ABSTRACT

The correlation of anteromedial foot bimalleolar angle with Pirani score evaluated prospectively in 120 children (204 feet) with congenital talipes equinovarus (CTEV). The patients were divided into groups I, II and III based on clinical severity before casting, having the Pirani score 0 to 2, 2.5 to 4 and 4.5 to 6 respectively. Mean foot bimalleolar angle 75.75º, 67.62º and 58.28º of groups I, II and III respectively was correlated by standard deviation with their Pirani scores to evaluate the severity difference among the groups before initiation of the casting treatment. The change in clinical severity or Pirani score was further correlated with the change in mean foot bimalleolar angle at the time of completion of casting and before bracing. The foot bimalleolar angle is an objective, quantitative and reproducible method which can be used to classify, prognosticate and to monitor the progress of the treatment.

Background: The prospective observational study on role of foot bimalleolar angle against the Pirani scoring in clinical evaluation of club foot in 120 children (204 feet) with mean age of 5.4 months treated by Ponseti technique of casting.

Keywords: Congenital talipes equinovarus, Foot bimalleolar angle, Pirani scoring and Podogram.

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INTRODUCTION

Congenital talipes equinovarus (CTEV) or club foot is a multidirectional complex foot deformity.13 Idiopathic CTEV is one of the commonest foot deformity seen by orthopedic surgeons.6

The true etiology of club foot is unknown. The three basic components of club foot are equinus, varus and adduction deformities which present with tibial intorsion deformity. Equinus occurs at tibiotalar joint, inversion at subtalar joint and adduction mainly at mid-tarsal joint (talonavicular and calcaneocuboid joint). The other associated secondary deformities can be cavus and clawing of toes.13

The goal of treatment of club foot is to correct all components of the deformity, to obtain a normal looking, functional, plantigrade, painless, supple foot.

Evaluation of idiopathic club foot is essential to assess the initial severity of deformity, to monitor the progress of treatment, to prognosticate and to identify early relapse. Before the evolution of scoring systems Ponseti and Smoley,19 Catterall,1 Dimeglio et al5 Harrold and Walker9 and Pirani scoring system19 there has been little objectivity in assessing the severity of the various components of the deformities. Kumar14 and Mckay15,16 took prints of plantar surface of feet to depict the correction. Among the several clinical scoring systems described by Ponseti IV and Smoley,19 Catterall,1 Dimeglio et al5 Harrold and Walker9 The Pirani scoring18 system which incorporates three components in hindfoot and three in midfoot, has gained popular acceptance. The hindfoot contracture score and midfoot contracture score were calculated to define the correction in each component. This system has been found to be user-friendly, reliable and predictable. It predicts the number of cast required to correct the deformity and the probability of Achilles tendon tenotomy.8,7 There are several scoring systems to accesses the severity of club foot such as in Catterall scoring1 four parameters were used depending upon deformity which was classified as ‘resolving’, by tendon or joint contracture and ‘false correction’. Harrold and Walker9 classified club foot into three parameters according to deformity, whether foot could be held at or beyond neutral position (grade I), fixed equinus <20º (grade II) and >20º (grade III). Dimeglio scoring system5 foot was based on four major and four minor parameters, such as measuring the angles of equinus in sagittal plane, varus deviation in frontal plane, derotation around talus calcaneo-forefoot block, adduction of the forefoot on hindfoot in horizontal plane. According to scores, the foot was classified into four types ‘benign’, ‘moderate’, ‘severe’ and ‘very severe’. Ponseti and Smoley19 classified foot according to ankle dorsiflexion, heel varus, forefoot supination and tibial torsion.

