doi: https://doi.org/10.5704/MOJ.2607.011

Relationship of Talar Dome Changes with Ankle Mobility in Conservatively Treated Idiopathic Congenital Equino-Varus Foot

Chattopadhyay A[1], MS Orth, **Sinha S[2],** MS Orth, **Raghav L[3],** MS Orth, **Gupta S[3],** MS Orth, **Sud A[3],** MS Orth, **Kanojia RK[3],** MS Orth

[1]Department of Orthopaedics, Aruna Asaf Ali Government Hospital, New Delhi, India
[2]Department of Orthopaedics, Hamdard Institute of Medical Science and Research, New Delhi, India
[3]Department of Orthopaedics, Lady Hardinge Medical College, New Delhi, India

Date of submission: 30th April 2025
Date of acceptance: 03rd October 2025

ABSTRACT

Introduction: The Ponseti technique (PT) is widely used for managing idiopathic congenital talipes equinovarus (CTEV), but it can lead to talar dome distortion and reduced ankle range of motion (ROM), resulting in compromise functional outcomes. This study aimed to evaluate talar distortion in children treated with the Ponseti method and explore the relationship between static ankle movement and talar distortion, using the radius-to-length (R/L) ratio.

Materials and methods: A prospective observational study was conducted involving 25 children aged 5 to 15 years with unilateral idiopathic CTEV, all of whom had achieved correction with the Ponseti method by the age of one. Detailed clinical histories, functional assessments, and radiographic evaluations were performed. The R/L ratio of the talus was calculated and correlated with ankle ROM, number of casts, number of tenotomies, and the Ponseti and Laaveg score.

Results: Talar dome distortion was observed in 64% of cases. A significant negative correlation was found between the treated foot's R/L ratio and its ankle ROM (Spearman's $\rho = -0.634$, $p = 0.001$), as well as with the Ponseti and Laaveg scores (Spearman's $\rho = -0.533$, $p = 0.006$). A positive correlation was identified between the R/L ratio and the number of casts applied (Spearman's = 0.417, $p = 0.038$). A statistically significant difference in both ROM and R/L ratio was noted between the treated and unaffected feet.

Conclusion: Talar Dome distortion is present in conservatively managed CTEV feet. There is also a significant negative correlation between R/L ratio, ankle ROM and Ponseti and Laaveg score.

Keywords:
CTEV, congenital talipes equino-varus, talar dome distortion, R/L Ratio, Ponseti method

INTRODUCTION

Over the years, the treatment of Congenital Talipes Equino Varus (CTEV) has undergone a phenomenal shift. Since the advent of the Ponseti technique, the need for surgical interventions has reduced significantly[1]. Deformation of the talus after correction of clubfoot using the Ponseti method has been a well-documented complication[2-4]. Many authors have reported the occurrence of talar flattening in up to 100% of patients[2]. Several studies have explored the roles of various factors responsible for talus deformation and its clinical outcomes. Flattening of the talar dome has been correlated with various physical characteristics of the participants, as well as their outcomes in terms of ankle range of motion and quality of life[1-4].

The ratio of the radius of the talar dome (R) to the length of the talus from the posterior extremity to the distal portion of the head (L) is a measure of talar flattening. It provides a numerical measure of the flattening of the talar dome[5,6]. The reliability and reproducibility of the R/L ratio have been evaluated, and it has been shown to be a reliable measure of talar dome flattening[7]. Another method of assessing the correction of clubfoot is total ankle motion, measured as ankle range of motion (ROM)[8]. As both measures are related to the anatomical structures involved in the pathology and assess the success of clubfoot correction, a relationship may exist between them. However, there is a dearth of evidence establishing a correlation between the two measures. Talar dome flattening is well documented ranging from 29-100%. There are controversies related to talar dome flattening, some authors attribute it to a complication of treatment rather while others consider it as patho-anatomical changes related to CTEV[9,10]. Ponseti method of correction has been reported to have the least incidence of talar dome flattening[10]. To the best of our knowledge no studies have compared the ankle

Corresponding Author: Siddhartha Sinha, Department of Orthopaedics, Hamdard Institute of Medical Sciences and Research, New Delhi 110062, India
Email: siddharthasinha87@gmail.com

ROM of the treated and unaffected feet in unilateral clubfoot, or the associated changes in the talar dome.

