# Treatment of clubfoot by modified Ponseti technique

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## Abstracts

**Background**
clubfoot is a complex congenital deformity composed of forefoot adductus, midfoot cavus, hindfoot varus, and ankle equinus.
The treatment aims to obtain a plantigrade painless and functional foot. Amongst the various treatment options, conservative treatment with Ponseti method is well accepted and has been reported to result in a good correction with the success rate ranging between 55 and 90% and we can assume that most of the failures are attributed to surgeon experience and non-compliance of the patients or their families to the long period of the treatment regimen after the serial casting which last to the age of 4 to 5 years.
**Patients and methods**
From March 2012 until December 2018, 283 feet for 260 patients (237 unilateral and 23 bilateral) were treated. The study included 177 males and 83 females with a ratio of 1.4:1 respectively. Age at presentation varied from 2- 36 weeks with a mean of 4.9 weeks. Follow up varied from 10-72 months with a mean 24 months.
**Results**
273 (96.46%) feet had good results with a Pirani score 0-1 at the end of follow up, 6 (2.1%) feet had fair results with a score of 1-2 out of which 5 feet (1. 7%) had relapsed forefoot adduction. 4 (1.4%) feet had poor results, two of which had rigid equinus and two cases didn't follow up after full correction at the age of six months.
Excluding the fair and poor results, all cases didn't need orthosis by the age of 1-1.5 years which we consider a great reduction in time factor causing family noncompliance in the usual regimen.
**Conclusion**
The Ponseti method is the gold standard in the management of clubfoot. By reducing the time factor which may conventionally reach up to 5 years we managed to increase the parent's and patient's compliance with treatment.
**Keywords**
club foot - equinus- varus - ponsti- resection- tendo-achilles.

## Introduction

Club-foot was first described by Hippocrates around 300 B.C. It has an incidence of 0.001–0.002 live births. Bilateral in about 50% of cases. When unilateral, the right side is more frequently affected than left. It's mostly idiopathic with male to female ratio 2:1.

The components of the deformity are Equius, hindfoot varus, midfoot cavus, and forefoot adduction. It's worth mentioning that the deformity has both psychological due to bad cosmetic appearance and functional impact.

Hypoplasia of all the soft tissues including neurovascular bundles on the medial side of the affected foot which become smaller than the normal foot even after successful treatment may still be present. [1]

## Clinical assessment and grading

A lot of classifications and grading systems were introduced from which, Demeglio and Pirani scores won the competition and are widely used and dependable. In Dimeglio classification, each major component of clubfoot (equinus, heel varus, medial rotation of calcaneo pedal block, forefoot adduction) is graded from I to IV. Additional points are added for deep posterior and medial creases, cavus, and poor muscle condition. [1]

Pirani score which we used in our study due to high inter-observer reliability consists of parameters in the hindfoot and mid-foot as shown in table1. [2]

**Table 1:** Pirani scoring system

| Parameter | | Score 0 | Score 0.5 | Score 1 |
|---|---|---|---|---|
| **HFS** | **PC** | Multiple fine creases | One or two deep creases | Deep creases change contour of heel |
| | **EH** | Tuberosity of calcaneus easily palpable | Tuberosity of calcaneus more difficult to palpate | Tuberosity of calcaneus not palpable |
| | **RE** | Normal ankle dorsiflexion | Ankle dorsiflexes beyond neutral but not fully | Cannot dorsiflex ankle to neutral |
| **MFS** | **Severity of MC** | Multiple fine creases | One or two deep creases | Deep creases change contour of arch |
| | **CLB** | Straight | Mild distal curve | Curve at calcaneocuboid joint |
| | **Palpation of TH** | Navicular completely "reduces"; Lateral talar head cannot be felt | Navicular partly reduces; lateral headless palpable | Navicular does not reduce, lateral talar head cannot be felt |

*HFS=Hind-foot scores, PC=Posterior crease, EH=Empty heel, RE=Rigid equinus, MFS=Midfoot score, MC=Medial crease, CLB=Curvature of the lateral border, LHT=Lateral head of the talus.*

