

Relapse following use of Ponseti method in idiopathic clubfoot

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Abstract

Purpose We assessed the pattern of relapse as well as the correlation between the number of casts required for correction and Pirani and Dimeglio scores at presentation, and age at presentation. We hypothesized that the Ponseti method would be effective in treatment of relapsed clubfoot as well.

Methods We evaluated 115 idiopathic clubfeet in 79 children presenting with relapse following treatment by the Ponseti method. The mean age was 33.8 months with mean follow-up of 24 months. All patients were assessed for various patterns of relapsed deformities. Quantification of deformities was done using the Pirani and Dimeglio scores. All relapsed feet were treated by a repeat Ponseti protocol.

Results Non-compliance to a foot abduction brace was observed to be the main contributing factor in relapse, in 99 clubfeet (86%). Combination of three static deformities (equinus, varus and adduction) together was observed most commonly (38.3% feet). Overall, relapse of equinus deformity was noted most commonly followed by adduction. A painless plantigrade foot was obtained in all 115 feet with a mean of five casts. In all, 71 feet (61.7%) underwent percutaneous tenotomy. A total of 15 feet (13%) required tibialis anterior tendon transfer. Re-relapse rate in group 1 was 21% compared with 12.6% in group 2 and overall 16.5%.

Conclusion We conclude that the Ponseti method is effective and the preferred initial treatment modality for relapsed clubfeet. Surgical intervention should be reserved for residual deformity only after a fair trial of Ponseti cast treatment. Regular follow-up and strict adherence to brace protocol may reduce future relapse rates. Further research is required to identify high-risk feet and develop individualized bracing protocol.

Level of evidence: IV

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Keywords: relapse; clubfoot; Ponseti; Dimeglio scoring; re-relapse

Introduction

A relapsed clubfoot is defined as recurrence of any component of deformity after a complete correction of clubfoot.^{1,2} Regardless of the mode of treatment, the clubfoot has an inherent and stubborn tendency to relapse.¹ Although the Ponseti method has now been established as the treatment of choice for idiopathic clubfoot, even this method has not solved the problem of relapse completely. Relapse following the Ponseti method is very common and has been reported even upto rates of 56% by various authors.³⁻⁶ Not only the aetiology of relapsed clubfoot is elusive, the satisfactory treatment of such feet is still obscure. Various methods ranging from recasting to soft-tissue releases and bony osteotomies to external fixators have been described in isolation or combination. None of the methods dealing with relapses are universally acceptable and each has its own drawbacks. We have evaluated a series of 115 idiopathic clubfeet in 79 children presenting with relapse after Ponseti method.

The aim of our study was to assess the effectiveness of a repeat of the Ponseti method in treatment of clubfeet relapsed following the Ponseti method and its limitations. Further we assessed not only the pattern of relapse, but also any correlation between the number of casts required for correction and Pirani and Dimeglio scores at presentation, and age at presentation of relapse. We hypothesized that the Ponseti method would be effective in treatment of relapsed clubfoot as well.

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Materials and methods

Institutional Ethical committee approval was obtained before the initiation of the study. A prospective study was carried out between July 2012 and June 2015 at our tertiary care institute. During this study period there were a total of 617 children with 817 idiopathic clubfeet registered at our clubfoot clinic. Relapse was defined as return to casting or surgery after documented correction of the initial deformity and initiation of bracing. A total of 125 idiopathic clubfeet in 85 children presenting with relapse were included in the study. Out of these, 25 children with 41 clubfeet were referred relapse cases from other institutes.

All the children included were treated previously by the Ponseti method. Syndromic clubfeet, neurogenic clubfeet and post-surgical relapses were excluded. Informed consent was taken for treatment and study from parents after explaining the nature of disease and mode of treatment.

A detailed history was taken from parents regarding the onset of deformity, history of treatment and general examination to rule out syndromic clubfoot. We relied on the parents' report with regard to the use of a brace, as objective measures of brace compliance were not available.^{7, 8} We considered it as non-compliance (NC) when the foot abduction brace (FAB) was not used for at least ten hours a day, as suggested by Morcuende et al.⁹ Quantification of deformities was done using the Pirani and Dimeglio scores.^{10, 11} All patients were assessed for pattern of relapse of static deformities i.e. equinus (E), varus (V), adduction (A), cavus (C) as well as for dynamic supination (D). We also observed the age at presentation, change in scores, number of casts required and amount of ankle dorsiflexion achieved.

