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ORIGINAL ARTICLE • FOOT - PAEDIATRICS

Accelerated Ponseti technique: efficacy in the management of CTEV

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Abstract
The current standard practice of treatment for congenital talipes equinus varus (CTEV) is the Ponseti method of manipulation and casting which requires great compliance by caregivers for casting as well as bracing. There is inconclusive evidence regarding optimal cast change interval. This was a prospective non-randomized study conducted at a tertiary care hospital in South India over a 2-year period with a minimum follow-up of 5 years. The patients were divided into 2 groups, one with cast change interval of 7 days and the other group at 3 days. Children with CTEV with age less than 1 year with no previous intervention were included in the study. Functional score devised by Ponseti was determined at final follow-up. The average number of casts in standard and accelerated group was 5.23 ± 0.59 and 4.72 ± 0.61 ($p < 0.01$). The average number of days required for correction of feet was 54.38 ± 8.01 and 33.88 ± 9.03 ($p < 0.01$) respectively, for standard and accelerated groups. The Pirani score showed a faster reduction in the accelerated group. This study is the longest prospective study published yet in literature, comparing standard and accelerated Ponseti protocols. Complication rate noted in our study was comparable to study by Morcuende but higher than other studies comparing the techniques. It increases compliance as well as reducing treatment and travel costs for parents, more so in developing countries. At 5-year follow-up, there is no significant difference in the functional outcome.

Keywords Congenital talipes equinovarus · Standard Ponseti · Accelerated Ponseti

Introduction

Congenital talipes equinus varus, commonly called clubfoot, is one of the most common musculoskeletal deformities of the lower extremity with an incidence of 1–6.8/1000 live births [1]. The treatment has varied from initial exclusive conservative treatment to increased surgical intervention and then turning back to increased conservative treatment. In today's time, primary surgical correction of clubfoot is not encouraged and retrospective as well as prospective studies have shown poor results in terms of mobility and the presence of pain secondary to surgical intervention [2]. Ponseti [3] published in 1963 his results for the method he devised. The acceptance of the method was still low among the surgeons till Ponseti published his long-term follow-up showing about 90% satisfaction rate among the patients [4]. The current standard care consists of weekly corrective manipulation and casting, resulting in gradual correction of the deformity. The final plaster requires a percutaneous tendoachilles tenotomy to be done. This has greatly reduced the need for surgery, in up to 98% of cases [5]. This treatment requires great compliance by the parents, both for casting and bracing. This is all the more important for parents in developing countries, where because of poor economic condition and long distance needed to travel to attend foot clinics makes the compliance difficult, if not impossible [6]. This prompted the investigators to device a faster cast change regimen—the initial published literature showing changing of casts in five days instead of seven days—leading to potential saving of 10–12 days in the initial casting period [7].

Also, there is inconclusive evidence regarding optimal cast change interval in application of serial casting to stretch soft tissue. A cast for a period of 3 days for contracted finger shows improvement of three degrees, whereas a cast period of 6 days shows an improvement of 5.2° [8]. But in case

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of ankle, knee and elbow, it showed shorter treatment with three days cast interval compared to seven days cast interval [9]. Whether the same findings regarding cast interval can be applied to clubfoot needs to be investigated. We hypothesized that faster cast change results in greater compliance from patients with equivalent results. This study compares the result between standard Ponseti (7-day interval) and accelerated Ponseti (3-day interval) with a minimum follow-up of 5 years.

Materials and methods

Study design and setting

This was a prospective non-randomised study set at Kerala Institute of Medical Sciences, Trivandrum. The study period was from September 2011 to September 2018. The choice of treatment was decided by the parents after detailed explanation of both the methods. Patients in a standard 7-day interval group were termed group I and those under 3-day interval group were termed group II. Informed consent was obtained from the parents of the patient after counseling them regarding the benefits of the treatment and their active role in the treatment protocol as emphasized by Ponseti himself. All the feet were followed up compulsorily for a minimum of 5 years. No extra funding was resorted to whatsoever. The study confirmed to the guidelines of the Declaration of Helsinki, 1964, revised in 1975.

Inclusion criteria

1. Age less than 1 year.
2. Spine and hip of the patient should have no abnormality.
3. Parents should provide consent for inclusion in the study.

Exclusion criteria

1. Congenital or neurological deformity in the child.
2. Relapsed or recurrent clubfoot.
3. Any previous intervention, conservative or surgical, done elsewhere.

Study protocol

The clubfeet were initially assessed with the Shafique Pirani scoring system giving scores to the deformities of the hindfoot and midfoot. After counseling the parents, and with their full active involvement to direct away the child's attention, and with the help of an assistant, the clubfeet were manipulated strictly in accordance with the scheme described by Ponseti. Every clubfoot under the study is scored on each visit for hindfoot score (HS), midfoot score (MS) and total score. Tenotomy was indicated when $HS > 1$, $MS < 1$, and the head of the talus is covered.