Despite the use of these scoring systems as assessment tools, the ‘gold standard’ remains to be established.
Footprints and podographic foot bimalleolar angle as suggested by Jain et al\textsuperscript{11} is now being increasingly recognized as an assessment and prognostic tool for objective assessment of club foot although its supremacy or equivalence with scoring systems is yet to be established. In view of poor predictability of the present scoring systems and imaging, this study was conducted to find the correlation of foot bimalleolar angle with Pirani scoring system.\textsuperscript{7}

**MATERIALS AND METHODS**

A total of 120 children with 204 feet were included in the study with mean age of 5.4 months. Six patients lost to follow-up were prospectively observed between the period of July, 2011 and August, 2014.

All children underwent treatment by Ponseti’s technique of casting with or without Achilles tendon tenotomy. Children older than 18 months, syndromic club foot, CTEV previously treated by soft tissue release and children with associated lower limb anomalies affecting casting or scoring were excluded. The foot of the child was examined clinically by three surgeons who also verified the podograms on which the foot bimalleolar angle was calculated according to method described by Jain et al\textsuperscript{11} and Jain et al.\textsuperscript{12} The foot was kept plantigrade over white plain sheet on hard base held by an assistant from upper leg. The tips of malleoli were marked on the sheet by dropping pencil on the paper perpendicular by palpating the malleolar tip one by one. First line was drawn from the most convex part of the heel to the center of second toe. Second line was drawn from the mark of medial malleolus to the mark of lateral malleolus on the paper. The anteromedial angle at intersection was taken as foot bimalleolar angle. The podograms recorded with hazy or doubled sole imprint were discarded. The average/mean of three readings of foot bimalleolar angles was calculated to decrease the interobserver variation. The feet were graded according to their severity score by modifying the grading used by Jain et al\textsuperscript{11} as depicted in (Table 1). The fully corrected foot was considered to have normalized to 0 Pirani score before bracing. The normal foot bimalleolar angle was considered to be 82.5º as observed by Jain et al.\textsuperscript{12}

The severity difference among the three groups was evaluated by the calculating the difference in the mean foot bimalleolar angle of the three groups. The statistical significance of the severity difference was evaluated by using one-way ANOVA test.

**Observation and Result**

The mean foot bimalleolar angle 36 feet in preplaster group I was 75.75º (70–84º; SD 4.309), foot bimalleolar angle for 72 feet in group II was 67.62º (59–76º; SD 5.815) and foot bimalleolar angle for 96 feet in group III was 58.28º (51–69º; SD 7.086) (Table 2). All these three groups were found to have statistical significant difference (p < 0.01) by using one-way ANOVA test (Table 3).

Post hoc ANOVA test was applied to quantify the severity difference in foot bimalleolar angles among three groups. The quantitative difference between the means of foot bimalleolar angle in group I with groups II and III was statistically significant and so among the groups II and III (Table 4).

The correlation of foot bimalleolar angle and clinical severity was prospectively evaluated in this study. The percentage change in foot bimalleolar angle of three groups was found to match with the percentage change in Pirani score at the time of tenotomy and before bracing.

| Table 1: Three severity groups based on Pirani score |
|-----------------------------------------------------|
| Groups according to Pirani score | Pirani scores |
|---------------------------------|---------------|
| Group I | 0–2 |
| Group II | 2.5–4 |
| Group III | 4.5–6 |

**Fig. 1:** Clinical photograph before initiation of treatment. Pirani’s score: 5.5 of both feet; FBM angle 51º on left side and 57º on right side
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The average FBM and Pirani score of the three groups reached the same change at the time of completion of the treatment. The improvement in the average foot bimalleolar angle of the three groups preceded the improvement of the Pirani's score but both plateau at the time of completion of the treatment, i.e. at the time of bracing.

DISCUSSION

Idiopathic club foot is a complex foot deformity that is difficult to correct. The goal of the treatment is to achieve a supple, pain free, plantigrade foot with good function, with healing of callosity which will not need any special foot orthosis after maturity. When starting a treatment it is important to describe the treatment to the parents and predict with reasonable accuracy the outcome of the treatment. Club foot is a condition which is variable both in severity and its expected response to the treatment which leads to unpredictability in the duration and type of the treatment required.