All relapsed feet were treated by a repeat Ponseti casting. All patients underwent weekly cast application in our day-care clinic using Ponseti's classical two hand technique. The initial stretching for two to three minutes was done before every cast application as the soft-tissue in elder children and relapsed cases was less yielding. All of the casts were applied under the supervision of the senior author (AM). Percutaneous tenotomy (PCT) of the tendo-Achilles, if required, was done mostly under local anaesthesia. Post-tenotomy casts were removed at three weeks. Tibialis anterior tendon transfer (TATT) was done in children older than three years with D where the third cuneiform showed ossification. TATT was done under general anaesthesia by the modified Garceau's procedure, as described by Ponseti.^{1, 12} To maintain the achieved correction, a Steenbeek FAB was given to all, excepting patients who underwent TATT. In non-ambulatory children (who had not started walking at the time of relapse), FAB was applied for 23 hours a day for the first three months and sleep and nap time (12 to 14 hours/day) until the age of five years was recommended. In ambulatory patients below five years,

FAB was given only for night and nap time until the age of five years. For children older than five years at presentation, the braces were advised for night time for only about three to six months. No special footwear was given for day time.¹³ Patients were followed-up every six weeks for the first six months and then every three months.

The quantitative variables were expressed as mean and sd and compared between pre- and post-treatment follow-up using the paired t-test. Also, the relation between the Pirani and Dimeglio score and age at presentation with number of casts required was evaluated using Pearson's correlation coefficient. Statistical analysis was performed using SPSS version 21.0 software (IBM; Armonk, New York) and a p-value < 0.05 was considered statistically significant.

Results

A total of 125 idiopathic clubfeet (85 children) that had relapsed after Ponseti management were included in the study. Six children (ten feet) were lost to follow-up. A total of 115 idiopathic clubfeet (79 children) with a minimum of 12 months follow-up were available for final assessment. The mean age at presentation was 33.8 months (7 to 100). The male to female ratio was 3.4:1. At relapse, 43 children had unilateral involvement (54.4%). In unilateral cases, the right foot was involved twice as many times as the left foot. The mean follow-up was 24 months (12 to 36). We divided children into two categories: age group (group 1 – age less than two years and group 2 – age two or more years). and deformity group (group A – less than three deformities and group B – three or more deformities) (Table 1).

Table 1 Cohort of our study

Study cohort		
Total children		79
Boys		61
Girls		18
Total feet		115
Age	< 2 yrs (group 1)	52 (45.2%) (feet)
	≥ 2 yrs (group 2)	63 (54.8%)
Bilateral feet		36 children
Unilateral	Right	31
	Left	12
Initial Dimeglio (at relapse)	I (Mild)	2 (feet)
	II (Moderate)	89
	III (Severe)	24
	IV (Very severe)	0
FAB	N	16 (feet)
	NC	99
Previous treatment method		Ponseti in all (100%)
Previous surgery	None	7 (feet)
	PCT	102
	PCT+TATT*	6

*six feet had primary relapse following previous TATT. On checking records, we noted all of them underwent this procedure at an outside institute between two and three years of age

FAB, foot abduction brace; N, FAB compliant feet; NC, non-compliance; PCT, percutaneous tenotomy; TATT, tibialis anterior tendon transfer

NC to FAB was observed in 99 clubfeet (86%). We noticed that the relapse of deformities occurred either singularly or more commonly in various combinations (Table 2). The most common relapse pattern observed was a combination of three deformities (E, A and V in 38% feet). In group 2, 78% of feet had three or more deformities whereas group 1 had only 40% of feet in this category ($p < 0.001$).

Table 2 Various combinations of deformities observed with number of feet involved

Deformity	Feet (n)	Total (n)
Patients with relapse of only one deformity:		
E	17	20
A	2	
D	1	
Patients with relapse of combination of two deformities:		
EA	8	17
EV	6	
EC	2	
ED	1	
Patients with relapse of combination of three deformities:		
EAV	40	51
EAD	9	
VCD	2	
Patients with relapse of combination of more than three deformities:		
EVAC	14	19
EVAD	4	
EVACD	1	
Patients with relapse as loss of correction achieved rather than frank deformity (Pirani score ≥ 1/difficulty in squatting):		
n/a	n/a	8

E, equinus; V, varus; A, adduction; C, cavus; D, dynamic supination

Table 3 Mean values of Pirani and Dimeglio scores, equinus (pre and post) and casts applied