The first element of management is correction of the cavus deformity by positioning the forefoot in proper alignment with the hindfoot. The cavus is always supple in newborns and requires only elevating the first ray of the forefoot to achieve a normal longitudinal arch of the foot. Alignment of the forefoot with the hindfoot to produce a normal arch is necessary for effective abduction of the foot to correct the adductus and varus. A cast is applied in this position.

For further casts, the manipulation consists of abduction of the foot beneath the stabilized talar head. All components of clubfoot deformity, except for the ankle equinus, are corrected simultaneously. To gain this correction, one must locate the head of the talus, which is the fulcrum for correction. First, the lateral malleoli with the thumb and index finger of one hand is palpated, while the toes and metatarsals are held with the other. Next, the thumb and the index finger of former hand are moved forward to palpate the head of talus in front of the ankle mortise. Because the navicular is medially displaced and its tuberosity is almost in contact with the medial malleolus, one can feel the prominent lateral part of the talar head barely covered by the skin in front of the lateral malleolus. The talus is stabilized by thumb. Stabilizing the talus provides a pivot point around which the foot is abducted. This further stabilizes the ankle joint, while the foot is abducted beneath it and avoids any tendency for the posterior calcaneal-fibular ligament to pull the fibula posteriorly during manipulation. Manipulating the foot next, the foot in supination is abducted as far as can be done without causing discomfort to the infant. Hold the correction with gentle pressure for about 60 s. Full correction should be possible after the fourth or fifth cast. For very stiff feet, more cast may be required.

During this phase of treatment, the adductus and varus are gradually corrected. The equinus deformity gradually improves with correction of adductus and varus. This is part of correction because the calcaneum dorsiflexes as it abducts under the talus. No direct attempt at the equinus correction is made until the heel varus is corrected.

After completion of the cast, the patient was monitored for 1 h during which time the parents were taught how to assess the capillary refilling in the toes of the clubfoot inside the plaster. In the event of a tight plaster as evidenced by no refill in 2 s, the plaster was immediately split and the whole procedure repeated with lesser amount of correction after half an hour. In the week that follows after each visit, the condition of the patient and the foot is regularly assessed through direct communication with the parents. Incessant cry, blue toes and absent refill if any would be met with immediate action in the form of an emergency visit or cutting of the plaster in an equipped nearby hospital. At each

visit, the patient is evaluated after cutting the plaster for the residual score and complications of plaster application.

For percutaneous tenotomy, the foot was prepared thoroughly form midcalf to midfoot with an antiseptic, while the assistant holds the foot from the toes with the fingers of one hand and the thigh with the other small amount of local anesthetic may be infiltrated near the tendon. The tenotomy was performed approximately 1.5 cm above the calcaneum with the foot held in maximal dorsiflexion by the assistant. The last cast was applied with the foot abducted 60°–70° with respect to the frontal plane of the ankle. This cast was left in place for 3 weeks after complete correction. The endpoint of casting was a score less than 1.5 with the feet having 70° of external rotation and 15° of dorsiflexion.

The foot abduction brace was applied immediately after the last cast is removed, 3 weeks after tenotomy. The brace consists of open toe high-top straight last shoes attached to a bar. For unilateral cases, the brace was set at 60°–70° of external rotation on the clubfoot side and 30°–40° on the normal side. On bilateral cases, it was set at 70° of external rotation on each side. The bar should be of sufficient length so that heels of the shoes are at shoulder width. The bar should be bent 5°–15° with the convexity away from the child to hold the feet in dorsiflexion. The brace was advised to be worn for 23 h for the first 3 months after the last cast is removed. After that, the child should wear the brace for 12 h at night and 2–4 h in the middle of the day for a total of 14–16 h during each 24-hr period. This protocol continued till the total bracing period was 3 years.

After applying the brace for the first time when the last cast was removed, the child returns according to the following suggested schedule

Two weeks to troubleshoot compliance issues
Three months to graduate to the nights-and-naps protocol
Every 4 months until age 3 years to monitor compliance and check for relapses
Every 6 months until age 4 years
Every 1–2 years until skeletal maturity

The parents were instructed to perform range of motion exercises for the ankle and foot when it was out of the brace. Two exercises were taught to the parents. In the first exercise, the infant was made to squat on level ground while being supported by the parents. In the second exercise, the parent uses one hand to stabilize the leg with knee bent. The other hand is used to grasp the foot and then place the ankle into maximum dorsiflexion followed by planter flexion. The exercises were performed twice a day till the weight bearing age (when the brace was applied for 23 h a day) and five times daily for the next 3 years (when the brace was applied for 12 h at night). The parent repeats this exercise twenty times at a seating.

