

Resistant Clubfoot: Can Surgical Correction Sustain the Corrected Deformity?

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Abstract

Introduction: Abnormally dense collagen fibers constitute the histological changes affecting Achilles tendon, tibialis posterior, tibionavicular, and calcaneonavicular ligaments. The deformity in club foot requires early and focused attention which is possible by involving and impressing the parents. Ponseti technique developed in 1940 and popularized subsequently has become a popular technique to correct the deformity. This technique involves serial manipulations and POP castings, each one lasting for 5 to 7 days, and maintenance phase to preserve the corrected deformity till the child starts bearing weight and beyond. The study is about persisting deformity even after surgical correction.

Materials and Methods: The study is in 38 cases of CTEV, who have missed the follow-ups, serial manipulations and Ponseti casts before the child has assumed weight bearing, walking, the rapid succession casts are applied which failed to correct the deformity below 1 of pirani score. These children are subjected for soft tissue release and POP casts.

Results: Even after missing the initial Ponseti serial manipulations and serial castings, the post-surgical correction period is also seen with irregular follow up to continue casts. The results were analyzed with Chi square test and Paired *t* test.

Discussion: The involvement parents is of utmost importance in getting the deformity correction, with or without surgical correction of CTEV deformity.

Keywords: CTEV – surgical correction with soft tissue release – persisting deformity – involvement of parents – regular follow-ups.

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Introduction

Clubfoot (talipes equinovarus) is a congenital deformity involving the foot, and ankle otherwise known as congenital talipes equinovarus. The presentation of congenital talipes equinovarus (CTEV) is with varying degrees and severity which manifest as cavus deformity involving

midfoot, Adduction at Forefoot, Varus at Heel / hindfoot, equinus at hindfoot. These deformities may vary relative to the extent of deformity and their stiffness. These deformities are gradable depending on the severity. The exact etiology remains debatable, and linked to multiple genetic and

environmental risk factors that result in varying degrees of severity. Maternal smoking, diabetes, alcohol consumption may also have an association. Foetal position in utero has been commonly mentioned throughout the literature. Though a definite genetic model of inheritance is not yet clear, 24.4% of cases have an associated family history. Occurrence in monozygotic twins is at 33% in comparison to 3% in dizygotic twins. Similar deformities as clubfoot occur in association with the conditions like, Distal arthrogryposis, Congenital myotonic dystrophy, Myelomeningocele, Amniotic band sequence, associated genetic syndrome Trisomy 18, Chromosome 22q11 deletion syndrome. Club foot is often associated with some other anomalies like neurodevelopmental conditions. [1]

Epidemiology

Clubfoot has a reported incidence of between 0.5 and 2 cases per 1000 births. [2] Certain ethnicities, such as the Hawaiians and Maori, demonstrate a predilection for higher prevalence rates, with the latter population cited at up to 6.8 per 1000 births. [3]

Males are twice as likely as females to be born with a clubfoot, and cases are bilateral in approximately 50% of cases. In unilateral cases, the right is most commonly affected. [4]

Pathophysiology

The deformity position is because of maximal flexion and adduction. There is medial and plantar flexion deviation of talus while the calcaneus is in varus and is rotated medially around the talus. The navicular and the cuboid are displaced medially.[5-6]

Histopathology

Abnormally dense collagen fibers constitute the histological changes affecting Achilles tendon, tibialis posterior, the tibionavicular, and calcaneonavicular ligaments. [7-8]

History and Physical

The prenatal ultra sound scans can usually detect the club foot deformity.[9] The Pirani system is commonly used to grade the deformities, it is easily reproducible also. Pirani scoring system involves assessing six separate parameters in the foot. Each parameter individually scores 0, 0.5, or 1 based on severity. With this scoring system the foot with deformity can be given a score of 0 to 6.[10]

The scoring is given as described below

In the hind foot the following parameters are graded Posterior crease, Equinus, Empty heel.

Posterior crease: For the hind foot deformity equinus deformity is corrected to give the grading to Hindfoot.