	N	Mean	sd	Standard error	95% confidence interval for mean			
					Lower bound	Upper bound	Minimum	Maximum
Initial Pirani	115	2.409	0.8825	0.0823	2.246	2.572	1.0	4.5
Final Pirani	115	.02	0.131	0.012	0.00	0.04	0	1
Change in Pirani scores	115	2.3913	0.90025	0.08395	2.2250	2.5576	1.00	4.50
Initial Dimeglio	115	7.92	2.086	0.195	7.54	8.31	4	14
Final Dimeglio	115	1.89	1.310	0.122	1.65	2.13	0	5
Change in Dimeglio scores	115	6.0348	1.99090	0.18565	5.6670	6.4026	1.00	11.00
Equinus (pre)	115	9.62	9.855	0.919	7.80	11.44	-5	48
Equinus (post) (DF achieved)	115	17.86	5.655	0.527	16.82	18.91	5	24
Change in equinus	115	8.2435	11.85852	1.10581	6.0529	10.4341	-43.00	27.00
Casts applied	115	5.0261	2.12941	0.19857	4.6327	5.4195	1.00	12.00
Follow-up (mths)	79	23.82	6.261	0.704	22.42	25.23	12	36

DF, dorsiflexion

However, overall, the relapse of E deformity was noted most in 102 clubfeet (89%). Deformity A was noted as the second most common deformity, involving 78 (67.8%) clubfeet. V and C involved 67 (58.3%) and 19 (16.5%) clubfeet respectively but were never observed as a singular deformity.

At presentation, D was noted in 18 (15.6%) clubfeet. Among these, ten feet required TATT.

Five more feet required TATT in which D was not appreciable at the time of presentation due to combination of severe deformities. But when feet became plantigrade after cast treatment, D became evident and required TATT. So, in our study of 115 clubfeet, 15 feet in total underwent TATT. Post treatment, D was corrected in all patients.

The mean values of Pirani and Dimeglio scores, E and casts applied in relation to deformities and age are shown in Tables 3, 4, 5. We noted a positive correlation between age at presentation with relapse and initial Dimeglio score ($p = 0.012$), E ($p = 0.087$) and casts applied ($p = 0.000$); but a negative correlation with initial Pirani score ($p = 0.224$).

On analyzing groups 1 and 2, we noted a lower mean initial Pirani score in group 2 despite higher Dimeglio score and E. However, p-values were not significant. The final Pirani score was also not significant between these two groups, but a p-value which was significant in the final Dimeglio score and DF was achieved. Also, changes in scores were not significant between groups 1 and 2. A statistically significant highest mean change in scores and E was noted in subgroup 1B (age less than two years and with three or more deformities).

The mean number of casts applied was 5.03 (1 to 12). Group 1 patients required fewer casts to regain correction (four versus 5.9, $p < 0.05$). Casts applied had statistically significant positive correlation with initial Dimeglio score,

Table 4 Mean values of Pirani and Dimeglio scores, equinus (pre and post) and casts applied in age group

	Age	n	Mean	sd	p-value
Initial Pirani	Group 1 (age < 2 yrs)	52	2.519	0.8854	0.224
	Group 2 (age > 2 yrs)	63	2.317	0.8767	
Final Pirani	Group 1 (age < 2 yrs)	52	0.00	0.000	0.198
	Group 2 (age > 2 yrs)	63	0.03	0.177	
Change in Pirani scores	Group 1 (age < 2 yrs)	52	2.5192	0.88540	0.167
	Group 2 (age > 2 yrs)	63	2.2857	0.90569	
Initial Dimeglio	Group 1 (age < 2 yrs)	52	7.38	1.952	0.012
	Group 2 (age > 2 yrs)	63	8.37	2.105	
Final Dimeglio	Group 1 (age < 2 yrs)	52	1.06	1.110	0.000
	Group 2 (age > 2 yrs)	63	2.57	1.043	
Change in Dimeglio scores	Group 1 (age < 2 yrs)	52	6.3269	1.71179	0.154
	Group 2 (age > 2 yrs)	63	5.7937	2.17877	
Equinus (pre)	Group 1 (age < 2 yrs)	52	7.885	8.9851	0.087
	Group 2 (age > 2 yrs)	63	11.048	10.3712	
Equinus (post)	Group 1 (age < 2 yrs)	52	-20.481	2.8731	0.000
	Group 2 (age > 2 yrs)	63	-15.698	6.4424	
Change in equinus (pre-post)	Group 1 (age < 2 yrs)	52	28.3654	9.48069	0.428
	Group 2 (age > 2 yrs)	63	26.7460	11.87566	
Casts applied	Group 1 (age < 2 yrs)	52	4.00	1.469	0.000
	Group 2 (age > 2 yrs)	63	5.87	2.225	