The Ponseti scoring system for functional results was used, with 100 points indicating a normal foot [4]. This includes a maximum score of 30 points for amount of pain; of 20 points each for level of activity and patient satisfaction; and of 10 points each for motion of the ankle and foot, position of the heel during stance, and gait. For satisfaction and function category, data have been recorded from the patients' parents considering patient as minor. The results were graded as excellent (90–100 points), good (80–89 points), fair (70–79 points) and poor (less than 70 points). Poor and fair results were considered failures and needed further management for residual or recurrent deformity.

Parameters measured

The age, sex, laterality and initial Pirani score were recorded at the final visit. At every further visit, subsequent Pirani scores were recorded. The developmental milestones like the age at which child walks independently and age at which patient tip toes were recorded. At final follow-up, the following information was recorded—position of heel on standing, varus valgus motion of heel, inversion eversion of foot and functional score. The last follow-up measurements were used for calculating Ponseti functional score. Any complications during the course of follow-up were recorded. Relapse or recurrence was defined as occurrence of equinus, shortening of medial column and dynamic supination. Forefoot adduction was not considered as relapse.

Statistical analysis

Statistical testing was conducted with the statistical package for the social science system version SPSS 17.0. Continuous variables are presented as mean ± SD, and categorical variables are presented as absolute numbers and percentage. The comparison of normally distributed continuous variables between the groups was performed using Student's t test, and mean difference ± standard error with 95% CI was calculated. Nominal categorical data between the groups were compared using *Chi-square* test or Fisher's exact test as appropriate. $p < 0.05$ was considered statistically significant.

Results

A total of 34 patients were included in the given study period. Four patients were lost to follow-up at the end. Finally, 30 patients were analyzed with respect to this study, of whom 22 were males (73.3%). Of these, 26 feet were included in group I and 25 feet in group II. There were 11 bilateral cases in group I compared to 10 in group II. Among the unilateral cases, six were right sided and three were left sided. The mean age of start of treatment

was 12.35 ± 16.37 days (mean, SD) in group I compared to 9.84 ± 8.97 days in group II. Average duration of follow-up was 71 months in group I compared to 68 months in group II.

The change in Pirani score for both the groups is tabulated in Table 1. The mean score at the start of casting was same (mean = 5.02). The scores changed more faster in the accelerated group ($p < 0.01$) (Fig. 1). Before tenotomy, the change in Pirani score was significant ($p < 0.01$). The mean score before tenotomy in group I was 1.71 compared to 1.12 in group II. Details regarding casting and attainment of milestones are shown in Table 2. The total number of casts before tenotomy was statistically different between both groups ($p < 0.01$). The mean difference between the number of days in casting was 20.5 days ($p < 0.01$). There was no significant difference in the tenotomy rate in both the groups which was around 84%.

There were two cases each of residual equinus and dynamic supination in group I which was managed by posterior release and transfer of tibialis anterior tendon to third cuneiform, respectively. In group II, three cases of residual equinus and one case of dynamic supination were managed accordingly as in group II. Three cases of skin rash or pressure sore were noted in group II compared to 1 in group I. The age at which child walked independently and started to tip toe was not significant. At the last follow-up, there was

Table 1 The change in Pirani score of both groups over the course of casting

Pirani score	Group 1 Mean ± SD	Group 2 Mean ± SD	*p* value	Mean difference	Std. error difference	95% Confidence interval of the difference
At baseline	5.02 ± 0.78	5.02 ± 0.73	0.997	0.000	0.212	− 0.426 to 0.425
At 2nd visit	4.44 ± 0.79	3.98 ± 0.71	**0.034**	0.462	0.211	0.037 to 0.887
At 3rd visit	3.75 ± 0.75	3.02 ± 0.84	**0.002**	0.730	0.222	0.283 to 1.177
At 4th visit	2.73 ± 0.78	1.78 ± 0.83	< **0.001**	0.951	0.225	0.498 to 1.403
At 5th visit	1.71 ± 0.66	1.12 ± 0.47	**0.004**	0.583	0.190	0.198 to 0.969
At 6th visit	1.25 ± 0.46	1.50 ± 0.00	0.486	− 0.250	0.342	− 1.039 to 0.539

