



2023

Section: Orthopedics

Comparative Study between Percutaneous Elongation and Z- Lengthening of Tight Achilles Tendon in Idiopathic Toe Walking Children

Eissa Ragheb Refaie

Department of orthopedic surgery, Faculty of Medicine For Boys, Al-Azhar University, Cairo, Egypt.

Mohamed Adel Abdelhamid Ibrahim

Department of orthopedic surgery, Faculty of Medicine For Boys, Al-Azhar University, Cairo, Egypt.

Mohamed Shawky Abdelsamie

Department of orthopedic surgery, Faculty of Medicine For Boys, Al-Azhar University, Cairo, Egypt., mohamedshawky.226@azhar.edu.eg

Follow this and additional works at: <https://aimj.researchcommons.org/journal>



Part of the [Medical Sciences Commons](#), [Obstetrics and Gynecology Commons](#), and the [Surgery Commons](#)

How to Cite This Article

Refaie, Eissa Ragheb; Ibrahim, Mohamed Adel Abdelhamid; and Abdelsamie, Mohamed Shawky (2023) "Comparative Study between Percutaneous Elongation and Z- Lengthening of Tight Achilles Tendon in Idiopathic Toe Walking Children," *Al-Azhar International Medical Journal*: Vol. 4: Iss. 12, Article 43. DOI: <https://doi.org/10.58675/2682-339X.2145>

This Original Article is brought to you for free and open access by Al-Azhar International Medical Journal. It has been accepted for inclusion in Al-Azhar International Medical Journal by an authorized editor of Al-Azhar International Medical Journal. For more information, please contact dryasserhelmy@gmail.com.

Comparative Study Between Percutaneous Elongation and Z-lengthening of Tight Achilles Tendon in Idiopathic Toe Walking Children

Eissa Ragheb Refaie, Mohamed Adel Abdelhamid Ibrahim,
Mohamed Shawky Abdelsamie*

Department of Orthopedic Surgery, Faculty of Medicine for Boys, Al-Azhar University, Cairo, Egypt

Abstract

Background: Idiopathic toe-walking (ITW) is a gait pattern in which the child walks on the balls of their feet or their toes without touch of the heel to the ground, in the absence of known medical conditions as neuromuscular problems.

Objective: To compare the two surgical methods for lengthening of Achilles tendon in ITW children with tight heel cords, regarding the technique of the operation, postoperative complication rates, functional results, and advantages of one technique over the other.

Materials and methods: A prospective study was done in the Hospitals of Al-Azhar University (Bab El Shaerrya, and Al-Hussein Hospitals), between October 2022 to May 2023, on ITW children with tight heel cords undergoing surgery for elongation of Tendo Achilles, chose two methods of lengthening, Open, and Percutaneous.

Results: All patients had excellent functional and satisfaction outcomes except 3 cases had fair satisfaction due to recurrence (inappropriate postoperative protocol): 2 feet of those treated by open technique (group B), 1 foot of those treated by percutaneous technique (group A). As regards complications no reported complications, except for one foot which had a superficial infection in group B, and improved after serial dressing and antibiotics, our follow-up period was 6 months postoperatively.

Conclusion: The technique of Percutaneous elongation technique is recommended as Open Z-lengthening technique for the treatment of ITW children with tight heel cord, because it produced excellent results in terms of safety, useful results, satisfaction, and the avoidance of additional morbidities at surgical site.

Keywords: Children, Idiopathic toe walking, Open lengthening, Percutaneous lengthening, Tight heel cord

1. Introduction

Toe walking means the initiation of the gait's stance phase on the toes or forefoot rather than the heel. It is regarded as a normal gait development stage up to the age of 3 years.¹ According to estimates, between 7 and 24 % of children population are affected.²

The diagnosis of idiopathic toe walking (ITW) is one of exclusion; it can only be made when all other possible explanations have been eliminated. Pediatricians, neurologists, podiatrists, and pediatric orthopedic surgeons frequently see children who are

toe walking, because severe plantar flexion of ankle impairs the gait of the child and prevents him from engaging in functional play.³