This study aimed to evaluate the shape of the talar dome and its correlation with ankle range of motion in conservatively treated unilateral idiopathic clubfoot, as well as to compare it with the contralateral normal foot. It also assessed the relationship between the talar distortion (R/L) ratio and the number of casts, the number of tenotomies, and the Ponseti and Laaveg score[11].

MATERIALS AND METHODS

This prospective observational study was conducted between November 2019 and September 2021 after obtaining appropriate institutional ethical clearance and included 25 patients. All patients aged 5 to 15 years with unilateral clubfoot who had completed treatment using the Ponseti method before the age of 1 year, and who were registered with the institutional CTEV clinic with a minimum follow-up of 4 years, were included in the study. Patients with neurological disorders, prior surgical intervention to the affected foot, or those whose guardians did not provide consent to participate were excluded.

Participants meeting the inclusion criteria were identified and contacted via telephone for follow-up at the CTEV clinic. A detailed history was obtained regarding initiation of treatment, number of casts applied, the need for percutaneous tenotomy (PCT), the number of PCTs required for correction, the age at which PCT was performed, and any instances of relapse, recurrence, or loss to follow-up during the treatment period. The total ankle range of motion on both the treated and unaffected sides was recorded using a goniometer, and functional outcome by assessed using the Ponseti and Laaveg score[11].

Radiological assessment was performed in the standing position using anteroposterior and lateral radiographs of the ankle for both the treated and unaffected feet[4]. Parameters assessed on the lateral radiograph included talar dome distortion and the radius-to-length (R/L) ratio. The R/L ratio was measured using serial concentric Mose rings; the circle that best fit the contour of the talar dome on the radiograph was identified. The radius of this circle was then determined, and a line drawn from the posterior-most point of talus to the distal-most point of the talar head was defined as the talar length. The ratio of these two measurements was calculated as the R/L ratio (Fig. 1). The R/L ratio was determined for both the treated and unaffected sides. The normal range for the R/L ratio has been reported to be 0.29 – 0.42 based on a study by Hjelmstedt and Sahlsted[5]. A high index (R/L ratio) indicates that the radius is abnormally large in relation to the length of the talus, i.e., that the talus is flattened.

The collected data were entered into Microsoft Excel 2019 and subsequently imported into SPSS version 25 for statistical analysis. Proportions, percentages, means, and standard deviations were used for descriptive statistics. Spearman's correlation coefficient was employed to determine the correlations between various parameters.

RESULTS

A total of 25 participants were recruited in this study. Of these, 68% (n=17) were male and 32% (n=8) were female. The mean age of the participants was 9.88 ± 2.14 years. Sixty percent (n=15) of participants had right-foot and 40% (n=10) had left-sided CTEV. The mean age at which the first cast was applied was 6.08 ± 3.8 weeks. The mean number of casts applied in our study was 7.2 ± 2.1. Of the 25 participants, 18 required PCT once during treatment, and 5 required PCT twice due to recurrence (recurrence rate = 20%). The mean age at which the first PCT was performed was 12.4 ± 4.76 weeks. The mean ankle ROM was 28.72 ± 6.59° and 61.12 ± 6.35° in treated and unaffected feet, collectively. An independent t-test showed that there was a statistically significant difference in the ankle range of motion between treated and unaffected feet ($p<0.05$). Sixty-four percent (n=16) of the participants showed talar dome distortion. The mean R/L ratio was 0.46 ± 0.06 in the treated and 0.36 ± 0.02 in the unaffected limbs. On applying independent t-test, there was a significant difference in the R/L ratio between treated and unaffected foot. The detailed results regarding ankle range of motion, functional scores, and radiological scores are summarised in Table I.

Correlation analysis was performed to ascertain the association between the R/L ratio and ankle ROM, the number of casts, the number of PCTs, and Ponseti and Laaveg score. A correlation matrix was generated, and Spearman's ρ was calculated for all variables. A positive correlation was observed between the R/L ratio of the treated foot and the number of casts applied (Spearman's $\rho=0.417$, $p=0.038$). The ankle ROM of the treated foot and the Ponseti and Laaveg score were negatively correlated with its R/L ratio. The R/L ratios of the treated feet did not show statistically significant correlations with the number of PCTs performed (see Table II).

DISCUSSION

The Ponseti method of clubfoot correction has become the gold standard for correcting clubfoot, whether idiopathic, congenital, or secondary. Although mostly successful, the Ponseti method is also associated with complications arising from flattening of the talar dome and restricted range of motion, which are hypothesised to result from overcorrection. Both talar dome curvature, measured in terms of the R/L ratio, and ankle range of motion are considered measures of successful clubfoot correction and functional foot performance. Talus deformities have been independently identified as causes of disability and

Table I: Summary of demographic, functional and performance scores and radiological parameters in this study.

