

Achilles Tendon Lengthening in Treatment of Equinus Foot Deformity in Children with Cerebral Palsy

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Abstract: Background: Cerebral palsy (CP) is a neuromusculoskeletal disorder caused by a static encephalopathy and characterized by progressive musculoskeletal pathology in the majority of patients. The most common deformity is ankle equinus, with equinovarus and equinovalgus deformities being equally common. A foot deformity can have significant effects on the patient's overall ambulatory level. **Aim of the Work:** To assess equinus foot deformity in cerebral palsy patients and its management by Achilles tendon lengthening. **Materials and Methods:** A follow-up study was made on 14 children (20 feet) with spastic forms of cerebral palsy in whom 20 Achilles tenoplasties had been performed on an average of 1 year earlier for equinus deformity of the foot. Spastic diplegia was present in 12 cases and 8 had spastic hemiplegia. The age at operation was between 3-11 years. Mean observation time was 9 months, range 6-12 months. **Results:** Results were evaluated according to Pattern of Gait gained after surgery, Parents' satisfaction, Presence or absence of complications and ability to voluntarily dorsiflex the foot between (0-10) degrees. **Conclusion:** Equinus deformity of the foot is one of the most common problems encountered in cerebral palsy. Equinus is defined as the inability to dorsiflex the foot above plantigrade, with the hindfoot in neutral and the knee extended. Equinus disrupts the gait cycle by decreasing stability in stance phase and causing inadequate clearance in swing phase. Open z-plasty lengthening technique through posteromedial longitudinal incision was used in this study. Further studies are needed with larger number of cases, comparison with other methods of Achilles lengthening and with long term follow up. [Mohamed Salah Abd-Elhafeez, Mohamed Abd Elmonem Negm and Emad Mohamed Nagy Mohamed. **Achilles Tendon Lengthening in Treatment of Equinus Foot Deformity in Children with Cerebral Palsy.** *Nat Sci* 2018;16(12):127-132]. ISSN 1545-0740 (print); ISSN 2375-7167 (online). <http://www.sciencepub.net/nature>. 20. doi:[10.7537/marsnsj161218.20](https://doi.org/10.7537/marsnsj161218.20).

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1. Introduction

Cerebral palsy (CP) is a neuromusculoskeletal disorder caused by a static encephalopathy and characterized by progressive musculoskeletal pathology in the majority of patients. The movement disorder, topographical distribution, and severity vary greatly, resulting in a wide range of clinical syndromes or phenotypes. The severity of motor involvement and the severity of the musculoskeletal pathology are closely linked⁽¹⁾.

The topographic classification of CP is monoplegia, hemiplegia, diplegia and quadriplegia; monoplegia and triplegia are relatively uncommon. There is a substantial overlap of the affected areas. In most studies, diplegia is the commonest form^(2,3).

The most typical symptoms of CP are the disorders of movement activities of various degrees and different locations. These are most often contractures of limbs and trunk, mostly of spastic type, balance disorders and motor hyperactivity. A special disorder is the restriction of walking efficiency or a child's inability to walk on its own. The lack of control is especially serious within the ankle joint and foot. The pathological mechanism of the foot movement is mostly visible in the foot support phase

and it results from the foot structural deformation and/or contracture of muscles⁽⁴⁾.

Foot deformities caused by altered or abnormal muscle forces are common in patients with cerebral palsy. The most common deformity is ankle equinus, with equinovarus and equinovalgus deformities being equally common. A foot deformity can have significant effects on the patient's overall ambulatory level. A patient's deformity may change over time, especially in young children. Spasticity of the smaller muscles of the foot can lead to other deformities, such as hallux valgus, claw toes, and forefoot adduction⁽⁵⁾.

Pure calcaneus deformity is rare in patients with cerebral palsy and usually is associated with calcaneovalgus. Cavus deformity is rare in children with cerebral palsy and typically is caused by an imbalance between the extrinsic and intrinsic musculature of the foot⁽⁶⁾.

Surgical lengthening of Tendo Achilles (TA) is one of the most common and widely used orthopedic operations performed to correct equines deformity. It is among the oldest procedure in orthopedics⁽⁷⁾.