A thorough history is obtained, followed by a thorough physical examination and neurological examination. The child's toe walking may be pathogenic if their medical history, physical examination, or neurologic exam are abnormal. A referral to neurology is then necessary to assess for potential pathologic reasons. So, the child is diagnosed as an idiopathic toe walker only, if the condition being present with the onset of walking, the physical examination is unremarkable, and no additional

Accepted 9 August 2023.
Available online 5 March 2024

* Corresponding author at: Department of Orthopedic Surgery, Al-Hussein University Hospital, Gawhar AlKaed Street, Al-Darrasa, Cairo, 11651, Egypt.
Fax: 0225128927.
E-mail address: MohamedShawky.226@azhar.edu.eg (M.S. Abdelsamie).

<https://doi.org/10.58675/2682-339X.2145>

2682-339X/© 2023 The author. Published by Al-Azhar University, Faculty of Medicine. This is an open access article under the CC BY-SA 4.0 license (<https://creativecommons.org/licenses/by-sa/4.0/>).

causes have been found. Once ITW has been diagnosed, the age of the child and the results of the physical examination will determine the course of treatment.⁴

Many different forms of treatment have been proposed, including physiotherapy, serial casting, and open or percutaneous surgery. In children who have a fixed equinus contracture, the surgical elongation of the triceps surae muscle–tendon complex is recommended. Considering the outcomes of the Silfverskiöld test, the surgical procedure should be chosen. Patients with restricted dorsiflexion of the ankle while the knee joint is flexed and extended should have their Achilles tendon lengthened, while those with limited ankle dorsiflexion who only have their knee extended should have their gastrocnemius lengthened. We advise moving through the appropriate surgical lengthening operation in cases with fixed deformity or after failure of nonsurgical treatment methods.^{5–7}

In the literature there is disagreement on the best method for lengthening of tight Achilles tendon, so in our study we compared 2 surgical options for lengthening of the tight heel cord in ITW children, open Z-lengthening of Achilles tendon, and the percutaneous elongation technique.^{8,9}

Our study aimed to compare the effect of percutaneous elongation and Z-lengthening of the tight Achilles tendon on gait pattern, and functional outcome of ITW children.

2. Materials and methods

From October 2022 to May 2023, a prospective study was carried out in the hospitals connected to Al-Azhar University (Bab El Shaerrya, and Al-Hussein Hospitals), on 12 patients (8 males and 4 female), 12 feet. Their average age was 6 years (3–13 years). They all ITW child with tight heel cords after the failure of conservative treatment, nine on the left and 11 on the right side. Ten feet were treated with percutaneous elongation and 10 feet were treated with Z-lengthening of the tight Achilles tendon (Fig. 1).

2.1. Inclusion and exclusion criteria

All of the cases in this study were more than 3 years, toe walking, could Walk independently but on toes with falling frequently, with moderate to severe heel cord contracture and equinus, no previous history of Achilles tendon lengthening, and failed conservative treatment.

Patients who are under 3 years, patients older than 13 years, and patients with known causes for toe walking were excluded from the study.

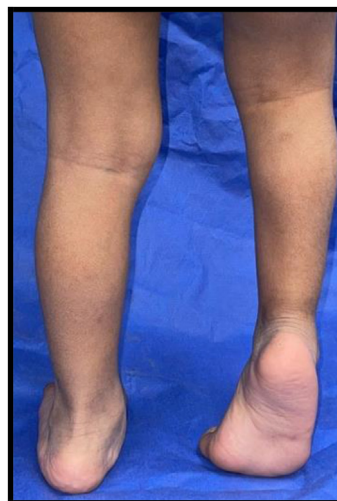


Fig. 1. Idiopathic toe walking child.

Demographic evaluation: name, age, sex, residence, and telephone no. of relative, clinical history: of ITW to exclude other causes of toe walking, and clinically: for the deformity, any skin condition, bilateral leg length, range of movement, neurovascular state, and any associated conditions, degree of Equinus deformity, and Silverskjold test results.

