Correlation of age and severity scores to the number of Ponseti casts in Indian infants with clubfeet

Prateek Rastogi^{*}, Anil Agarwal, Satyam Singh, Chaitanaya Prakash Meena, Neeraj Gupta

Department of Paediatric Orthopaedics, Chacha Nehru Bal Chikitsalaya, Geeta Colony, Delhi, 31, India

ARTICLE INFO

Article history:

Received 26 March 2020
Received in revised form
10 June 2020
Accepted 11 June 2020
Available online 26 June 2020

Keywords:

Clubfoot
Pirani score
Dimeglio score
Number of casts
Age

ABSTRACT

Purpose: World over, age and various severity scores are among the foremost variables studied in relation to the number of casts in clubfoot. We studied the correlation between child's age at presentation, initial Pirani, Dimeglio scores to the number of Ponseti casts in Indian clubfoot children. Further, we matched Pirani versus Dimeglio scores at different severities of deformity to derive a correlation between them.

Methods: We included 90 idiopathic clubfeet in 55 infants and scored them according to Pirani and Dimeglio grading systems. Syndromic, neurological, surgically intervened, atypical or complex clubfeet were excluded from the study. The number of casts before percutaneous tenotomy was counted. Correlations were calculated between corrective casts and age, Pirani, Dimeglio scores and their individual components.

Results: Mean age of children was 63.7 days and average number of casts applied was 3.2. Age at presentation and number of casts had no correlation with $r = 0.034$ ($p < 0.001$). The correlation between initial Pirani score (average 5.39) and Dimeglio score (average 13.4) to number of casts was 0.35 ($p < 0.001$) and 0.56 ($p < 0.0001$) respectively. Among individual components of Pirani score, medial crease and rigid equinus had maximum correlation to the number of casts whereas empty heel sign had the lowest. For Dimeglio score, equinus and varus correlated the most and posterior crease the least. Pirani and Dimeglio scores were highly correlated ($r = 0.87$) to each other except for very supple or severe deformity.

Conclusions: In infancy, the age at presentation had no bearing on number of casts. Both scoring systems had positive correlation in terms of corrective casts for our population. The Dimeglio fared slightly better than Pirani scores.

© 2020

1. Introduction

Clubfoot is one of the most common congenital and paediatric foot deformity with reported incidence up to 1 per 1000 live births.^{1,2} Various methods of treatment have been suggested but over the time Ponseti technique has become the standard of treatment.³

There are various systems to classify clubfoot and quantify its severity.^{4–8} Among these, Pirani and Dimeglio scores are the most commonly used and studied.^{6,8} Studies have documented good

inter-observer reliability of these two classification systems but can these classifications guide the treatment duration and prognostication is still unclear.⁹ Few studies have shown a correlation between the initial scores and total number of casts whereas others could not.^{9–14} A study on European population has reported a strong correlation of $r = 0.53$ and $r = 0.73$ respectively for Pirani and Dimeglio scores with total number of casts.¹³ On the other hand, a study done in New Zealand has reported just a weak correlation of Pirani ($r = 0.12$) and Dimeglio scores ($r = 0.21$) with the number of casts.¹² The variations in scores and their correlation with the number of casts prompted us to conduct a similar study for infants with clubfoot in Indian subcontinent. The main aim was to establish the therapeutic and prognostic significance of these scores for our children.

We studied the correlation between child's age at presentation, initial Pirani, Dimeglio scores to the number of Ponseti casts in

^{*} Corresponding author. 46-C, Pocket A, Sukhdev Vihar, New Delhi, 110025, India.
E-mail addresses: prateek.rastogi12@gmail.com (P. Rastogi), anilrachna@gmail.com (A. Agarwal), maytas29@gmail.com (S. Singh), drpc2911@gmail.com (C.P. Meena), drsonugupta@rediffmail.com (N. Gupta).

children undergoing treatment for clubfeet. Further, we matched Pirani versus Dimeglio scores at different severities of deformity to derive a correlation between them.