## Treatment

The treatment aims to obtain a plantigrade, painless, and functional foot. Bensahel et al., (1980) recommended manipulative treatment by physiotherapists, then taping the leg and foot to a splint. Anyhow it was lengthy, expensive, and failed to correct more than one-fourth of the cases mostly due to lack of efficient immobilization. Other historic trials suggested continuous passive movement (CPM) machine rather than surgical release and noticed improved equinus and varus in all cases and thus can eliminate the need for surgery in mild clubfeet, and delay surgery in more severe cases. [1] Serial casting was firstly professionally used by Kite. He started slow conservative manipulation long before Ponseti. In his technique; a wedge of plaster directed dorsolaterally was removed and the foot abducted to close the wedge. Once the adduction and inversion were corrected he removed a wedge from the dorsal aspect of the ankle and corrected the equinus. Later he realized that only forefoot is corrected so he started to change the plaster every time the baby comes to correct both heal adduction and equinus. Then he started correcting each component of the deformity separately instead of simultaneously. He was able to correct the cavus and to avoid foot pronation, but correcting the heel varus took many casts. In his technique, he used to press on the lateral side of the foot near the calcaneocuboid joint while he was abducting the forefoot which leads to that the calcaneus is blocked and correction of the heel varus was not amenable. Therefore, it took many months and cast changes to slowly correct the heel varus and obtain a plantigrade foot. [1]

Ignacio V. Ponseti (1963) described his method of cast application for conservative management of clubfoot. The technique includes the following;

Short and gentle manipulation before casting which is important to stretch the structures and additionally to get a feeling for the flexibility of the foot and the amount of correction which can be achieved with the cast. Serial casting is performed with above the knee casts holding the foot in the abduction. In the first cast, the forefoot pronation is corrected by supinating the first metatarsal to correct the relationship between the forefoot and hindfoot and decrease cavus. 2nd cast pure abduction with counter pressure on the neck of talus is performed and this prevents the talus from rotating inside the ankle mortise, while the rest of the foot is abducted underneath it including the calcaneus which everts and dorsiflexes at the same time. At this point of manipulation, the forefoot has to be abducted to 60-70 degrees to achieve full correction of the subtalar joint. Active dorsiflexion must not be performed before the subtalar joint is fully corrected and/or until after tenotomy. Cast change is done once weekly with a few little exceptions. [3]

Two to three casts are often applied after manipulations in an attempt to correct equinus deformity. If it failed, a simple percutaneous Achilles tenotomy is performed under general anesthesia. Ponseti carried out this tenotomy in 79% of his cases in the original article. A toe-to-groin cast with the foot in maximum dorsiflexion and the knee at a right angle then applied for three weeks. The equinus deformity is thus corrected, obviating a rocker-bottom deformity which often results from prolonged forceful manipulation. After three weeks in the cast, the defect in the tendon is healed. [4]

After reaching full correction, Denis Browne splints with high-top shoes with well-molded heels were ap-

plied full time for about three months then at night for an average of ten to thirty months [4] with recurrence about 56% for which he decided to continue night splinting for4 to 5 years in later study. [3]

## Patients and materials

In our research, we investigated the effect of a new modification that we made on the Ponseti management and follow up protocol of clubfoot.

All cases were done in private clinics in Menoufia and Tanta, Egypt. Our inclusion criteria were all moderate to severe cases with scores of 3-6 as per Pirani score (213 feet scored 3-5 and 70 cases scored 6), idiopathic and flexible clubfoot. Our exclusion criteria were mild cases with Pirani score below 3 and syndromic cases or cases with neuromuscular disorders.

From March 2012 until December 2018 we treated 283 feet for 260 patients (237 unilateral and 23 bilateral). The study included 177 males and 83 females with a ratio of 1.4:1 respectively. Age at presentation varied from 2- 36 weeks with a mean 4.9 weeks. Follow up varied from 10-72 months with a mean 24 months. Ponseti technique of foot manipulation was done as usual in the same sequence of cavus, adductus, varus then equinus.

In the plan of treatment, we took into consideration the age at presentation and expected time to walk. **Patients below 6 months old** were subjected to manipulation and stretching for 2 to 3 minutes (it was one minute in original Ponseti technique) to get more stress relaxation and plastic deformation of the soft tissues before each cast. Serial casting for about 6 to 10 weeks (4 to 6 casts). One week for cavus, one for adductus one for varus then Achilles tenotomy was carried out at 4th to 5$^{th}$ week and a cast was applied for 3 weeks.