There is no uniform agreement of the definition of Equinus. Anecdotally, some use inability to dorsiflex beyond 5 degrees, while others indicate that 10 degrees may be limited⁽⁶⁾. Generally, Ankle

Equinus defined as inability to do or limitation of passive dorsiflexion of the foot at the ankle minimum of 5 degrees with the knee in full extension. This deformity divided as either:

A. Dynamic Equinus: This is passively correctable.

B. Static (Fixed) Equinus: This cannot be passively corrected.

In most cases the deformity starts as Dynamic which turns into Static if not correctly managed. Equinus deformity occurs with high frequency in patients with lower extremity CP in both the Hemiplegic and the Diplegic patients, which limits passive ankle dorsiflexion to less than the neutral position and results in characteristic toe-walking gait⁹. Equinus deformity in spastic CP can be treated by either nonsurgical or surgical method. Many surgical methods are used to correct this deformity such as selective dorsal rhizotomy, neurectomy of some branches of tibial nerve, gastrocnemius head transplantation or anterior advancement of TA, but Surgical Lengthening of the A.T remains the most common and widely used orthopaedic surgery performed to correct equinus deformity. There are different modalities of surgical intervention are performed to elongate the TA¹⁰:

A- Open lengthening of TA: which included:

- **Z-plasty:** The T.A is divided by Z-cut fashion, the vertical part of the incision split the tendinous fibers in the midline of the sagittal plane, at the lower end of this vertical incision the tendon transected medially at its insertion. At the upper end of the incision, near the musculotendinous junction, the tendon is transected laterally¹¹.

- **Open sliding:** Cut the tendon partially at 2 or 3 levels under direct vision as follows:

- The lower cut: done by incise the tendon sheath, and cutting the medial half of the tendon just above its insertion into calcaneum.

- The upper cut: done by incise the tendon sheath and cutting the lateral half of the tendon at a Level below the musculotendinous junction.

- If a third cut is decided, it is done like others in stepwise fashion. 2 cuts at one side and the 3rd between them on the other side as in Open Hoke TA Lengthening Technique.

B- Percutaneous lengthening of TA:

After preparing the patients and giving appropriate anesthesia, with palpation make 3 partial tenotomies in the TA as follows:

1. Make the first medial, just at the insertion of the tendon into the calcaneus; cut through the half of the width of the tendon.

2. Make the second tenotomy proximally and medially, Just below the musculotendinous junction about 5 cm. from the first tenotomy.

3. Make the third tenotomy laterally, through the half of the width of the tendon midway between the two medial cuts. [The two incisions on the medial side if the heel is in slight varus as it usually are].

In our study we used the open z-lengthening procedure to elongate the Achilles tendon.

Aim of the work

In this study we reviewed the literature aiming to assess equinus foot deformity in cerebral palsy patients and its management by Achilles tendon lengthening.

The goals of our treatment procedures include:

- Relieve contracture; improve posture & walking and creating as much as possible normal heel-toe gait with good push-off power, in order to facilitate child communication, education, toilet and total body care.

- The lengthening was performed by me at National Institute of Neuro Motor System.

- Follow-up of cases for mean of (9) month at the Outpatient Unit.

The questionnaire included the followings information:

- 1) Demographic: name, age, gender and residence.

- 2) Clinical history of CP.

- 3) Silverskjold test results.

- 4) Degree of Equinus.

- 5) Operative procedures: Open lengthening of TA: which is:

Z-plasty:

The T.A is divided by Z-cut fashion, the vertical part of the incision split the tendinous fibers in the midline of the sagittal plane, at the lower end of this vertical incision the tendon transected medially at its insertion. At the upper end of the incision, near the musculotendinous junction, the tendon is transected laterally.¹²

2. Materials and Methods

Material

Clinical randomized trial carried out in National Institute of Neuro Motor System and Al-Azhar University Hospital for a period of 1 year in 2018 on a convenient sample of 14 ambulatory spastic CP children selected from outpatients unit. 12 boys (4 of them are bilateral) and 8 girls (2 of them are bilateral).

Inclusion criteria

1. Spastic CP children.

2. Equine deformity severe enough [approximately between 10-40 degree of fixed equines (plantar flexion) when examination with extended knee].

3. Toe-Walking gait and difficulties in ambulation.

Exclusion criteria

1. Mild cases which can be treated conservatively.
2. Associated comorbidities.
3. Patients in whom equinus deformity associated with significant component of varus or valgus.
4. Patients younger than (3) years or older than (10) years of age.
5. Patients with dynamic equines deformity, because most of them treated conservatively.
6. Prior foot surgery or trauma to the area of surgical operation.
7. Patients with other neurological disorders or systemic disease potentially affecting the foot or ankle (e.g: Duchenne Muscular Dystrophy).
8. Non ambulant patients.

Method

All patients had shown failure of conservative orthotic treatment for at least six months before surgery. All cases developed progressive equinus deformity.

Surgical indications:

Achilles tendon lengthening was performed in the following:

- 1- Moderate to severe fixed (rigid) equinus deformity not responding to conservative orthotic treatment and physiotherapy.
- 2- Intolerance to footwear or orthoses with or without skin problems.
- 3- Pain either persistent or in relation to walking.

Contraindications:

The procedure was not suitable in the following:

1. Children below 3 years old because of high recurrence rate specially in diplegia.
2. Flexible (correctable) foot deformity in which orthotic treatment or other conservative treatment such as Botox injection (in cases of spasticity not contracture) may be useful.
3. Skin problems at site of incision.
4. Associated bony deformities of foot such as cavovarus and pesplanus.