Posterior crease:

0 – multiple fine creases, 0.5 – Two or three moderate creases, 1 – Single deep crease.

Equinus: The equinus is corrected as much as able with the knee in extension to give the grading.

0 – Able to dorsiflex beyond plantigrade, 0.5 – Able to reach plantigrade., 1 – Unable to meet plantigrade.

Empty heel: It is Palpated directly over calcaneum posteriorly to give grading.

0 – Calcaneum easily palpable beneath the skin, 0.5 – Layer of tissue felt between finger and calcaneum, but calcaneum palpable, 1 - Calcaneum not palpable.

In the Midfoot the following parameters are graded, Medial crease, Curved lateral border of the foot, Lateral head of the talus. Medial crease is graded after gently correcting cavus deformity by lifting the 2nd toe and assess medial plantar crease.

0 – multiple fine creases, 0.5 – Two or three moderate creases, 1 – Single deep crease.

Curved lateral border of the foot is assessed by placing a straight object.

0 – Lateral border is straight in line with the pen without deviation, 0.5 – Lateral border of the foot deviates from the pen at the level of metatarsals, 1 – Lateral border of the foot deviates from the pen at the level of the calcaneocuboid joint.

Lateral head of the talus is assessed by palpating the head of the talus and passively correcting the deformity.

0 – Lateral head of talus covered by navicular on passive correction of the deformity, 0.5 – Lateral head of talus partially covered on passive correction of the deformity, 1 - Lateral head of talus remains uncovered on the passive correction of the deformity.

Obviously a higher Pirani score indicates severe deformity and the number of manipulations and cast required as well as tenotomy. [10]

There is a difference in size of the foot in unilaterally affected foot appearing smaller in size compared to normal foot. 20% of CTEV cases are often associated with other congenital anomalies like developmental dysplasia of hip. In children with late presenting age who have already started walking and with relapsing deformity parallelism between talus and calcaneum and negative talus first metatarsal angles are noted in radiographs.

Treatment / Management

Ponseti technique developed in 1940 and popularized subsequently has become a popular technique to correct the deformity. This technique involves serial manipulations and POP castings, each one lasting for 5 to 7 days, and maintenance phase to preserve the corrected deformity till the child starts bearing weight and beyond. The deformity correction is better started in the first or second week after birth. [11,12].

A step wise deformity correction is done during the manipulation and casting phase. The first deformity correction is by elevating the first metatarsal, which will adjust the alignment of the forefoot with the hindfoot. Once the cavus is corrected, fore foot abduction deformity correction is done till 60 degrees with reference to tibia, which also corrects hind foot varus. The equinus deformity correction is then attempted with dorsiflexion and if it is not within 10 degrees of dorsiflexion, percutaneous tenotomy is done for tendo achilles. [13].

The bracing phase: Parents compliance to bracing protocol is crucial, and appropriate counseling and support are essential. With poor compliance, there are recurrence rates of up to 80% reported, in comparison to 6% in those who are compliant. [12] The parents are advised to keep the bracer on for 24 hours a day for initial three months after the correction and 12 hours during sleep and 2 to 4 hours in the day upto 4 years of age. The brace will maintain the distance between two feet as the distance between the shoulders and in 70 degrees external rotation.

This bracing period warrants close observation, because any signs of recurrence is indicated for discontinuing the brace and to resume casting again. [14]

Achilles tenotomy, percutaneously is the most commonly required procedure for persisting equinus in 80% of the patients.

Complications

The ponsetti method has been associated with total deformity correction in 98 % of the cases, provided there is strict compliance. Noncompliance will result in recurrence of the deformity.