We replaced the conventional percutaneous complete tenotomy of the Achilles' tendon with a new partial resection in multiple points (3 or 4) in a stepladder manner until satisfactory dorsiflexion is reached. We use an 11 blade and start from distal to proximal with the back of the blade directed towards the posteromedial NVS bundle we take some of the medial aspects of the cord width then go up as shown in **figure 1** from lateral to medial then again at a higher point from medial to lateral.

We did all the cases with local anesthesia in the clinic after proper consenting of the parents and with their help and under their direct observation as well. (Fig 2)

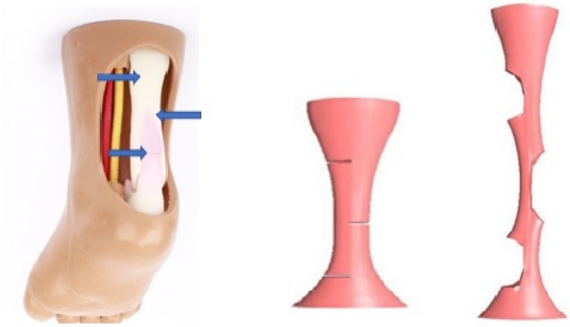

**Fig 1:** showing simulation of how the tenotomy will look like

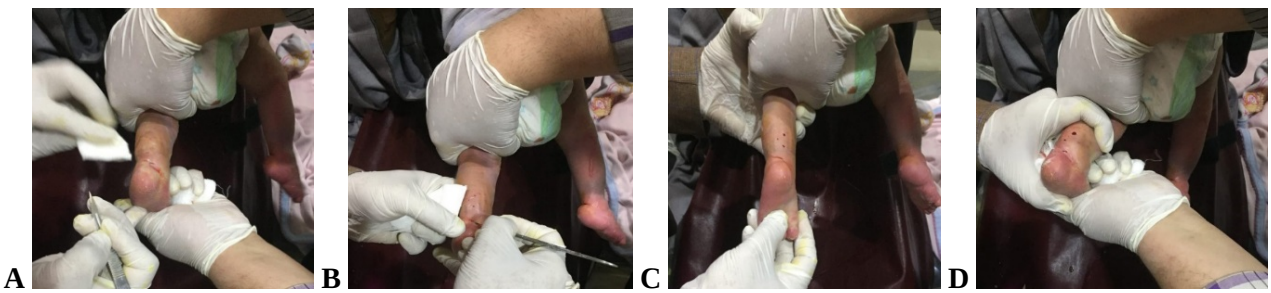


**Fig 2 A-D:** showing how we do the tenotomy under stretch to see how far can we dorsiflex the foot and the final appearance of the wounds (D)

Denis Brown abduction orthosis with a hole in the back to make sure that the heal is well seated in place and reduce the chances of losing correction of the ankle equinus (Fig 3) was then applied full time for 3 months (23 hours/day) then during bedtime for another 3 months together with abduction AFO during

the day time. Denis brown orthosis is then discontinued and the child continues with AFO for 3 months more by which time most of the children would be able to walk at least supported.

**Fig 3**: Denis brown with heel opening

Then a custom made foot shoes with 30 degrees abduction of the forefoot and the lateral wedge is applied till the age of 12 months or the patient is totally independent and the normal footprint is well established in his brain.

**Patients above 6 months** old at presentation were subjected to the same scenario with a little difference which is; after finishing the correction we put them in the Denis brown boots for 3 months at bedtime only with abduction AFO (ankle and foot orthosis) during day time, as by that time they were able to stand and then they continued in the AFO alone for 3 months more, then the custom made shoes till independence.

So the whole management protocol ranges from 8-12 months which is inversely proportional to the age at presentation and which means that the child will end the regimen by the age of 1 to 1.5 years.

## Results

All cases were treated conservatively by our new modification, 273 (96.46%) feet had good results with a Pirani score 0-1, with complete ankle range of motion and plantigrade painless feet and normal sizes. (**Fig4)** 30 feet out of the 273 had a recurrence of equinus and revision of the percutaneous tenotomies without a change in the net results.

