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ORIGINAL ARTICLE

Is Sonographic Calculation of Talonavicular Angle During Ponseti Correction of Clubfoot a Reliable Prognostic Indicator?

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ABSTRACT

Background: Ultrasonographic evaluation of clubfoot is an objective method of severity assessment. The objective of this article is to assess the reliability of clubfoot severity assessment by sonographic evaluation of talonavicular angle (TNA) and the reliability of assessing change in angle on simulated Ponseti manipulation.

Materials and methods: Twenty-six infants with unilateral idiopathic clubfoot, treated by serial manipulation and casting by Ponseti technique, were prospectively evaluated by clinical scoring (Dimeglio and Pirani scores) and sonographic measurements of TNA at the start of treatment, after midfoot correction and after complete correction achieved. The TNA and the change in TNA on simulated Ponseti manipulation were noted. Total number of POP casts required to achieve final correction were noted; and correlated with change in TNA on attempted Ponseti manipulation.

Results: Mean TNA in clubfoot (66.46º) in static position was significantly different from that of contralateral normal foot (101.3º). Mean change in TNA on simulated Ponseti manipulation was 22.54º (5-50º) and it showed negative correlation with clinical scores and total number of casts required for final correction ($p < 0.05$). Linear regression analysis revealed that the change in TNA on simulated Ponseti manipulation was the best predictor of treatment outcome in congenital talips equinovarus (CTEV) (with predictability of 60% compared to 19 and 25% of Dimeglio score and Pirani score respectively).

Conclusion: Sonographic evaluation of TNA and change in TNA on simulated Ponseti manipulation can better assess the severity of clubfoot in infants. This objective method of assessment is less expensive, clinically applicable reproducible and it can better predict the treatment outcome.

Keywords: CTEV, Club foot, Ponseti, Talonavicular angle, Ultrasonography.

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INTRODUCTION

Congenital talipes equinovarus (CTEV), the most common congenital orthopedic conditions requiring intensive treatment from birth, has the primary abnormality of talonavicular subluxation and the dislocation of talus out of its socket (acetabulum pedis).[1] Additionally, the soft tissues around the foot are abnormally shortened and stiff, especially medially and posteriorly and the degree of suppleness of the foot is determined by these.

The current treatment consensus of CTEV is nonoperative, with the preferred method being serial manipulation and casting as per Ponseti principles.[2] Despite the high success rates of the Ponseti method, some feet fail to achieve complete correction and some get relapses. Researchers have proposed several clinical scoring systems to assess the severity of clubfoot and to predict the treatment outcome.[3,4] However, the inter and intraobserver variations, and inclusion of multiple variables into these scores make these scoring systems somewhat less accurate. On the other hand radiographic evaluation in infants can be misleading due to incomplete ossification of the cartilaginous tarsal bones with eccentrically placed ossific nucleus.[5,6] The applicability of MRI is largely restricted as it is expensive, requires sedation and is not suitable for serial evaluation.[7] Ultrasound (US) on the otherhand is a less expensive, noninvasive, and easily available procedure, that can be performed with the foot at rest and during manipulation. US can best locate the position of cartilaginous tarsal bones and can be dynamically performed while correcting the deformity[8-13] thus, providing a good idea regarding the flexibility/rigidity of the clubfoot.[8-11]

Some recent studies have reported the utility of ultrasound and its dynamicity during simulated Ponseti manipulation. These studies are based on medial malleolus-navicular distance (MND), the calcaneocuboid angle and the calcaneo-cuneiform angle.[10,11,13] As the prime deformity of clubfoot is talonavicular subluxation, we hypothesize that sonographic measurement of talonavicular angle (TNA) (angle between long axis of talus and long axis of navicular in oblique medial coronal projection on sonogram, in static condition and the change in angle during simulated Ponseti manipulation) would better assess the severity and rigidity of the clubfoot, and indirectly predict the treatment outcome. In this prospective study, we evaluated the TNA as a predictor of treatment outcome while correcting the club-feet with the Ponseti method.