Prior to surgery, all patients underwent routine evaluations (laboratory, chest radiograph, pediatric, and anesthesia consultations) to determine their suitability for surgery, and consent for the operation was taken.

2.2. Operative procedures

There were two operative techniques used on patients included in our study, percutaneous Elongation and Z-lengthening technique.

2.3. Percutaneous elongation of the heel cord

They were preparing the patient and giving appropriate anesthesia, spinal or general anesthesia. We prefer supine position, keeping the feet a short distance from the table's edge, the location of the incision was marked, the tourniquet was inflated and the patient was draped. Following the creation of three 0.5 cm long longitudinal skin incisions, hemostatic forceps were used to dissect the subcutaneous tissue.

We make three partial tenotomies in the heel cord as follows: first, we make the first medial one, placing it 0.5 cm away from the proximal calcaneus, just above the tendon insertion in the calcaneus; through cutting the half of the width of the tendon. Next, make the second highest tenotomy medially, site Just below the musculotendinous junction.

Then, make the third tenotomy laterally, site 5 cm away from the most distal incision, through the half of the width of the tendon in between the two medial cuts (Fig. 2).

After that the ankle dorsiflexion was gradually increased, and heel cord lengthening was carried out by the slidable tendon. The goal of surgical treatment was attained when ankle joint dorsiflexion exceeded 10° .^{10–12}

2.4. Open Z-lengthening of the tendon

A longitudinal posterior skin incision is made, medial to the heel cord, the tendon sheath is then opened, then a long longitudinal split is done down the tendon's center. The tendon is then divided by making cuts at the bottom and top of the split in either the medial and lateral or anterior and posterior directions. The knee is extended, the ankle joint is dorsiflexed to neutral, and the foot is in the neutral position. Multiple horizontal mattress sutures are used to stitch the tendon together in tension. To reduce adhesions, the paratenon and skin are stitched carefully and separately.⁸ (Figs. 3 and 4).

2.5. Post-operative

First, above knee cast is left in place for three weeks with the knee bent at a 15° angle, with the understanding that it should be changed after fifteen days to assess the wound's healing, remove any skin stitches used for open-type lengthening, and install a new above knee cast to complete the 3 weeks. Then below knee cast is left in place for another 3 weeks after that we remove the cast and start physiotherapy. Postoperative physiotherapy is an important section of our surgery, after the removal the cast, it will increase the muscles

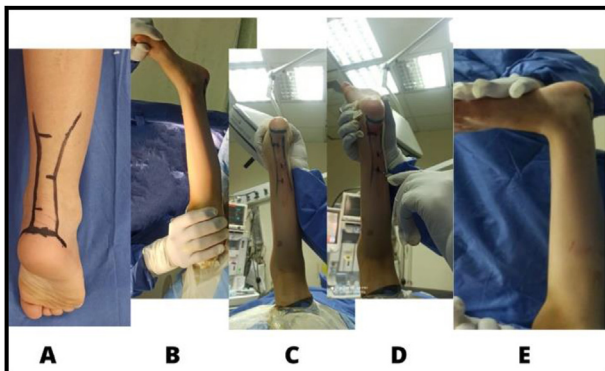


Fig. 2. Incision position was marked (A), Patient supine position (B), Three 0.5 cm longitudinal incisions at the skin (C), blade rotated 90° (D), ankle joint dorsiflexion was increased above 10° (E).

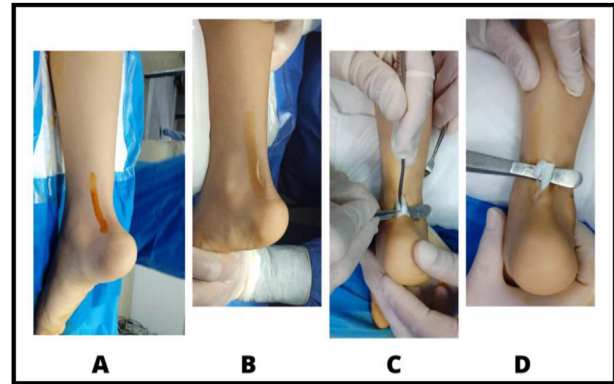


Fig. 3. Incision position was marked (A), Paramedian skin incisions (B), longitudinal split of the tendon (C), the tendon divided in a z-fashion (D).