It has been encountered in the bracing phase. The recurrence has been noted in 80% of cases. The surgical correction for recurring deformity is associated with extensive release procedures with potential long term

complications as arthritis, overcorrection, mechanical weakness, and even avascular necrosis.[15]

Repeated attempts for surgical correction of deformity, and requirement of extensive procedures will be associated with sub optimal outcomes and complications in the long run. The poor outcomes are directly proportional to the extensive procedures. Some of these extensive procedures need to be augmented with derotation of talus along with postero medial soft tissue release.[16]

Extensive soft-tissue release has been relied up on for many decades because it results in definitive correction of the deformity. Surgical approaches most commonly used can be classified into three main categories: the Turco posteromedial incision, the Crawford's circumferential Cincinnati incision, and the two-incision Carroll approach. Patients who underwent extensive soft tissue releases for the management of idiopathic clubfoot, have encountered pain, stiffness, and degenerative arthrosis. The significant disabilities found in these patients are decrease in dorsiflexion, decrease of pronation-supination. The occurrence and grade of osteoarthritis was consistently higher in the clubfeet than in the contralateral normal feet.[17]

The residual deformities are attributed to undercorrection, overcorrection, dorsal bunion, anterior ankle impingement, and lateral hindfoot impingement. [18]

The discontinuation and non-compliance in the casting phase, maintenance phase and even in the post operative period after surgical correction are reportedly due to cast loosening, cast-associated skin irritation.[19]

The number of serial castings cannot be predicted after surgical correction, which often require more castings than feet treated with ponseti manipulations and castings. Any method can produce results and optimal

outcomes with serial castings only. The compliance of the patients to immediately report complications and to seek intervention is highly essential. Managing a recurring deformity is with better outcomes when the ponseti method is followed.[20]

Even for residual deformity, ponseti method is advised for patients with persisting deformity in the follow up after surgical correction.[21]

The recurrence rates of ponseti method are noted to be high in patients with non-compliance, whereas the subsequent correction results with manipulations serial castings is good to excellent when done to ponseti method cases than with other methods of manipulation.[22]

It has been found that irrespective of level of care regular follow ups and compliance to the treatment protocol has produced good results, in a tertiary centre compared to an attached physiotherapy centre where same ponseti technique is followed. For non-technical reasons and expertise, availability and access of services plays an important role in achieving better results. [23]

Usually the relapse of deformity occurs with varus heel and restricted dorsal flexion of the ankle which are the main features of recurrences. During the standing and walking phase, the recurring deformity presents with a varus position of the heel and dorsiflexion of the ankle.

A severe thickening of the paratenon of the Achilles in the medial side, with adhesions with the subcutaneous tissue is the reason for the heel varus and decreased dorsiflexion at the ankle.[23]

The correction procedure should address all the deformities for a long lasting result and also for the remodeling potential of the tarsal bones.

The normal physiological stimulus of weight-bearing for remodeling can be put to maximum benefit by the timing of surgery around the weight bearing age.

Recurrence of deformity can occur even after complete correction, especially during the first few years of life. Though the initial correction is of the ponseti manipulations and casting, approximately around 2.5 years of age, the deformity correction requires anterior tibialis tendon transfer to third cuneiform and lengthening of tendo achilles.[23]

Surgical correction of the deformity can have number of complications in the postoperative period such as delayed wound healing, gaping, infection, and recurrence of the deformity. In hot and humid countries like India healing gets markedly delayed if the surgical wound gets infection or there is wound dehiscence. To maintain a corrected deformity with a window cut into the cast for dressings, and subsequent soiling is difficult. Residual fore foot adduction is the common deformity noted with wound complications.

Wound complications following posteromedial release are inherent to the technique only as the contracted skin posteromedially will never suffice as a cover once the foot is brought to the neutral position. [23] The horizontal subtalar rotation is corrected to achieve improvement in ankle motion by flexor tendon sheath recession and early motion.

Single or staged posteromedial releases did not prevent relapses, even though those done in one stage obtained better results. The long term results can be achieved by the transfer of the anterior tibial tendon to the third cuneiform.

Materials and Methods

We are presenting a study on recurring deformities in CTEV following surgical correction. This study has been done on 38

cases of club foot infants who are treated for the deformity correction during 2019 to 2022. All the children are found to be with resistant deformities during the initial manipulations and were found to be resistant after partial deformity corrections, which were subjected to surgical corrections subsequently. The criterion to include an infant in the study is based on the persisting deformities of the foot with a minimum Pirani score of 1.5. The infants in the study have history of unrelated illness to the deformity or parent's non-compliance for discontinuing the manipulations and casting before the total or desired correction is achieved. The usual age at which the parents seek medical advice is around 10 months of age where in the child has attempted to assume erect posture and started to walk.