2. Methods

This prospective study (March 2019–October 2019) was conducted at a tertiary care hospital in northern India. We included 90 idiopathic clubfeet in 55 children aged less than 1 year treated with Ponseti technique. Syndromic, neurological, surgically intervened, atypical or complex clubfeet were excluded from the study. Ethical clearance and parent's consent were obtained for the study.

All included infants were scored according to Pirani and Dimeglio grading systems at each casting session before application of weekly casts. All castings were done by a trained Paediatric Orthopaedic fellow under the supervision of senior Paediatric Orthopaedic surgeon. Reduction of lateral head of talus (lateral head talus = 0, midfoot score ≤ 1 , hind foot score > 1) was taken as the indication to perform a percutaneous Achilles tenotomy. Three weeks post tenotomy, child was prescribed a foot abduction brace to maintain the correction achieved.

Pirani score has 6 components (rigid equinus, posterior crease, empty heel sign, curved lateral border, medial crease and lateral head of talus) which are scored 0, 0.5 or 1 on the basis of increasing severity.⁸ In Dimeglio system, 4 major components (equinus, varus, derotation of calcaneo-pedal block and adduction) are scored from 0 to 4 on the basis of increasing severity whereas 4 minor components (cavus, medial crease, posterior crease & poor calf muscles) are scored 0 or 1 on their absence or presence respectively.⁶

2.1. Statistical analysis

The child's age at presentation and number of pretenotomy casts required were recorded and Pearson correlation coefficient (r) between the two was calculated. In children not requiring tenotomy, total casts used for deformity correction were considered for calculations. Spearman correlation coefficient (r_s) was calculated for

total Pirani, Dimeglio score at presentation and the number of casts. It was also used for individual components of both these scores except for the minor components of Dimeglio score. Correlation between minor components of Dimeglio score and number of casts was established by point biserial correlation coefficient (r_{pb}).

For the purpose of correlating Pirani score and Dimeglio score on the basis of severity of deformity, the clubfeet were divided into categories (from 1 to 7) on the basis of number corrective casts required for their correction. Categories 1 and 2 represented mild, 3 and 4 moderate and 5–7 severe deformities.⁹ The relationship between the two scores at different severity of disease was established using the Pearson correlation coefficient (r).

Interpretations of correlation coefficients were done as described by Chu et al.¹¹ Correlation coefficients from 0 to 0.20 were considered as having no correlation. Similarly, 0.20 to 0.40 were low correlation; 0.40 to 0.60 were moderate correlation, 0.60 to 0.80 were marked correlation and lastly 0.80 to 1.00 were considered high correlation.

3. Results

There were 35 bilateral clubfeet whereas 20 had unilateral involvement. There were 40 males and 15 females. Percutaneous Achilles tenotomy was performed in all except 2 feet. Average age at presentation was 63.7 ± 82.4 days (range, 4–360 days). Average number of casts applied before tenotomy were 3.2 ± 1.4 (range, 1–7). The Pearson's correlation coefficient between age and number of casts was 0.034 ($p < 0.005$). This showed that there was no correlation between age at presentation and the number of casts among infants.

Average Pirani and Dimeglio score at presentation were 5.4 (range, 1.5–6) and 13.4 (range, 4–20) respectively. Around 54% feet ($n = 49$) in our study had the maximum Pirani score of '6'. A maximum Dimeglio score of '20' however was found in just 2 feet (2%). For Dimeglio scores, the maximum percentage of patients i.e. 23% ($n = 21$) were in '15–16' range instead of '20'. Also by observing Figs. 1 and 2, one can visualize the concentration of dots to the

Fig. 1. Scatter plot showing frequency distribution and trend of initial Pirani score and the number of casts (ps_initial = Initial Pirani score).

Fig. 2. Scatter Plot showing frequency distribution and trend of initial Dimeglio score and the number of casts (ds_initial = Initial Dimeglio score).

extreme right in Pirani plot whereas for Dimeglio plot, the dots were scattered less towards right. Thus, Pirani score measured the deformity more severely.