The factors that challenge the management of this condition, apart from the deformity itself, are the variations in the description of the observed deformities by various scoring systems. The need is felt by all foot surgeons to develop a method of assessment which is not only easy to learn and apply but is also reproducible.

Table 2: Preplaster mean foot bimalleolar angle and standard deviation in three groups

| Groups according to Pirani scoring | Mean foot bimalleolar angle and SD | Std. error of mean |
|-----------------------------------|-----------------------------------|--------------------|
| Group I (0–2) \(n = 36\)          | 75.75\(^\circ\) (70–84\(^\circ\))   | 4.309              |
| Group II (2.5–4) \(n = 72\)       | 67.62\(^\circ\) (59–76\(^\circ\))   | 5.815              |
| Group III (4.5–6) \(n = 96\)      | 58.28\(^\circ\) (51–69\(^\circ\))   | 7.086              |

SD: Standard deviation

Table 3: Mean difference in preplaster foot bimalleolar angles in three groups

| Groups        | Sum of square | Difference | Mean square | F-ratio | \(p < 0.01\) |
|---------------|---------------|------------|-------------|---------|--------------|
| Between groups| 2988.877      | 2          | 1494.438    | 38.268  | < 0.01       |
| Within groups | 2538.344      | 65         | 39.051      |         |              |
| Total         | 5527.221      | 67         |             |         |              |

Table 4: Mean difference between preplaster foot bimalleolar angles in three groups

| Groups        | Mean difference between groups (\(p < 0.01\)) |
|---------------|-----------------------------------------------|
| I and II      | 8.125 (< 0.01)                               |
| II and III    | 9.344 (< 0.01)                               |
| III and I     | 17.469 (< 0.01)                              |
in multiple hands and has objectivity in assessing the response to the treatment. The ideal grading system for club foot on a severity scale should be ideally applicable to all form of CTEV and should not be affected by age of the child so that it can provide objective recoverable data for a retrospective analysis.

The observations by Wynne-Davies et al, Cohen-Sobel et al, McKay found that most patients had excellent levels of function despite having anatomically and radiographically imperfect feet have reinforced this disparity. The studies by Thompson et al and Cohen-Sobel et al further supported this dilemma. Herbsthofer et al emphasized that clinical evaluation should be the yardstick against which any other method can be compared. Wainwright et al established that the clinical method suggested by Dimeglio et al is more reliable than method suggested by Ponseti and Smoley. Catterall and Harrold and Walker. The use of foot prints or foot tracings has been described in the orthopedic literature. Pirani score objectifies the hindfoot and midfoot contracture scores which are responsible for the appearance of the forefoot in club foot deformity.

The relation of calcaneal axis with bimalleolar plane, described by Cummings et al by CT scan motivated the description of podographic foot bimalleolar angle by Jain et al as an angle between bimalleolar line and the longitudinal foot axis which depended on the shape of the heel and the position of the forefoot. It is a combined indirect indicator of forefoot adduction and the hindfoot varus which are the main components of the club foot deformity and this corresponds anatomically to the amount of calcaneal rotation beneath the talus. The improvement in the shape of the heel and forefoot corresponds to the change in the foot bimalleolar angle and correction of the calcaneal rotation which is the basic pathoanatomical abnormality in club foot as proved by Ponseti and Smoley.

Jain et al studied the foot bimalleolar angle in normal infants and concluded that this angle is simple, objective and reproducible criterion to classify the severity of foot deformity and to evaluate the results of treatment. They found the average FBM to be 82.5° in the normal population. In patients with idiopathic CTEV they found the average FBM to be 73.2, 66.6 and 54.7 degree in Grade I, II and III respectively based on the Kite's method of treatment. They also observed a correlation of foot bimalleolar angle with the outcome of the treatment. This supported the fact that foot bimalleolar angle improves with the correction of the alignment of hindfoot with the forefoot irrespective of the method used for correction and reported a failure rate of 56% in grade III feet. They, however, used a very subjective method to grade the outcome of their results which is not universally acceptable.