Each such child is included in the study. The Pirani score and the rigidity encountered for the manipulations attempted again to correct the deformity forms the basis for advising surgical correction for the deformity. The infants have undergone repeat manipulation with ponseti technique for minimum of three times and pop casting for achieving correction with a gap of three days between each cast. After three manipulations and castings the progress is measured with pirani scoring the infants with no improvement of pirani scoring ≥ 1.5 are taken up for surgical correction of the deformity.

The progress of each child has been recorded from the manipulations and castings which are started after a period of discontinuation for reasons not related to the deformity. Such second phase of manipulations and corrections are done every fourth day so as to save some time before the child is diagnosed as resistance club foot child. The deformities are assessed at each visit, and ones which are found to be resistant are planned for soft tissue correction at 3 to 4 weeks after the second phase of manipulations and POP casts

started. Few such children have already started to assume erect postures or walking.

The deformities which were resistant in the second phase of correction were planned for surgical correction of the deformities. The infants are subjected for pre anaesthetic check-up for their fitness to undergo the surgery. Postero medial soft tissue release is the surgical correction of the deformity advised for these children with resistant deformities. The deformities to be corrected are graded for all the infants included in the study are plotted in the chart given below.

The combination of deformities that became resistant in the cases involved in the study are mid foot adduction and equinus. The radiological assessment of the foot with AP and Lateral views is done. After a thorough clinical assessment and functional ability of the child to assume plantigrade foot, the surgical deformity correction is planned as soon as the child is fit for General Anaesthesia. Common components of resistant clubfoot deformity are adduction or supination, or both, of the forefoot, a short medial column or long lateral column of the foot, internal rotation and varus of the calcaneus, and equinus.

Operative Treatment

Resistant Clubfoot

Common components of resistant clubfoot deformity are adduction or supination, or both, of the forefoot, a short medial column or long lateral column of the foot, internal rotation and varus of the calcaneus, and equinus.

Correction of the forefoot with residual adduction or supination or both is similar to correction of isolated metatarsus adductus by multiple metatarsal osteotomies or by combined medial cuneiform and lateral cuboid osteotomies, when the deformity is in the forefoot. Evaluation of the hindfoot

should determine whether the deformity is caused by isolated heel varus, a long lateral column of the foot, or a short medial column. In children younger than 2 or 3 years who have had no previous surgery, residual heel varus may be corrected by extensive subtalar release. The components of residual deformity are essentially assessed accurately and the treatment is directed appropriately.

Evaluation of the hindfoot should determine whether the deformity is caused by isolated heel varus, a long lateral column of the foot, or a short medial column. In children younger than 2 or 3 years who have had no previous surgery, residual heel varus is corrected by extensive subtalar release, Residual heel equinus is corrected by Achilles tendon lengthening and posterior ankle and subtalar capsulotomies.

Results

The children who underwent Soft tissue release procedures are followed up for two weeks in immediate post operative period with above knee POP cast till suture removal and second cast for another month after the surgery. The results are as follows,

Out of 38 children who have undergone the rapid ponseti casting followed by surgical correction for the resistant CTEV, 15 children have discontinued the pop casts after the surgical correction. The reasons being post operative infection in 4 children and 11 children with unrelated illness during the post operative period for which the children were not brought for follow ups or their POP cast to maintain the reduction achieved with surgical correction. The Pirani scores in these 14 children out of 15 continued to be ≥ 1.5 in the follow up visits. In the remaining 23 children who have continued POP casting post operatively the results were 21 corrected deformities and 2 were uncorrected following the same casting post operatively.