Table 5 Mean values of Pirani and Dimeglio scores, equinus (pre and post) and casts applied in deformity group

	Deformity	n	Mean	sd	p-value
Age (months)	Group A*	33	23.24	15.678	0.000
	Group B*	46	41.35	22.968	
Initial Pirani	Group A*	45	1.800	0.6342	0.000
	Group B*	70	2.800	0.7958	
Final Pirani	Group A*	45	0.00	0.000	0.257
	Group B*	70	0.03	0.168	
Change in Pirani scores	Group A*	45	1.8000	0.63425	0.000
	Group B*	70	2.7714	0.84135	
Initial Dimeglio	Group A*	45	6.00	1.128	0.000
	Group B*	70	9.16	1.557	
Final Dimeglio	Group A*	45	1.22	1.363	0.000
	Group B*	70	2.31	1.084	
Change in Dimeglio scores	Group A*	45	4.7778	1.75666	0.000
	Group B*	70	6.8429	1.69941	
Equinus (pre)	Group A*	45	5.222	5.2175	0.000
	Group B*	70	12.443	11.0632	
Equinus (post)	Group A*	45	-18.000	5.4062	0.834
	Group B*	70	-17.771	5.8463	
Change in Equinus (pre-post)	Group A*	45	23.2222	7.12514	0.001
	Group B*	70	30.2143	11.93569	
Casts applied	Group A*	45	4.04	1.461	0.000
	Group B*	70	5.66	2.258	

*Group A (less than three deformities); group B (three or more deformities)

E and age; but not with initial Pirani score. The mean time taken for treatment was eight weeks.

The pre-treatment mean E was 9.6° (-5° to 48°). The mean dorsiflexion achieved was 17.8° (5° to 24°). The mean DF achieved in group 1 was 20° compared with 15° in group 2 with a p-value < 0.05.

In 44 feet (38.3%), complete correction was achieved with casting only. 75% of these feet (33) were in group 1.

In the remaining 71 feet (61.7%) PCT was also required, whereas TATT was added to PCT in 15 feet (13%). Three feet belonging to group 2 required percutaneous plantar fasciotomy for 'C' correction. This was done under general anaesthesia at the time of PCT.

Thus, all 115 feet (100%) were corrected by the Ponseti treatment protocol. None of the feet required capsular release or osseous procedures. Figures 1 and 2 show some of our results.

In all, 19 feet (16.5%) relapsed again. Eleven of these feet were in group 1. NC to FAB was found in all. E was the only deformity to re-relapse in all 19 feet. These re-relapse cases were managed again in a similar way with the Ponseti method and are currently under follow-up.

Three feet developed plaster sores over the talar head region which was managed by sterile dressing and gentle casting with extra padding. One foot developed wound infection on the sole at the button site after TATT. This was managed by antiseptic dressing and button removal at three weeks post-surgery.

Discussion

With a large number of clubfoot cases, there is an obvious load of relapse cases, especially in developing countries. Long-term studies of surgical procedures have shown poor results with complications like painful feet, arthritis, stiffness of the ankle and subtalar joint and residual deformity.¹⁴⁻¹⁶ Relapses after soft-tissue releases and osteotomies are further difficult to treat as they result in rigid foot due to extensive scarring after surgery.¹⁷ The Ponseti method is essentially a conservative method, which has



Fig. 1 (a) Deformity at presentation - from front; (b) cavus at presentation; (c) deformity at presentation - both feet.

shown more than 90% successful long-term results in idiopathic clubfoot.^{1,18-20} It seemed interesting and judicious to evaluate the role and efficacy of the Ponseti method in the management of relapsed clubfoot (previous Ponseti treatment) which formed the basis of our study. Also, this is one of the preliminary attempts to study pattern of relapse in clubfeet treated by the Ponseti method.

In the literature, there is no consensus on the definition of 'non-compliance' to FAB.⁷⁻⁹ But most authors agree on the fact that NC to FAB is the single most significant risk factor for relapse.^{1,7-9,21,22} Reported NC ranges from 0% to 51%.^{7,20-22}

NC to FAB was observed in 99 clubfeet (86%). Among relapse feet with NC to FAB, 66% had more than three deformities. Thus, NC to FAB was not only associated with increased chances of relapse, but also with increased severity of deformity ($p < 0.05$). Mahan et al²³ reported

that relapse in patients aged less than two years was more related to NC than relapse in patients aged two or more years. In our study, NC was similar in both groups 1 and 2.