Surgical technique

Operative procedures:

Under general anesthesia, the patient is supine. A tourniquet is applied in the upper thigh. Skin is prepared and limb draped, with the knee free to provide orientation.

A- Open lengthening of TA which included:

Z-plasty: The T.A is divided by Z-cut fashion, the vertical part of the incision split the tendinous fibers in the midline of the sagittal plane, at the lower end of this vertical incision the tendon transected medially at its insertion. At the upper end of the incision, near the musculotendinous junction, the tendon is transected laterally 7.

Operative steps:

1- The incision is made in the medial aspect just anterior to the bulk of the tendon Achilles (do not make the incision directly posterior). These direct posterior incisions often cause rubbing on the backs of the shoes. The incision is carried down to the subcutaneous tissue by sharp dissection into the peritenon of the tendon Achilles, then the soft tissue is retracted posteriorly.

2- A knife is utilized and longitudinal cut is made through the midsubstance of the tendon Achilles over 3 to 4 cm, with the distal end detached medially if the child has varus tendency (most common) and laterally if the child has valgus tendency (less common) and the contralateral side detached proximally.

3- The tendon is allowed to slide into lengthening, and is repaired with arunning absorbable suture. The tendon should be repaired with the foot in 10 o dorsiflexion so that there is some tension on the muscle with the foot at neutral position.

4- Subcutaneous tissue is closed and the skin is closed in sutures.

5- Sterile dressing of the wound, padding and above knee cast is applied with the knee in full extension and the ankle in neutral position.

Post-operative Measures (After treatment): Above knee cast is left in place with the knee in full extension for 3 weeks, taking in consideration that we should change it after 10 days from operation to check the healing of the wound and remove skin stitches and new above knee cast placed to complete the 3 weeks.

Post-operative Physiotherapy: Post-operative physiotherapy is complementary section for our surgical work, since it will strengthen the muscles and improve coordination of movement and gait. This program starts after 6 weeks from the operation (i.e: after removal of the cast). Then assess if orthotics is needed or not.

Post-Operative Follow-up: Follow-up of cases done weekly in the first 6 weeks postoperatively and 2 weeks interval till about 6 month post-operatively, though in many cases the follow-up was not so regular either because of the family or other causes. However, all patients are clinically reviewed after 6 months, the results were collected and they were based on:

- Assessment of patient's lower limb function (standing, walking & active dorsiflexion and plantar flexion).
- Parent's satisfaction.
- Morbidity and Complications.

And from all of the above we assess the advantages and disadvantages of our method of surgical treatment.

3. Results

Table (1): Gait results after 6 month follow up

Grade	No. of feet	%
Excellent	16	80
Good	2	10
Fair	2	10
Poor	0	0
Total	20	100.0

Table (2): Ability of active dorsiflexion

	No. of feet	%
Able	16	80%
Non able	4	20%
total	20	100%

Table (3): Parents satisfaction

	No. of feet	%
Completely satisfied	15	75%
Little satisfied	3	15%
Not satisfied	2	10%
total	20	100%

Table (4): Description of End result among studied patients

		Studied patients (N = 20)
End result	Excellent	16 (80%)
	Good	2 (10%)
	Fair	2 (10%)
	Poor	0 (0%)

Complications

Table (5): Complication recorded

Complications	Number of feet.
Bleeding	0
Sural N. injury	0
Inadvertent tenotomy	0
Hematoma formation	0
Wound edge necrosis	0
Infection	2
Recurrence	0
Calcaneus deformity	0
Hypertrophic scar	0

Table (6): Description of complications among studied patients

		Studied patients (N = 20)
complications	Yes	2 (10%)
	No	18 (90%)

4. Discussion

In our study we tried to assess the efficacy of open z-lengthening of T.A and correct the equinus deformity depending on the statistics and results we got from the patients in our study.

Graham et al. studied ETA by Open White Slide Technique in 35 hemiplegic children, included patients less than (4) years of age in his study and follow them. He noted that most of the recurrences were in the group of children less than (4) years of age, so he suggested that early surgery are not advised¹³. We nearly follow this advice in our study, and the mean age of children in our study was 6 years with a minimum age of 4 years (2 feet 3years old). In the younger patients (below 4 years of age) even with severe dynamic equinus, some authors still prefer using splints rather than early surgery. As we observed in many anatomy texts this twist is not present in all humans and there is a personal variation. However, in our study (like many other studies e.g.: Marc J. Moreau & David M. Lake study who done Percutaneous Lengthening of T.A for 90 feet of 55 children on an outpatient bases). Heel cord torsion was virtually ignored, and no problems were encountered. There is no any lengthening failure and all tendons remain in continuity¹³.