Table 1

	Corrected Deformity	Persisting Deformity	Row Totals
Continued POP Cast	21	2	23
Discontinued POP Cast	1	14	15
Column Totals	22	16	38 (Grand Total)

Analysis

Chi-square test: These results were analyzed with Chi square test to compare the observed results of persisting deformity with expected results of corrected deformity. The purpose of this test is to determine if a

difference between observed data and expected data is due to chance, or if it is due to a relationship between the variables that are studied.

Table 2: Analysis of results at significance level .05

	Corrected Deformity	Persisting Deformity	Row Totals
Continued POP Cast	21 (13.32) [4.43]	2 (9.68) [6.10]	23
Discontinued POP Cast	1 (8.68) [6.80]	14 (6.32) [9.35]	15
Column Totals	22	16	38 (Grand Total)

The chi-square statistic is 26.6801. The p-value is < .00001. The result is significant at $p < .05$

All the cases were with the history of manipulation and deformity correction with ponseti cast who discontinued and presented after the child has started walking. The deformity correction even after the postero medial soft tissue release depends on Ponseti casts, which are a must even after surgical correction with soft tissue release postero medially.

Paired *t* Test: The Pirani scores of both groups as who Discontinued castings and who continued castings were analyzed with Paired *t* Test . Paired *t* test results are as follows

P value and statistical significance: The two-tailed P value equals 0.0916. By conventional criteria, this difference is considered to be not quite statistically significant.

Confidence interval: The mean of Discontinued castings minus Continued castings equals 0.500.

95% confidence interval of this difference: From -0.092 to 1.092.

Intermediate values used in calculations:

$$t = 1.8114$$

$$df = 14$$

$$\text{standard error of difference} = 0.276$$

Discussion

Functional ability of the child, the severity of symptoms associated with the deformity, and the likelihood of progression if the deformity is left untreated must be considered when treatment decisions are being made. Repeat manipulation and casting should always be considered as an option for the recurrent clubfoot. Repeat manipulation and casting can sustain the corrected deformity.

Recurrence of the deformity is infrequent if the bracing protocol is followed closely. Early recurrences (usually mild equinus and heel varus) are best treated with repeat manipulation and casting. The analysis of Pirani scores of patients who have undergone soft tissue release procedures as a group which discontinued POP Castings and which continued POP castings indicates that the

groups do not have significant differences in the Pirani scores as indication for the surgery. But the resulting deformity correction has been affected by discontinued POP castings.

Several long-term evaluations of surgically treated clubfeet have demonstrated good results. The feet typically are plantigrade, functional, and relatively painless; however, persistent stiffness and mild discomfort with prolonged standing or activity are common.

The manipulations as per Ponseti technique are advised with focused approach to impress upon the parents to continue the treatment as per ponseti technique till total sustainable correction is achieved, The study reveals that the parents involvement to bring the child for follow ups is as important as it is before and after surgical corrections. The deformities are better planned and corrected to get a plantigrade foot before the child starts to bear weight.



Figure 1: Pre Operative Resistant Deformity with Second episode of serial castings and Post Operative



Figure 2: Sustained deformity correction with surgical release and Continued castings

Master Chart:

S.No:	Side	Pre Operative							Post Operative							Cast
		HFCS			MFCS			Pirani Score	HFCS			MFCS			Pirani Score	
		PC	EH	RF	MC	CLB	HT		PC	EH	RF	MC	CLB	HT		
1	Right	0	0.5	1	1	1	0.5	4	0	0.5	0.5	0	0.5	0	1.5	Dc
2	Left	1	1	1	0.5	0.5	0.5	4.5	0	0	0	0.5	0.5	0.5	1.5	Dc
3	Left	0	0	0.5	0.5	0	0.5	1.5	0	0	0	0	0	0	0	C
4	Right	0	0.5	0.5	1	0.5	0	2.5	0	0	0	0	0	0	0	C
5	Right	1	0	0.5	0.5	0	0.5	2.5	0	0	0	0	0	0	0	C
6	Right	1	0.5	0.5	0.5	1	0.5	3	0.5	0	0.5	0.5	0	0	1.5	Dc
7	Left	0.5	0.5	0.5	1	0.5	0.5	3.5	0	0	0	0	0	0	0	C
8	Left	1	0.5	0.5	1	0.5	0.5	4.5	0	0	0	0	0	0	0	Dc
9	Right	0.5	0.5	0.5	0.5	0.5	0.5	3	0	0	0	0	0	0	0	C
10	Left	1	0	0	0.5	0.5	0	2	0	0	0	0	0	0	0	C
11	Right	0.5	0.5	1	0.5	0.5	1	4	0.5	0.5	0.5	0	0	0	1.5	Dc
12	Right	1	0.5	0.5	0.5	1	0.5	4	0	0	0	0	0	0	0	C
13	Right	0.5	0.5	1	1	0.5	0.5	4	0	0	0	0	0	0	0	C
14	Left	0.5	1	0.5	0.5	0	0.5	3	0	0.5	0.5	0	0	0.5	1.5	C
15	Right	1	1	0.5	0	0	0.5	3	0.5	0.5	0	0	0	0.5	1.5	Dc
16	Left	0.5	0.5	0.5	1	0.5	0.5	3.5	0	0	0	0	0	0	0	C
17	Left	0.5	1	0.5	0.5	0.5	0.5	3.5	0.5	0.5	0.5	0.5	0	0	2	Dc
18	Left	1	0.5	1	0.5	1	0.5	4.5	0	0	0	0	0	0	0	C
19	Left	0.5	1	1	0.5	0.5	0.5	4	0	0	0	0	0	0	0	C
20	Right	1	0.5	0.5	0.5	1	1	4.5	0	0	0	0	0	0	0	C
21	Left	1	1	0.5	0.5	1	1	5	0.5	0.5	0	0.5	0.5	0	1.5	C
22	Right	0.5	1	0.5	0.5	0.5	0.5	3.5	0	0	0	0	0	0	0	C
23	Right	1	1	1	0.5	0.5	0.5	4.5	0.5	0.5	0.5	0.5	0.5	0	2.5	Dc
24	Left	0.5	1	0	1	0.5	0.5	3.5	0.5	0.5	0	0.5	0.5	0.5	2.5	Dc
25	Right	0.5	0.5	1	0.5	1	0.5	4	0	0	0	0	0	0	0	C
26	Left	1	1	1	1	1	0.5	5.5	0.5	0	0.5	0.5	0	0	1.5	Dc
27	Left	1	0.5	0.5	0.5	1	0.5	4	0	0	0	0	0	0	0	C
28	Right	1	1	1	0.5	0.5	0	4	0	0	0	0	0	0	0	C
29	Left	0.5	1	0.5	0.5	0.5	0	3	0	0.5	0.5	0	0.5	0	1.5	Dc
30	Right	1	1	0.5	0.5	1	1	5	0	0	0	0	0	0	0	C
31	Left	0.5	0.5	1	0.5	1	1	4.5	0	0	0	0	0	0	0	C
32	Right	1	1	0.5	0.5	0.5	1	4.5	0.5	0.5	0.5	1	0.5	0.5	3.5	Dc
33	Right	0.5	1	0.5	0.5	1	1	4.5	0.5	0.5	0.5	0	0.5	0.5	2.5	Dc
34	Left	1	0.5	0.5	0.5	1	0	3.5	0	0	0	0	0	0	0	C
35	Right	0.5	1	0.5	0.5	0.5	0	3	0.5	0.5	0.5	0	0	0	1.5	Dc
36	Left	1	0.5	0.5	0.5	0.5	1	4	0	0	0	0	0	0	0	C
37	Left	0.5	1	1	0.5	1	0.5	4.5	0	0	0	0	0	0	0	C
38	Right	1	0.5	1	0.5	1	0.5	4.5	0.5	0.5	0	0.5	0.5	0	1.5	Dc

Hind foot contracture score (HFCS) PC: Posterior Crease, EH: Emptyness of Heel, RE: Rigidity of Equinus

Mid foot contracture score (MFCS): MC: Medial Crease, CLB: Curvature of Lateral Boarder, PT: Palpation of Head of Talus, C: Continued castings, Dc: Discontinued castings

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