Bhaskar and Patni²⁴ suggested a classification for relapse. However, they did not describe various combinations of deformities that could relapse. They used various surgical procedures including abductor hallucis release, posterior release and osteotomies (Table 6).

We observed relapse of E most commonly (89% feet), and this was more severe in feet with a combination of deformities ($p < 0.05$). This may probably be due to the relapse of E first in most cases, with other deformities added later. Eight feet from group 1 had no frank deformity but had a Pirani score ≥ 1 and presented with difficulty in squatting or loss of previous dorsiflexion to neutral. We included these in our study as early relapse cases as we believe this would progress to a fixed E (grade



Fig. 2 (a) Correction achieved - from front; (b) dorsiflexion achieved - right foot; (c) dorsiflexion achieved - left foot; (d) correction of heel varus; (e) correction of cavus.

la of Bhaskar and Patni²⁴). Also, a relapse of V or C deformity alone was never noticed. Thus, loss of dorsiflexion can be seen as the earliest sign of relapse.

We included D as a relapse because we believe that it signifies muscle imbalance in the foot and may progress to severe static deformities, if not addressed timely.

Contrary to earlier reports^{1,25} we found that the relapse of forefoot A was as common as relapse of hind foot deformities. Bhaskar and Patni²⁴ also described similar findings. They noted that dynamic forefoot A or in-toeing was the most common relapse pattern after treatment by the Ponseti technique.

We described various patterns and combinations of deformities that have rarely been described in literature. We observed 14 possible combinations of deformities. However, distribution of feet was skewed with one combination (EAV) contributing to more than one-third of feet

with relapse. A larger study should be able to describe deformities/combination patterns which are more prone to recurrences and are difficult to treat. This may help us in guiding/modifying treatment and bracing protocols.

We acknowledge that in any study design it is difficult to pinpoint when a relapse first began to happen. It is a very likely possibility that some children had relapse before two years of age but reported it after two years of age. It may suggest some cases of relapse with multiple deformities presented very late after relapse. The upper age limit for bracing was set somewhat arbitrarily. After observing relapses even after the age of six years, bracing protocol needs a re-evaluation. Further research is required to develop an individualized bracing schedule at least in some selected cases.

A review of the literature revealed relapses managed by Ilizarov with or without soft-tissue/bony procedures.

Table 6 Comparison with various published studies

	Refaie al ²⁷	Prem et al ²⁶	Bhaskar and Patni ²⁴	Our study
Study group	Idiopathic (Ponseti + post-surgical relapse)	Idiopathic (post-surgical + post-Ilizarov relapse)	Idiopathic, post-Ponseti relapse	Idiopathic, post-Ponseti relapse
Type of study	Retrospective case series	Retrospective	Prospective	Prospective
Number of feet	19 (9 post-Ponseti)	19	164	115
Mean age (range)	8 yrs (2 to 6)	5 yrs (2 to 8)	48 mths (24 to 72)	33.8 mths (7 to 100)
Mean Pirani score	Pre NA Post NA	NA NA	NA NA	2.4 .02
Mean Dimeglio score	Pre NA Post NA	NA (all at least grade III Dimeglio) NA	NA NA	7.92 1.89
Mean casts applied (range)	Cast for consolidation for 4 to 6 wks	Consolidation cast for 6 wks	NA	5.03 (1 to 12)
NC to FAB in relapse cases	NA	NA	89%	86%
Average time taken for treatment	11 wks	22 wks	NA	8 wks
Average dorsiflexion	NA	NA (only 1 foot had dorsiflexion > 10°)	NA	17.9°
Re-relapses	15.8%	5.3%	NA	16.5%
Soft-tissue procedures	<ul style="list-style-type: none"> Abductor hallucis release and plantar fasciotomy in all Tenotomy for toe contractures 	None	<ul style="list-style-type: none"> PCT TATT Routine abductor hallucis tenotomy Posterior release Subtalar release (exact values not described) 	PCT = 61.7% feet TATT = 13% feet Plantar fasciotomy = 2.6% feet
Osseous procedures	<ul style="list-style-type: none"> Trans-fixation of midfoot joints 3 recurrences required osteotomies 	None	<ul style="list-style-type: none"> Lateral closing osteotomy Medial column lengthening 	None
Complications	36 minor complications including 4 flat topped-talus	<ul style="list-style-type: none"> 17 feet flat top talus Wedge navicular 7 patients Pin-site infection in most of cases 	NA	3 plaster sores 1 button site infection
Braces/special shoes	FAO for 6 mths Followed by CTEV shoes for 1 yr	<ul style="list-style-type: none"> FAO 	<ul style="list-style-type: none"> FAB followed by AFO CTEV shoes at walking age 	FAB only
Mean follow-up(range)	4.5 yrs (2 to 6)	6.9 yrs (5 to 10)	24 mths (12 to 28)	24 mths (12 to 36)