Figures in bold means *p* value < 0.05

Fig. 1 Rate of change of Pirani score in both groups

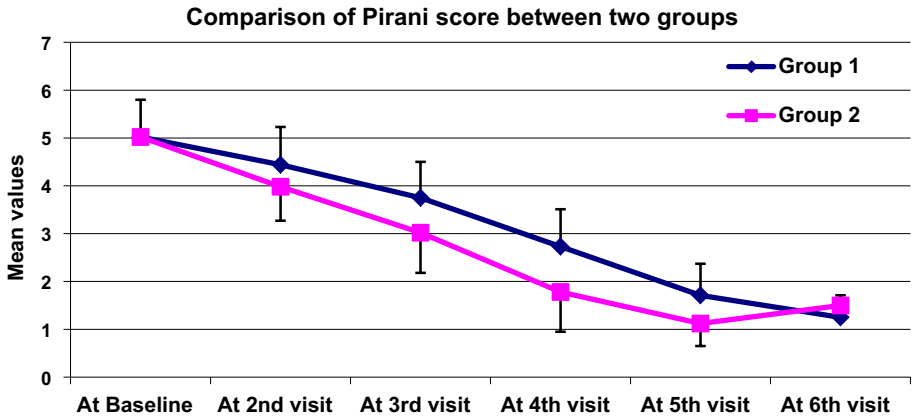

Table 2 The details about casting and milestones of both groups are noted

	Group 1 Mean ± SD	Group 2 Mean ± SD	*p* value	Mean difference	Std. error difference	95% Confidence interval of the difference
Total cast before final cast	5.23 ± 0.59	4.72 ± 0.61	**0.004**	0.511	0.168	0.173 to 0.849
Total duration of treatment (days)	54.38 ± 8.01	33.88 ± 9.03	< **0.001**	20.505	2.386	15.71 to 25.30
Age at which walks independently	13.58 ± 1.14	13.48 ± 1.12	0.761	0.097	0.317	− 0.539 to 0.733
Age at which tip toes	16.08 ± 1.38	16.04 ± 1.49	0.927	0.037	0.402	− 0.772 to 0.846

Figures in bold means *p* value < 0.05

no significant difference in the position of heel on standing, final dorsiflexion, varus valgus motion of heel, eversion inversion of foot and final functional score.

Discussion

There have been previous studies either explaining or comparing the accelerated Ponseti method with the standard weekly method [7, 10–15]. The results of our study are comparable to the findings of the previous studies. This prospective study has a minimum of 5 years follow-up which is significant because most recurrences or relapses would have occurred by 5 years. Other prospective studies had a shorter follow-up. The study by Elgohary was having the longest follow-up of 25 months. A longer retrospective analysis of the cases was performed by Morcuende [7]. The total number of casts in our study was 5.23 ± 0.59 in standard group compared to 4.72 ± 0.61 in accelerated group. Similarly, the total duration of treatment days was 54.38 ± 8.01 in standard group compared to 33.88 ± 9.03 in accelerated group. In the study by Elgohary [11], Ibraheem [14] and Sahu [15], the patients in the accelerated group required a greater number of casts compared to the standard group but this wasn't statistically significant. But comparing the number of days to foot correction was significant statistically in all the previous studies, as noted in our study too. The rate of tenotomy in the above studies was comparable to our study. However, with regards to rate of relapse or recurrence, our study showed similar results as shown by Morcuende [7]. There were four (26.6%) cases of relapse in each of the both groups in our study showing no statistical significance. In the study by Morcuende, the relapse rate was 23% in standard group compared to 11% in the accelerated group, which was noted as statistically significant. This difference can be explained on the basis of our different inclusion and exclusion criteria for both the studies.

The reduced duration of plaster has clear advantages. It is preferable for the patient as well as its caregivers. This should reduce the overall time the lower limb is in plaster. It is easier to detect pressure sores or skin rashes, if it occurs, at an early state. Along with it, the effects of prolonged immobilization like disuse atrophy of tissues are avoided. The patient is able to proceed to bracing phase at a younger and probably amenable age. With studies which have showed a positive correlation between compliance with bracing and incidences of relapse, the earlier introduction of patients into bracing phase might be more beneficial than as thought [16–18]. The current literature also points to good evidence regarding correction of deformity by the accelerated Ponseti method [10–15]. There is also increased convenience for caregivers because the treatment is prolonged which requires them to travel long distances away from home and work, a common occurrence in developing countries [19]. This leads to increased savings with respect to living away from home and time lost from work and which would also probably increase compliance if accelerated Ponseti method is followed.

The strengths of our study are that it's a prospective study of a long follow-up of minimum 5 years. The limitations are that it's a non-randomized study with a small sample size. Our inclusion and exclusion criteria may have inherent biases. Further randomized control trials with a large sample size with study conducted at multiple centers may be needed in future to validate our findings.

In conclusion, the feet treated by standard Ponseti and accelerated Ponseti have same functional outcome at the end of a 5-year follow-up. Accelerated Ponseti offers the advantages both to the patient as well as to the caregivers. We can conclude that accelerated Ponseti is as effective as the standard Ponseti technique.

Compliance with ethical standards

Conflict of interest The authors declare that they have no competing interests.

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