In our study we got an overall significant improvement of gait in (80%) of cases, and it is near the percentage of Grant AD, et al in his study when gained (84.6%) of significant gait improvement from a total number of 84 feet¹⁴.

Parental Satisfaction is a parameter used by many studies (as in studies of Kogan on 15 children & Moreau on 55 children, on patients treated by Percutaneous method on an outpatient bases), and we think it is an important parameter especially if the family is well educated¹².

The child spends most of the time with the family and his parents who really can touch the changes occur to the child before and after operation, and whether these changes are to the best or to the worse.

Fortunately, most of the parents of the child in our study were completely satisfied with the result. The child's gait and performance were greatly improved and this gives another push to the family to continue on physiotherapy program. In those who are little or not satisfied, the main cause was the development of complications which cause a delay in improvement of child's performance. We think most of these complications developed because of family neglecting or low level of education even to understand our notes and instructions. Regarding Recurrence which defined in our study as any fixed equines greater than (5) degrees which results in toe-heel gait. However when it is below (5) degrees it

seems to be acceptable because it is compatible with near good gait with either flat-footed strike or heel-toe strike when wearing suitable shoe heel⁹.

Voluntary active control of dorsiflexion enables the patient to be free from orthosis more time during the day and can become completely brace free after 2 years post-operatively¹⁵. In our study, we instruct the family that we prefer to continue on night brace till growth completion. We think that prolonged protection of the foot with casting and bracing may account in large part of our success as advised by Grant AD, et al in his long term study for 10 years on 39 cases when shows that there is a decrease in recurrence rate with prolonged management programs with night bracing⁹.

Post-operative care and physiotherapy programs we have outlined in our study seems to be significantly improve both active plantar flexion and dorsiflexion and reduce the recurrence rate that reported in many previous studies¹⁶.

In our study, the psychological support has been also clearly observed on both child and parents. This is also certified by Dr. Walter B.Green study when he compared between 24 Inpatient and 15 patient treated by Ambulatory surgery to Elongate TA¹⁷. There is reduction of the emotional effect of the long time staying in hospital especially for the child who needs only simple nursing care immediately after surgery. No IV or IM drugs needed post-operatively (except single dose of IV antibiotic) and this greatly reduce the fear of the child and improve his self-esteem which in turn increase his threshold of pain and reduce post-operative analgesia used.

As mentioned by Joseph L.Garbarino in his study on 26 feet of 20 spastic CP children treated by ETA, the main beneficial effect of surgery become obvious in the first 6 months after surgical intervention and the child continue to progress in the following periods¹⁸.

We must concentrate especially during the first 6 months because most early and late complications in our study and other studies are due to neglect¹⁹.

Conclusion

Equinus deformity of the foot is one of the most common problems encountered in cerebral palsy. Equinus is defined as the inability to dorsiflex the foot above plantigrade, with the hindfoot in neutral and the knee extended. Equinus disrupts the gait cycle by decreasing stability in stance phase and causing inadequate clearance in swing phase.

Non operative treatment for an equinus deformity of the foot include stretching exercise, serial casting, bracing, and temporary or permanent denervation with botox, alcohol, or phenol.

Operative treatment include surgical denervation, Achilles tendon lengthening, gastrocnemius and or soleus fascial lengthening and anterior advancement of the Achilles insertion. Numerous heel cord-lengthening techniques have been described including tendon (slides) performed open or percutaneously, coronal z- lengthening, and sagittal z- lengthening.

The operative procedures depend on which muscle have contracture. if gastrocnemius complex contracture, then the silverskiold test will be negative and the suitable procedure is Achilles tendon lengthening. Fixed equinus is treated by Achilles tendon lengthening. there are Many techniques of Achilles tendon lengthening as open sliding, z-plasty and percutaneous lengthening.

In our study we used the open z-plasty lengthening technique through posteromedial longitudinal incision.

All patients had shown failure of conservative orthotic treatment for at least six months before surgery. All cases developed progressive equinus deformity.

Achilles tendon lengthening was performed in Moderate to severe fixed (rigid) equinus deformity not responding to conservative orthotic treatment and physiotherapy, Intolerance to footwear or orthoses with or without skin problems and Pain either persistent or in relation to walking.

The procedure was not suitable in Children below 3 years old because of high recurrence rate specially in diplegia, Flexible (correctable) foot deformity in which orthotic treatment or other conservative treatment such as Botox injection (in cases of spasticity not contracture) may be useful, skin problems at site of incision and associated bony deformities of foot such as cavovarus and pesplanus as they need other associated procedures.

Preoperative clinical examination, observational gait analysis and Silverskiold test was done to all cases.

All cases had open z-lengthening of Achilles tendon with no need of posterior ankle capsulotomy.

Further studies are needed with larger number of cases, comparison with other methods of Achilles lengthening and with long term follow up.

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