NA, not available; NC, non-compliance; FAB, foot abduction brace; PCT, percutaneous tenotomy; TATT, tibialis anterior tendon transfer; FAO, foot abduction orthosis; AFO, ankle foot orthosis; CTEV, congenital talipes equino varus

Results from Prem et al²⁶ and Refai et al²⁷ are summarized in a comparison in Table 6.

Utukuri et al²⁸ studied patient-based outcomes after Ilizarov surgery in 26 resistant clubfeet (all had previously undergone surgery). Mean age was nine years with a mean follow-up of 47 months. The total time taken was around 23 weeks. They noted a 65% recurrence rate. They described better functional results in spite of a poor surgical outcome. All Ilizarov procedures require at least two general anaesthesia procedures in each case (adding further to cost of frame).

A painless plantigrade foot was obtained in all 115 feet with casting and/or minimal surgery as per Ponseti protocol with a mean of 5.02 casts. Children in group 1 achieved statistically significant higher DF with fewer number of casts ($p < 0.05$). Children and parents were satisfied with the final results as they were able to wear normal footwear and carry out most of the functions. Our results are better than studies

with surgical and fixator treatment for post-Ponseti relapses in terms of very few complications, less treatment time taken, no capsular release or osseous procedures needed and supple feet with better final scores and higher DF (Table 6).

We recommend use of the Dimeglio score, as relapse cases may score less on Pirani despite stubborn deformity. Many of these children lack deep posterior and medial crease. Initial Pirani score had a negative correlation with age at relapse. Also, improvement in the 20-point Dimeglio score is a better indicator for correction achieved between consecutive casts, as the Pirani score may remain unchanged.

Younger age at TATT has been found to be a risk factor for recurrence.^{6,29} We noted that six feet presenting with primary relapse had a history of TATT. On checking records, all of them underwent this procedure at an outside institute between two to three years of age. We did not perform TATT in children under the age of three years.

In this study, none of our patients who underwent TATT at our institute re-relapsed until last follow-up.

The re-relapse rate in group 1 was 21% compared with 12.6% in group 2 and overall 16.5%. Mahan et al²³ also reported higher a recurrence rate at age less than two years. A higher re-relapse rate should be anticipated in a longer follow-up but these re-relapses after Ponseti treatment are less stiff and can be managed again with the Ponseti protocol. Also, prophylactic TATT can be considered in children above three years of age. However, further study would be required to validate its role.

There are a few limitations to this study. A larger study group and longer follow-up from multiple centres is desirable to validate results of repeat Ponseti method in relapse. Also, we recorded recall-based NC to FAB. A total of 25 children with 41 clubfeet included in this study underwent first treatment elsewhere. It is often difficult to distinguish incomplete correction from true relapses. Final outcome assessment based on functional scoring was not used in this study.

Despite these shortcomings, our study describes rarely described patterns and combinations of deformities that relapse following use of the Ponseti technique and achieved correction by repeat Ponseti.

We conclude that the Ponseti method should be the preferred initial treatment modality even for relapsed idiopathic clubfeet. Surgical intervention should be reserved for residual deformity only after the fair trial of Ponseti treatment. It would be a good cost-effective method especially in developing countries with a high occurrence of clubfoot and scarce resources. Strict adherence to brace protocol and good communication between doctor and parents may reduce future incidences of relapse. Further research is required to identify high risk feet and develop individualized bracing protocols.

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ETHICAL STATEMENT

Ethical approval: Institutional Ethical Committee approval was obtained prior to the initiation of the study. All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/

or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent: Informed consent was obtained from all individual participants included in the study.

ICMJE CONFLICT OF INTEREST STATEMENT

The authors declare no potential conflicts of interest.

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