S. No	Parameter	Results
1.	Age of first cast (weeks)	6.08 ± 3.83
2.	Number of Casts	7.2 ± 2.1
3.	Number of PCTs	1.12 ±0.45
4.	Age of first PCT (weeks)	12.4 ± 0.52
5.	Affected ankle ROM (degrees)	28.72 ± 6.59
6.	Unaffected ankle ROM (degrees)	61.12 ± 6.35
Functional and Performance scores		
7.	Ponseti and Laaveg functional score	76.84 ± 7.19
8.	Performance score	
	Good	11 (44%)
	Fair	11 (44%)
	Poor	3 (12%)
Radiological Parameters		
9.	Radius-length ratio affected	0.46 ± 0.06
10	Radius-length ratio unaffected	0.36 ± 0.02

Table II: Correlation of various radiological and clinical parameters of the study.

Variables Compared	Spearman's ρ	p-value (significant if p<0.05)	Significance (significant if p<0.05)
R/L ratio (treated foot) – No. of casts	0.417	0.038	Significant
R/L ratio (treated foot) – Number of PCT	0.266	0.198	Not Significant
R/L ratio (treated foot) – Ankle ROM (treated foot)	-0.634	0.001	Significant
R/L ratio (treated foot) – Ponseti and Laaveg score	-0.533	0.006	Significant
Ankle ROM (treated foot) – Ponseti and Laaveg score	0.799	<0.001	Significant

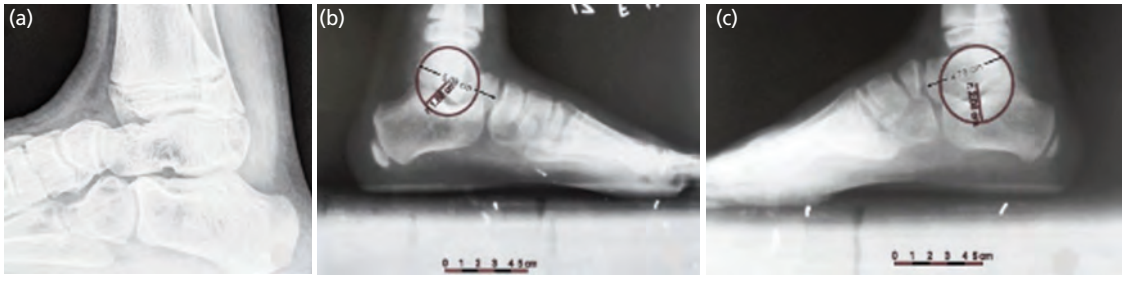

Fig. 1: (a) Plain lateral radiograph of the left foot after CTEV correction. (b) R/L ratio calculation in unaffected right foot. (c) Calculation of R/L ratio in affected left foot.

functional limitations[12]. Bach *et al* identified talar distortion as an important finding in corrected clubfeet and suggested in-depth evaluation of the talar dome in relation to ankle range of motion. He later described the R/L ratio and its significance and reliability in assessing talar flattening in idiopathic clubfoot[7,8]. Epeldegui emphasised the functional implications of talar structure in the management of clubfoot[13]. These findings suggest that the talar dome, its flattening, and its association with ankle ROM are decisive factors in determining the functional outcomes of idiopathic clubfoot[14,15]. Roche *et al* demonstrated shortening of the talar bone in the affected foot compared to the contralateral foot[16]. In the current study, there was a male predominance (68%). Most studies on clubfoot have reported that the incidence in males is nearly twice that in females[17,18]. The mean age of participants in our study was 9.88 ± 2.14 years. This is higher than the mean age reported by Tripathy *et al* (7.3 years)[19]. The mean age at first PCT was reported to be 12.4 ± 0.52 weeks in our study. This is similar to the average age at first tenotomy, which has been reported to be 12.5 weeks by MacNeille *et al*[20].

The mean number of casts applied to participants in this study was 7.2 ± 2.1. This number is lower than that reported by Lourenço and Morcuende, who observed an average of 9 casts[21]. Sinha *et al* and Verma *et al* also reported higher

average numbers of casts—10 and 12.8, respectively[22,23]. The higher average age at treatment initiation contribute to the increased number of casts required.