The relationship between the Pirani scores, Dimeglio scores, their individual components and the total number of casts for each foot are tabulated in Tables 1 and 2. Total Pirani score (Table 1) had a low positive correlation to the number of casts ($r_s = 0.35$). Amongst individual components, medial crease ($r_s = 0.38$) followed by rigid equinus ($r_s = 0.34$) had highest correlation to the number of casts, whereas empty heel sign had the lowest correlation ($r_s = 0.18$). The correlation between total initial Dimeglio score and the total number of casts (Table 2) was moderate at $r_s = 0.56$. Among components, equinus had the highest correlation ($r_s = 0.59$) followed by varus ($r_s = 0.58$) whereas posterior crease had the lowest ($r_{pb} = 0.02$). These analyses indicated that even though both Pirani and Dimeglio score are positively correlated to the number of casts, Dimeglio score appeared to be a better choice statistically.

The total Pirani score strongly correlated to the total Dimeglio score ($r = 0.87$) (Table 3). When Pirani and Dimeglio scores were compared for various severities of clubfeet as inferred by the number of corrective casts, both scores correlated well in the 2, 3 and 4 cast categories. For categories 1 (mild deformity) or 5–7 (severe deformities) casts, correlation was not found statistically significant.

4. Discussion

There have been many researches to facilitate the prediction of treatment duration and prognostication in clubfoot patients.^{9–15} The foremost investigated parameters are the age of child and the severity scores. We found no correlation between child's age at presentation and the number of casts required for treatment in our population. In view of peculiar socioeconomic and religious circumstances prevailing in our country, there may be some delay in seeking medical consultation. Thus, a slight delay (up to age less than 1 year) in seeking treatment for clubfoot did not significantly increase the treatment duration or the number of casts. However, it

Table 1

Correlations of Pirani score and its components to the number of casts (r_s = Spearman correlation coefficient, '*' = statistically not significant; $p \geq 0.05$).

Score component	Correlation Coefficient (r_s)	P- Value	Correlation
Rigid Equinus	0.34	0.001	Low
Empty Heel Sign	0.18	0.099*	No
Posterior Crease	0.28	0.007	Low
Lateral Head Talus	0.27	0.009	Low
Curved Lateral border	0.30	0.005	Low
Medial Crease	0.38	<0.0001	Low
Hind Foot Score	0.34	0.001	Low
Mid Foot Score	0.37	<0.0001	Low
Total Pirani Score	0.35	<0.001	Low

Table 2

Correlations of Dimeglio score and its components to the number of casts (r_s = Spearman correlation coefficient, r_{pb} = Point biserial correlation coefficient, '*' = statistically not significant; $p \geq 0.05$), DCPB = Derotation of calcaneo-pedal block).

Score component	Correlation coefficient	P- value	Correlation
Equinus	$r_s = 0.59$	<0.0001	Moderate
Varus	$r_s = 0.58$	<0.0001	Moderate
DCPB	$r_s = 0.48$	<0.0001	Moderate
Adduction	$r_s = 0.53$	<0.0001	Moderate
Cavus	$r_{pb} = 0.20$	0.059*	Low
Medial Crease	$r_{pb} = 0.22$	0.039	Low
Posterior Crease	$r_{pb} = 0.02$	0.871*	No
Poor Calf Muscles	$r_{pb} = 0.39$	<0.0001	Low
Total Dimeglio Score	$r_s = 0.56$	<0.0001	Moderate

is always advisable to start treatment of clubfoot as early as possible because of a suppler foot and better results with early intervention. Similar inferences were drawn in studies by Gao et al., Lampasi et al. and Alves et al.^{12,13,16} Contrarily, Patil et al. and Agarwal et al. suggested that the total number casts required for treatment increase with age at presentation.^{14,15} This could be attributed to the fact that these later studies included older children up to age of 3 and 10 years respectively.

Table 3Correlation of Pirani and Dimeglio scores at different severity of deformity ($p < 0.05$ significant).