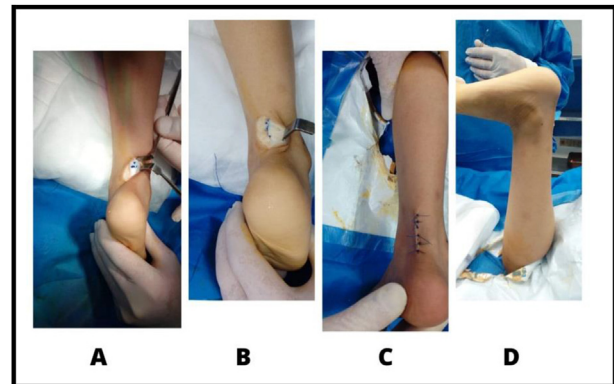


Fig. 4. Side-to-side tendon repair (A), closure of the paratenon (B), closure of skin (C), ankle joint dorsiflexion increased more than 10° (D).

strength and improve the gait and range of movement.¹³

Follow-up our cases was done every 2 weeks in the first 6 weeks postoperatively, and 4 weeks until about 6 months postoperatively in our outpatient clinic (Fig. 5), but the follow-up in some patients was

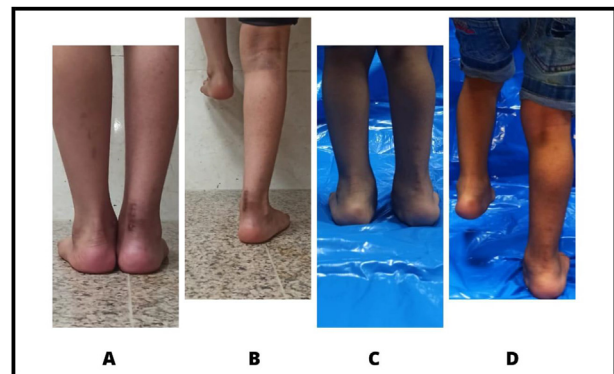


Fig. 5. Standing child, 6 months postoperatively of percutaneous Achilles tendon lengthening (A), single limb heel rise (B). Standing child, 6 months postoperatively of open Z-lengthening (C), single limb heel rise (D).

not regular due to noncompliance for postoperative protocol. However, most of cases are clinically investigated after 6 months, the outcomes were collected according to: operative time, hospital stay, assessment of ankle function by American Orthopedic Foot and Ankle Score (AOFAS),¹⁴ complication, equinus recurrence rate.

2.6. Ethical considerations

Objectives of the study were clarified and informed consent had been taken from the parents' verbal and written on ethical paper with privacy.

2.7. Statistical analysis

The statistical analysis was done using the SPSS 22.0 application for Windows (Chicago, IL, USA, 2007). While continuous (quantitative) variables are presented such mean SD, categorical (qualitative) variables are displayed as percentages. Additionally, the variance analysis test [paired t-test] compared continuous variables, whereas the χ^2 test analyzed categorical variables between groups (Table 1).

3. Results

This prospective study included 12 patients (8 bilateral and 4 unilateral giving total number of 20 feet). With an average age of 6 years, who have ITW with tight heel cord, (10) of those feet treated by Percutaneous Elongation Technique group A. (10) of them were treated by Open Z-Lengthening Technique group B (Table 2).

The AOFAS score exhibited significant progress in both techniques. For Percutaneous Technique: mean AOFAS score increased from 65.91 ± 9.43 preoperatively to 95.87 ± 3.82 at final follow-up, For Open Technique: the AOFAS score increased from 64.28 ± 7.52 to 86.34 ± 9.33 . AOFAS score is significantly higher in group A compared with group B postoperatively. However, there is no significant difference between the groups regarding preoperative AOFAS (Table 3).