Six feet (2.1%) had fair results with a score of 1-2 out of which 5 feet (1. 7%) had relapsed forefoot adduction and surgical tibialis anterior transfer was done for them and abduction shoes were used for extra 6 months and One (0.35 %) foot had metatarsal adduction for which a basal metatarsal abduction osteotomy **(Fig 5)** was done and abduction shoes were applied for 2 years.

4 feet (1.4%) had poor results, two of which had rigid equinus and were treated by posteromedial release with an orthosis for two years and two cases didn't follow up after full correction at age of six months and presented at the age of two years with a rigid clubfoot for which classical posteromedial release and double wedge osteotomy were done and orthosis were applied for two years.

## Discussion

Club foot is one of the most common congenital deformities affecting mobility. It leads to pain and disability if untreated. The Ponseti method is considered the gold standard in the management of this condition. However, there is still no consensus on how to assess and report the results of clubfoot management. [5]

Pain, gait, heal position, and range of motion plus questionnaires measuring the overall satisfaction, foot appearance, and physical limitations were all used as outcome measures. [6-7]

Since the evolution of the Ponseti technique, it has always been a subject of assessment and modification in lots of comparative studies. Bor et al. [8] assessed foot motion in 74 patients treated with the Ponseti technique and followed up for a mean period of 6.3 years and they concluded an 89% good results and at the same time they put DSI questionnaire in which all patients showed high satisfaction.

In his comparative study, Ipoliot et al. [9] concluded that Ponseti technique is more effective than Marino-Zuco technique in deformity correction using only

simple Achilles tenotomy compared to the later which requires more aggressive release surgeries with the significant difference in the outcome of the two cohorts (78% vs 43% excellent and good results respectively).

In one of the trials, researchers tried serial casting every 3 days and a percutaneous Achilles needle tenotomy and concluded that it had fewer complications and scarring of the skin apart from the reduced plaster immobilization period. [10]

**Fig4** from left to right showing the same patient at 2 weeks, 5 weeks and 9 months old

**Fig 5**: showing one of the bilateral cases after relapsed adduction of the right forefoot and corrective osteotomy and we can see the left foot in acceptable condition with no further intervention

Generally, it's still believed that the Ponseti technique provides superior results to others either surgical or non-surgical however it's not free from complications that can be encountered. [11] Relapse is on top of the list and it usually happens due to failure to stick to the long regimen of bracing and orthosis. Other factors may add to caregiver non-compliance e.g.; Socioeconomic and cultural factors. That leads to the emergence of new braces hoping to overcome these factors of noncompliance. [12]

Dobbs MB et al., [13] concluded that noncompliance was the factor most related to the risk of recurrence, with an odds ratio of 183 ($p < 0.00001$). Parent educational level (high-school education or less) also was a significant risk factor for recurrence (odds ratio = 10.7, $p < 0.03$).

In our study, we did some modifications to the Ponseti technique as illustrated in the material and methods section starting from the amount of soft tissue stretching before casting, then the stepladder tenotomy and ending with the new bracing regimen and follow up which have the following advantages.

Our tenotomy is simple with fewer complications and nearly no bleeding and negligible scars. Triceps surae muscle power and activity are preserved. In our bracing regimen which lasts till the age of 1 year in early presenters and to the age of 1.5 years in late presenters, when the child can walk independently and the brain preserved the normal footprint we stop orthosis

and follow the patients every 6 months with the encouragement of walking exercises.

Our results were as good as most of the studies in addition to a less cost and better compliance and acceptance form the family side due to reduction in the period of follow up and bracing which used to be till the school-age on original protocol.

## Conclusion

The Ponseti method is still a gold standard in the management of clubfoot that depends, from a basic science point of view, on the creep and stress relaxation properties of the ligaments and tendons. We increased the manipulation time up to 2-3 minutes before our serial casting to get the best yield and plastic deformation of soft tissues before the application of the plaster. We replaced the usual complete tenotomy with a partial recession then we modified the post-correction bracing protocol. From our point of view, we think that our modifications lead to outcomes that are as good as those of most of the studies and at the same time it helped reduction in time and hence improved compliance to treatment which was found to be the factor most related to the risk of recurrence. However, we might need a further prospective comparative study.

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