Number of total casts	Number of cases	Pirani score	Dimeglio score	Pearson Correlation (r)	P value
Total	90	5.4 ± 1.0	13.4 ± 3.7	0.87	<0.001
1	6	4.2 ± 1.5	9 ± 2.3	0.585	0.22
2	24	5.2 ± 1.1	11.8 ± 3.2	0.86	<0.0001
3	33	5.4 ± 0.9	13.2 ± 3.2	0.81	<0.0001
4	13	5.8 ± 0.3	15.2 ± 3.1	0.88	<0.0001
5	7	5.9 ± 0.2	16 ± 2.8	0.63	0.13
6 & 7	7	5.9 ± 0.2	17.6 ± 3.2	0.84	0.019

A positive correlation of the scoring systems to the number of casts indicated their relationship to severity of clubfoot deformity. A child with higher score at presentation is expected to need higher number of casts for deformity to correct and this can be accordingly explained to the parents. The scores may therefore be used judiciously for prognostication of care receivers. Lampasi et al. in their study on European population found correlation coefficients slightly lower for Pirani score ($r_s = 0.56$) as compared to Dimeglio score ($r_s = 0.73$) against the number of casts.¹³ Fan et al. from China reported a moderate correlation for both scores (Pirani- 0.49 and Dimeglio- 0.42).⁹ Chu et al. from USA reported the correlations to be low (Pirani- 0.33 and Dimeglio-0.34) whereas Gao et al. from New Zealand reported no correlation for Pirani ($r_s = 0.12$) but a low correlation for Dimeglio score ($r_s = 0.21$).^{11,12} Our Indian study demonstrated a low correlation for Pirani score ($r_s = 0.35$) and a moderate correlation for Dimeglio score ($r_s = 0.56$). Thus, most studies from different regions of world conclude a variable (low to marked) positive correlation for initial scores with the number of casts. The correlations are slightly better for Dimeglio score.

Correlation of individual components to the number of casts helped determine which components contribute maximum in prognostication of the number of casts. These components can be used to develop future scores which will have better correlation to number of casts. For our study, amongst Pirani's individual components, medial crease followed by rigid equinus had highest correlation to the number of casts, whereas empty heel sign had the lowest correlation. For Dimeglio individual components, equinus had the highest correlation followed by varus whereas posterior crease had the lowest. Chu et al. reported equinus in Dimeglio score to be most correlated and posterior crease be least correlated to number of casts.¹¹ In Pirani score, lateral head of talus and medial crease were the components which had highest and lowest correlations respectively. Gao et al. reported equinus in Dimeglio score and rigid equinus in Pirani score as having highest correlation whereas medial crease, posterior crease and poor calf muscles in Dimeglio score and empty heel sign in Pirani score were lowest.¹² Equinus of Dimeglio score was the only component persistently

found to have significant correlation to the number of casts when we interpret our results and above literature. Similar conclusion cannot be drawn as far as components of Pirani score were concerned. A comparison of studies showing correlation of individual components with the number of casts is given in Table 4. Since the correlation of individual components to the number of casts in available studies is variable, further studies in larger groups and different geographic regions are recommended to arrive at precise relationships.

The finding (Table 3) that Pirani and Dimeglio scores correlated well when clubfoot severity was moderate was also reported by Fan et al.⁹ A good correlation between the scores established their significance in treatment of clubfoot and implied that any one of these can be used to grade moderate clubfoot deformity with expected similar results. At extremes of deformity, the correlations were however not statistically significant. A possible explanation may be the number of patients on the extremes of severity were few, making statistical calculation non significant.

There were limitations of our study that should be considered. Being a cross-sectional study limited to a short period of time, there was no follow up and thus relapse rates cannot be predicted with respect to initial Pirani and Dimeglio scores. Both feet in bilateral clubfoot were counted as separate which could be a potential bias. As a single researcher recorded the scores and applied all casts, blinding was not possible. Scoring and number of casts can vary with the applicator's expertise. This very fact is also strength of the study. As a single trained fellow performed both these tasks observer bias is minimized. Another strength is that it was a prospective study as compared to most other which are retrospective.^{9–11,14}

In conclusion, the tested scoring systems had low to moderate positive correlation in terms of corrective casts for our population. Thus, their prognostic value is valid across the geographic regions. The Dimeglio scores fared slightly better than Pirani. With use of these systems, the care receivers can be provided an approximate cast number and duration of treatment. Equinus in Dimeglio scoring system had maximum correlation to the number of casts among individual components. Both scores correlated to each other

Table 4

Correlation of individual components of Pirani and Dimeglio score to the number of cast in various studies. (RE = Rigid equinus, PC= Posterior crease, LHT = Lateral head of talus, CLB= Curved lateral border, DCPB = Derotation of calcaneo-pedal block, MC = Medial crease, PCM= Poor calf muscles).