Table 1. Demographic data of the two studied groups.

Variable	Group A (n = 6)	Group B (n = 6)	t/ χ^2	P
Age (y)				
Mean \pm SD	5.61 ± 1.27	5.78 ± 1.14	0.557	0.584
Sex				
Male	4 (66.67 %)	4 (66.67 %)	–	>0.99
Female	2 (33.33 %)	2 (33.33 %)		

Table 2. American Orthopedic Foot and Ankle score of the two studied groups.

	Group A (n = 10)	Group B (n = 10)	T	P
Preoperative				
Mean \pm SD	65.91 ± 9.43	64.28 ± 7.52	0.427	0.674
Postoperative				
Mean \pm SD	95.87 ± 3.82	86.34 ± 9.33	2.99	0.008

On outpatient clinic follow-up, for Percutaneous Technique: 1 (10 %) feet developed recurrence, 1 (10 %) feet with limited ankle dorsiflexion, no incision and infection complication occurred. For Open Technique: 2 (20 %) feet developed recurrence, 1 (10 %) feet with limited ankle dorsiflexion, 1 (10 %) feet with superficial infection, there is no significant difference between the two studied groups regarding complications.

4. Discussion

A toe walk is an irregular gait where the forefoot bears the majority of the weight and the normal heel strike is absent. After an ITW diagnosis has been made, we suggest a course of treatment depending on the child's age and the results of the physical examination.⁵

We think observation is the best course of action for toddlers under 3 years old because many youngsters eventually develop a more typical heel-toe walking pattern. We believe that observation, passive stretching, bracing, or a short leg casting are all viable treatments for children older than 3 years old who have dynamic toe walking without a permanent contracture of the ankle, because the superiority of any one particular treatment approach has not been established. We advise surgical elongation of the triceps surae muscle–tendon complex in children who have a fixed contracture of the ankle. The surgical technique should be chosen depending on the Silfverskiöld test findings.^{5–7,15}

In our study, the American Orthopedic Foot and Ankle Society scoring system has been accepted as a valid tool for the clinical assessment of the patients

Table 3. Complication recorded for both techniques.

	Percutaneous	Open	P
Infection	0	1	0.171
Recurrence	1	2	
Slight stiffness	1	1	
Hematoma formation	0	0	
Wound edge necrosis	0	0	
Bleeding	0	0	
Sural N. injury	0	0	
Calcaneus deformity	0	0	
Inadvertent tenotomy	0	0	

with the pathologies of hind foot. The AOFAS score increased from 65.91 ± 9.43 preoperatively to 95.87 ± 3.82 at the end of follow-up, whereas the score in group B increased from 64.28 ± 7.52 to 86.34 ± 9.33 , the average improvement in group A according to AOFAS score was 29.96 while in group B was 22.06, which was significantly greater in group A than group B postoperatively. However, there is no discernible difference between the groups regarding preoperative AOFAS.

We achieved similar outcomes to Yangjing Lin et al.,¹⁰ who examined 30 cases of open Z-lengthening (group B), and 25 cases of percutaneous Achilles tendon lengthening (group A) during the same time period. The average period of follow-up in group A was 42.04 months, but it took 61.7 months in group B. The mean AOFAS score in group A went from 64 ± 10.16 points preoperatively to 96.08 ± 3.17 points after the trial, whereas the score in group B was increased from 63.48 ± 6.2 points to 85.4 ± 10 .

Additionally, Shivanna et al.¹⁶ conducted a review following the percutaneous triple-level Achilles tendon tenotomy treatment of 51 cases with equinus deformity. The mean AOFAS score climbed from 53 % points before the treatment to 96 % at the end of the study, which is similarly consistent with our findings using the percutaneous sliding approach.

As regards our study no reported wound infection except in one case in group B which was superficial and treated by serial dressing and antibiotics. We have favorable results compared with Khatri et al.¹⁷ who reported wound infection in 12 (23.0 %) cases after treating 37 patients with tight heel cored with Z-lengthening operation.