In this study, the ankle ROM was restricted in the treated limb and the difference between the treated and unaffected limbs was statistically significant. The static ankle ROMs were 28.72° ± 6.59° and 61.12° ± 6.35° for treated and unaffected feet, respectively. Bach *et al* also reported a significant difference in the ankle ROM. They reported a static ROM of 35° and dynamic ROM of 17.9° in clubfeet as compared to 68° static and 24.9° dynamic ROMs in normal feet7. A study by Kalenderer *et al* also reported a mean ankle ROM of 47° in treated feet[24].

Talar flattening has been reported by Khan *et al*, Bach *et al*, Cooper *et al*, Hutchins *et al*, with an incidence of up to 81%[3,7,10,25,26]. The R/L ratio serves as a reliable indicator of talar dome flattening. In the present study, the R/L ratios were 0.46 ± 0.06 and 0.362 ± 0.02 for the treated and unaffected feet, respectively and there was a statistically significant difference between the treated and unaffected feet ($p<0.001$). Hamel *et al* reported similar ratios of 0.43 ± 0.04 and 0.39 ± 0.03 in treated and unaffected individuals, respectively, based on age- and gender-matched controls[27]. Bach *et al* reported an R/L ratio of 0.597 (range: 0.31–1.33), which was higher than the ratio observed in the present study[8]. In our study, The R/L ratio of the unaffected feet in unilateral clubfoot cases was within the normal range and resembled that of normal feet.

The mean Laaveg–Ponseti functional score in the current study was 76.84 ± 7.19. There was a significant negative correlation of Ponseti and Laaveg score to the R/L ratio indicating that talar dome flattening adversely affected functional outcomes. This is lower than the scores reported by Chueire *et al*, who reported a score of 89.76, and Singh *et al*, who reported a score of 87.2[28,29]. The score obtained in our study is comparable to findings reported by İşyar *et al* and Tripathy *et al*, who reported scores of 74 and 75.47, respectively[19,30]. These discrepancies in scores may be attributed to the longer follow-up durations and the inclusion of both unilateral and bilateral clubfoot cases in these studies.

A strong positive correlation was observed between the R/L ratio of the treated foot and the number of casts required during correction, suggesting that greater talar flattening is associated with the need for more casts. This study is also among the few that demonstrated a significant correlation between the R/L ratio and ankle range of motion in feet treated with the Ponseti method. Although it remains unclear whether talar flattening results primarily from the treatment process or from the underlying pathoanatomy of CTEV, the findings indicate both anatomical and functional differences between treated feet and unaffected feet.

Radiological parameters, such as the talo-navicular angle and the metaphyso–talo–calcaneal angle, have previously been evaluated for their prognostic value in clubfoot, often in conjunction with physical findings. However, the R/L ratio's translational potential and ease of use make it an attractive candidate for predicting clinical and surgical outcomes in patients with unilateral clubfoot.

The primary limitation of this study is the potential for intra-observer variability in measuring the R/L ratio, which could have influenced the results. Although there are numerous other causes of decreased ankle ROM in patients with CTEV, this study did not evaluate the influence of the distal tibial articular surface, joint congruity, or soft tissue condition. The study also did not compare the R/L ratios of treated and untreated CTEV feet. Only static ankle ROM was measured, although dynamic range of motion is often more clinically relevant in children with CTEV. Recall bias may have influenced the findings, as some patients lacked complete medical records at the time of data collection. Functional scores are inherently subjective and may not reliably reflect post-treatment outcomes. Additionally, the sample size was relatively small.

CONCLUSION

Definite talar dome distortion is observed in conservatively managed idiopathic clubfoot. The R/L ratio positively correlated with the number of casts applied during treatment and negatively correlated with functional scores and ankle ROM. This study also demonstrated a significant difference in the mean R/L ratio and ankle range of motion between the treated and unaffected feet. Considering that this is one of the few studies to report the incidence of talar distortion following Ponseti's serial casting, further studies with larger sample sizes and higher levels of evidence are warranted.

CONFLICT OF INTEREST

The authors declare o potential conflict of interest.

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Cite this article:

Chattopadhyay A, Sinha S, Raghav L, Gupta S, Sud A, Kanojia RK. Relationship of Talar Dome Changes with Ankle Mobility in Conservatively Treated Idiopathic Congenital Equino-Varus Foot. *Malays Orthop J.* 2026; 20(2): 90-5. doi: 10.5704/MOJ.2607.011