	Chu et al., 2010 ¹¹		Gao et al., 2014 ¹²		Current study	
	Pirani	Dimeglio	Pirani	Dimeglio	Pirani	Dimeglio
Low Correlation	RE PC LHT CLB	Equinus Varus DCPB Adduction	—	Equinus	RE PC LHT CLB MC	MC PCM
Moderate Correlation						Equinus Varus DCPB Adduction

as well when clubfoot deformity was moderate. Further prospective studies involving different centres and larger sample size may precisely establish the exact relationship between scoring systems and the number of casts.

CRedit authorship contribution statement

Prateek Rastogi: Writing - original draft, Formal analysis. **Anil Agarwal:** Writing - original draft. **Satyam Singh:** Writing - original draft. **Chaitanaya Prakash Meena:** Writing - original draft. **Neeraj Gupta:** Writing - original draft.

Declaration of competing interest

We wish to confirm that there are no known conflicts of interest associated with this publication and there has been no significant financial support for this work that could have influenced its outcome.

References

1. Dobbs MB, Gurnett CA. Update on clubfoot: etiology and treatment. *Clin Orthop Relat Res.* 2009;467:1146–1153.
2. Davies RW. Family studies and the cause of congenital club foot, talipes equinovarus, talipes calcaneovalgus and metatarsus varus. *J Bone Joint Surg Br.* 1964;46:445–463.
3. Ponseti IV. Treatment of congenital clubfoot. *J Bone Joint Surg.* 1992;74:448–454.
4. Ponseti IV, Smoley EN. The classic: congenital clubfoot: the results of treatment 1963. *Clin Orthop Relat Res.* 2009;467:1133–1145.
5. Catterall A. A method of assessment of the clubfoot deformity. *Clin Orthop Relat Res.* 1991;264:48–53.
6. Dimeglio A, Bensahel H, Souchet P, Mazeau P, Bonnet F. Classification of clubfoot. *J Pediatr Orthop B.* 1995;4:129–136.
7. Staheli L. *Clubfoot: Ponseti Management.* Seattle, WA: Global HELP; 2009.
8. Pirani S, Naddumba E, Staheli L. *Ponseti Clubfoot Management: Teaching Manual for Healthcare Providers in Uganda.* Seattle, WA: Global HELP; 2008.
9. Fan H, Liu Y, Zhao L, et al. The correlation of Pirani and Dimeglio scoring systems for Ponseti management at different levels of deformity severity. *Sci Rep.* 2017;7:14578.
10. Dyer PJ, Davis N. The role of the Pirani scoring system in the management of club foot by the Ponseti method. *J Bone Joint Surg Br.* 2006;88:1082–1084.
11. Chu A, Labar AS, Sala DA, van Bosse HJ, Lehman WB. Clubfoot classification: correlation with Ponseti cast treatment. *J Pediatr Orthop.* 2010;30:695–699.
12. Gao R, Tomlinson M, Walker C. Correlation of Pirani and Dimeglio scores with number of Ponseti casts required for clubfoot correction. *J Pediatr Orthop.* 2014;34:639–642.
13. Lampasi M, Abati CN, Bettuzzi C, Stilli S, Trisolino G. Comparison of Dimeglio and Pirani score in predicting number of casts and need for tenotomy in clubfoot correction using the Ponseti method. *Int Orthop.* 2018;42:2429–2436.
14. Agarwal A, Gupta N. Does initial Pirani score and age influence number of Ponseti casts in children? *Int Orthop.* 2013;38:569–572.
15. Patil MS, Sasnur AH, Ali MN, Patil RM. Role of age in management of clubfoot by Ponseti method and relapse rate. *Al Ameen J Med Sci.* 2014;7:154–159.
16. Alves C, Escalda C, Fernandes P, Tavares D, Neves MC. Ponseti method: does age at the beginning of treatment make a difference? *Clin Orthop Relat Res.* 2009;467:1271–1277.