Yangjing Lin et al.,¹⁰ reported no infection complication and incision in group A, but rate of infection in group B was 3.3 % which is lower than our study due to relatively larger sample size.

In line with the present study Ammar et al.,¹⁸ reported, 2 feet developed wound infection: 1 (7 %) foot was superficial infection, 1 (7 %) foot was deep infection, in cases treated by Open method. No complications for those treated by percutaneous technique.

Regarding recurrence rate, in our study, 1 (10 %) foot developed recurrence in group A, and 2 (20 %) feet developed recurrence in group B, it was because neglect of postoperative physiotherapy, the recurrence rate in group B was 20 %, rate of recurrence between group A and group B was significant may due to high adhesions rate in open type.

As well Hall's et al.,¹⁹ reviewed that the Achilles tendon was contracted in all 20 patients with an average age of 8 years, and the dorsal extension of the ankle ranged from -30 to -60° . The 20 patients underwent surgery to extend their Achilles tendons

after first being monitored for 6–24 months. Follow-up following surgery lasted anywhere from 1.5 to 7 years, with a mean of roughly 3 years. All of the children at the follow-up stage walked normally with their toes occasionally touching the ground.

Hemo et al.²⁰ looked into surgically lengthening the heel cord in patients between the ages of 4 and 13. They showed that surgery enhanced dorsiflexion of the ankle with no causing the triceps surae muscles to weaken.

In comparable results, Yangjing Lin et al.¹⁰ reported recurrence of equinus was 4 % in group A, and 21.4 % in group B. This result is slightly higher than our study in the open lengthening type which may be a relatively larger sample size, and lower than our study in the percutaneous type which may be a relatively small sample size of our study.

Regarding the mean operative time, our study was 15.4 ± 2.1 min in group A and 50.7 ± 8.39 min in group B. The mean hospitalization days was 1.4 ± 0.516 days in group A and 2.7 ± 0.823 days in group B. Group A were less than those in group B in both previous data.

In agreement with our study Yangjing Lin et al.¹⁰ who reported that the total operating time, and average hospitalization period were shorter in group A than group B.

Finally, we reach full correction in all cases either done by percutaneous elongation or open Z-lengthening of the tight heel cord, but complications more in open than percutaneous through superficial infection, slight stiffness, prolonged operation time, hospital stay, and high recurrence rate relatively, additionally, we should focus, especially in the first 6 months, because neglect is a major cause of early and late difficulties in both other studies and our one, that is what are we recommending.

4.1. Strength and limitation

The positive features of our study that we used the similar score of other surgeons who performing surgical correction methods of equinus deformity for evaluation of the functional outcome of the patient postoperative (AOFAS). So, we can simply compare our outcomes with them. Though, the limitation in our study is a small number of cases, short period of follow-up, and the moderate to severe equinus deformity among ITW children is not so common.

4.2. Conclusion

This study concluded that the Percutaneous elongation technique of tight heel cord in ITW

children is recommended than Open Z-lengthening technique, as seen in our study, high rate of parental satisfaction, shorter hospital stays and operating times, lower incidence rates of incision complications, and improved soft tissue strength balance between ankle plantarflexion and dorsiflexion, assisting in preventing the abnormality from recurring.

Disclosure

The authors have no financial interest to declare about the content of this article.

Authorship

All authors have a substantial contribution to the article.

Conflicts of interest

The authors declared that there were NO conflicts of Interest.