Jain et al did a point study and classified the feet into three groups, based on the Pirani severity score. The maximum Pirani score was 2, 4 and 6 of groups I, II and III respectively. They used more objective criteria as compared to clinical grading criteria used by Jain et al. They analyzed the patients in the pretreatment stage and established an indirect correlation between the clinical severity grading and average foot bimalleolar angle. They reported a statistical significant difference in the means of

| Groups     | Average Pirani score, foot bimalleolar angle and percentage change | Preplaster | Before tenotomy | Before bracing |
|------------|--------------------------------------------------------------------|------------|----------------|---------------|
| I (n = 36) (0–2) | Average Pirani score | 2          | 1.37          | 0             |
|            | Percentage severity     | 33.33%     | 22.92%        | 0%            |
|            | Percentage change       | 10.41%     | 22.92%        |               |
|            | Average foot bimalleolar angle | 75.75° | 80.67°        | 82.5°         |
|            | Percentage improvement  | 91.82%     | 97.7%         | 100%          |
|            | Percentage change       | 5.88%      | 2.3%          |               |
| II (n = 72) (2.5–4) | Average Pirani score | 3.6        | 1.4           | 0.041         |
|            | Percentage severity     | 61.45%     | 23.83%        | 0.68%         |
|            | Percentage change       | 37.62%     | 23.14%        |               |
|            | Average foot bimalleolar angle | 67.62° | 76.08°        | 82°           |
|            | Percentage improvement  | 81.96%     | 92.21%        | 99.39%        |
|            | Percentage change       | 10.25%     | 18%           |               |
| III (n = 96) (4.5–6) | Average Pirani score | 4.02       | 3.15          | 0.34          |
|            | Percentage severity     | 66.92%     | 52.50%        | 5.72%         |
|            | Percentage change       | 14.42%     | 46.78%        |               |
|            | Average foot bimalleolar angle | 58.28° | 71.71°        | 79.12°        |
|            | Percentage improvement  | 70.64%     | 86.90%        | 95.98%        |
|            | Percentage change       | 16.26%     | 9.08%         |               |

Table 5: Improvement in Pirani score and foot bimalleolar angle with casting
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foot bimalleolar angles of groups I, II and III among each other but did not study a relation between the change in FBM and clinical correction with the course of the treatment. This forms the basis of the present study.

The Pirani scoring system has been the most widely used clinical system so in this study, groups were divided on the basis of the severity denoted by Pirani score. The three groups made on the basis of severity of the Pirani’s score were found to have average FBM of 75.75°, 67.62° and 58.28° in groups I, II and III respectively, which are comparable to the studies done previously by Jain et al.11 and Jain et al.11 The three groups found to have overlapping values of foot bimalleolar angle as also noticed by Jain et al.11

In our study, the relation of foot bimalleolar angle and clinical severity by Pirani score was found to have average FBM of 75.75°, 67.62° and 58.28° in groups I, II and III respectively, which are comparable to the studies done previously by Jain et al.11 and Jain et al.11 The three groups found to have overlap ping values of foot bimalleolar angle as also noticed by Jain et al.11

In this study, we found that Podographic foot bimalleolar angle provide objective evidence of correction of deformities of idiopathic club foot which can be easily documented without affecting hospital resources. The implication of this interesting observation is that when measured sequentially, podographic foot bimalleolar angle can give indirect objective evidence whether the deformities were getting corrected or not so that surgery could be recommended. Whether podographic foot bimalleolar angle measurement would equally be useful in evaluating feet undergoing postero medial soft tissue release or not requires to be validated by further study. Several studies have shown that many scoring systems in current use lack adequate interobserver and intraobserver consistency. Pirani scoring after Ponseti casting has the maximum impact factor due to its simplicity in orthopedic practice and is most widely used for the assessment of deformity and comparison of the results.

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