distal stump. In this exam, other signs may suggest complete lesion of the Achilles tendon: herniation of Kager's fat into the site of the lesion, refraction artifacts with acoustic shadow and even herniation of the plantar muscle.[34]

When the lesion is incomplete, a well-defined hypoechoic image appears at the rupture site, yet without affecting the entire tendon thickness; the proximal stump does not undergo retraction and, upon dynamic maneuver, there is transmission of movement from the heel to the calf through the tendon. Therefore, the Thompson test adapted to ultrasonography is negative.[34]

We concluded that the technique described here is viable and relatively simple for those orthopedists already familiar with percutaneous tenotomy. The results provide support to the safety of the procedure, but an upper limit of age for its performance has not yet been established. This issue may be an important point in the near future, as the Ponseti method is being used in older children[15-17] or children with associated syndromes,[21-23] which may be a topic of further investigations.

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