References

- De Oliveira V, Arrebola L, De Oliveira P, Yi L. Investigation of muscle strength, motor coordination and balance in children with idiopathic toe walking: a case-control study. *Dev Neurorehabil.* 2021;24:540–546.
- Caserta A, Reedman S, Morgan P, Williams CM. Physical activity and quality of life in children with idiopathic toe walking: a cross sectional study. *BMC Pediatr.* 2022;22:1–8.
- Soangra R, Shiraishi M, Beuttler R, et al. Foot contact dynamics and fall risk among children diagnosed with idiopathic toe walking. *Appl Sci.* 2021;11:2862.
- Caserta A, Morgan P, McKay MJ, Baldwin JN, Burns J, Williams C. Children with idiopathic toe walking display differences in lower limb joint ranges and strength compared to peers: a case control study. *J Foot Ankle Res.* 2022;15:1–8.
- Bartoletta J, Tsao E, Bouchard M. A retrospective analysis of nonoperative treatment techniques for idiopathic toe walking in children: outcomes and predictors of success. *PM&R.* 2021; 13:1127–1135.
- Caserta AJ, Pacey V, Fahey M, Gray K, Engelbert RH, Williams CM. Interventions for idiopathic toe walking. *Cochrane Database Syst Rev.* 2019;10(10):1–41. CD012363. <https://doi.org/10.1002/14651858.CD012363>.
- Brierty A, Walsh HPJ, Jeffries P, Graham D, Horan S, Carty C. Dynamic muscle-tendon length following zone 2 calf lengthening surgery in two populations with equinus gait: idiopathic Toe Walkers and Cerebral Palsy. *Clin BioMech.* 2021;84:105323.
- Kim HT, Oh JS, Lee JS, Lee TH. Z-lengthening of the Achilles tendon with transverse skin incision. *Clin Orthop Surg.* 2014;6: 208–215.
- Dietz FR, Albright JC, Dolan L. Medium-term follow-up of Achilles tendon lengthening in the treatment of ankle equinus in cerebral palsy. *Iowa Orthop J.* 2006;26:27–32.
- Lin Y, Cao J, Zhang C, Yang L, Duan X. Modified percutaneous achilles tendon lengthening by triple hemisection for achilles tendon contracture. *Biomed Res Int.* 2019; 2019(1491796):660–672. <https://doi.org/10.1155/2019/1491796>.
- Phillips S, Shah A, Staggers JR. Anatomic evaluation of percutaneous Achilles tendon lengthening. *Foot Ankle Int.* 2018;39:500–505.
- Hoh TK, Hung RW, Steinberg JS, Raspovic KM. A wound complication after percutaneous Achilles tendon lengthening requiring surgical excision: a case report. *J Foot Ankle Surg.* 2017;56:680–682.
- Harris J, Gelfer Y, Cashman J, Eyre-Brook A, Kothari A. Current management of idiopathic toe-walking gait in children and young people in the UK: a cross-sectional survey to reflect physiotherapists' and surgeons' perspective. *J Surg.* 2022;7:1688.
- Van Lieshout EMM, De Boer AS, Meuffels DE, et al. American Orthopaedic Foot and Ankle Society (AOFAS) Ankle-Hindfoot Score: a study protocol for the translation and validation of the Dutch language version. *BMJ Open.* 2017;7(2): 1–8. e012884. <https://doi.org/10.1136/bmjopen-2016-012884>.
- Armand S, Watelain E, Mercier M, et al. Identification and classification of toe-walkers based on ankle kinematics, using a data mining method. *Gait Posture.* 2006;23:240–248.
- Richetta S, Andreacchio A, Monforte S. Percutaneous Achilles tenotomy using a 18 gauge needle in the treatment of clubfoot with Ponseti method. *Pediatr Med Chir.* 2022;44(s1): 10.4081/pmc.2022.295.
- Khatri KK, Akhund MA, Tunio ZH, Shah NH, Jhatiyal RA, Jokhio MF. Results of Achilles tendon lengthening using Z-plasty in equinus feet. *Pakistan J Med Health Sci.* 2019;1:127–135.
- Jaddue DAK, Abbas MA, Sayed-Noor AS. Open versus percutaneous tendo-achilles lengthening in spastic cerebral palsy with equines deformity of the foot in children. *J Surg Orthop Adv.* 2010 Winter;19(4):196–199.
- Hall JD, Salter RB, Bhalla SK. Congenital short tendo calcaneus. *J Bone Jt Surg.* 1967;49:695–697.
- Hemo Y, Macdessi SJ, Pierce RA. Outcome of patients after Achilles tendon lengthening for treatment of idiopathic toe walking. *J Pediatr Orthop.* 2006;26:336–340.