MATERIALS AND METHODS

Twenty-six infants (23 males and 3 females) with idiopathic unilateral clubfoot were included for sonographic evaluation of the foot deformity in a 2 years prospective study. Children with systemic illnesses, arthrogryposis multiplex congenita, spina bifida or other associated congenital anomalies were excluded. The infants were enrolled after obtaining the consent of their parents for participation in this study.

The clubfeet were treated by weekly serial manipulation and casting as per Ponseti principles. The severity of the foot deformity was assessed clinically (by Dimeglio-Bensahel scoring and Pirani scoring) at initial presentation (Fig. 1A); after midfoot correction and finally after complete correction was achieved (Fig. 1B).

Sonographic evaluation of the feet at these times in the treatment phase was conducted in oblique medial coronal plane on Phillips H11 machine (Phillips Electronics Ltd, Saronno, Italy) with 3 to 12 MHz linear probe by an experienced radiologist (Fig. 2).

The radiologist was blinded about the clinical severity of the foot. Two linear probes of 26 and 45 mm size were used depending upon the foot size. The talonavicular angle of the deformed foot (Test, Fig. 3A) and contralateral normal foot (control, Fig. 3C) was measured by drawing lines over the sonographic images along the long axis of talus and navicular bone. The change in TNA was noted on simulated Ponseti manipulation on maximum possible abduction of the foot (Fig. 3B).

The feet were labeled as plantigrade if two of the following three criteria were met: (1) Dimeglio/Bensahel score <6; (2) Catterall/Pirani score <1.5, (3) Functional foot score >30. The total number of POP casts required for complete correction was noted. After complete correction was achieved, the children were put on Denis Brown splint till 1 year of age and CTEV shoes were used subsequently. They were followed every month till 1 year and then every 3 months to an average follow-up of 12 months (minimum 3 months and maximum 15 months). Statistical analysis using SPSS software (SPSS Inc., Chicago IL version 15.0 for Windows) was performed to establish a correlation between the initial TNA, the change in TNA and the total number of casts required for complete correction.

RESULTS

The mean age of presentation was 50.46 days (range 7-130 days) with left side (14 feet) as the predominant side of involvement. Ten feets were grade IV and 16 feet were of grade III severity (Dimeglio score) system at presentation. The initial mean Dimeglio score of 14.8 decreased to 4.23 at final correction. The mean Pirani score decreased from 4.54 at presentation to 0.692 after complete correction. The improvement in the Dimeglio and Pirani scores was quite significant as analyzed by Wilcoxon signed ranks test ($p < 0.05$).

The average number of casts required for complete correction was 8 (minimum 6, maximum 14). All feet were completely corrected with this method of casting except one, in which subsequent surgical soft tissue release was done. One foot relapsed within 6 months and needed re-manipulation and casting, and correction was achieved after application of 5 more casts.

The mean TNA as measured on initial sonograophy was 66.46º (range 48º-78º) compared to 101.3º in the normal foot. Mean change in TNA on simulated Ponseti manipulation was 22.54º, (angle change range 5º-50º). The initial clinical assessment scores (by Dimeglio and Pirani scores) showed negative correlations with both the initial TNA and the change in TNA as analyzed by Pearson correlation coefficient test ($p < 0.05$). This can be interpreted as follows: The more severe the initial clinical scoring of the foot, the less will be change in talonavicular angle on simulated Ponseti manipulation.

Figs 1A and B: (A) Clinical photograph showing the severity of clubfoot, (B) clinical photograph after complete correction achieved

The change in mean value of TNA at start of treatment (66.4º) and mean value at the end of treatment (98.19º) (Fig. 3D) was found to be statistically significant ($p < 0.001$), as analyzed by paired t-test. Mean talonavicular angle of the normal control feet was 101.3º and mean talonavicular angle of the deformed foot at end of treatment was 98.19º; the difference between these two angles was found to be statistically insignificant ($p > 0.072$). Two feet (one that required surgery and other one with relapse) were excluded from this analysis as the end TNA was grossly different from the normal foot. The foot that relapsed after 6 months appeared to be clinically correctible but the end TNA (85º) was different from that of the normal contralateral foot.

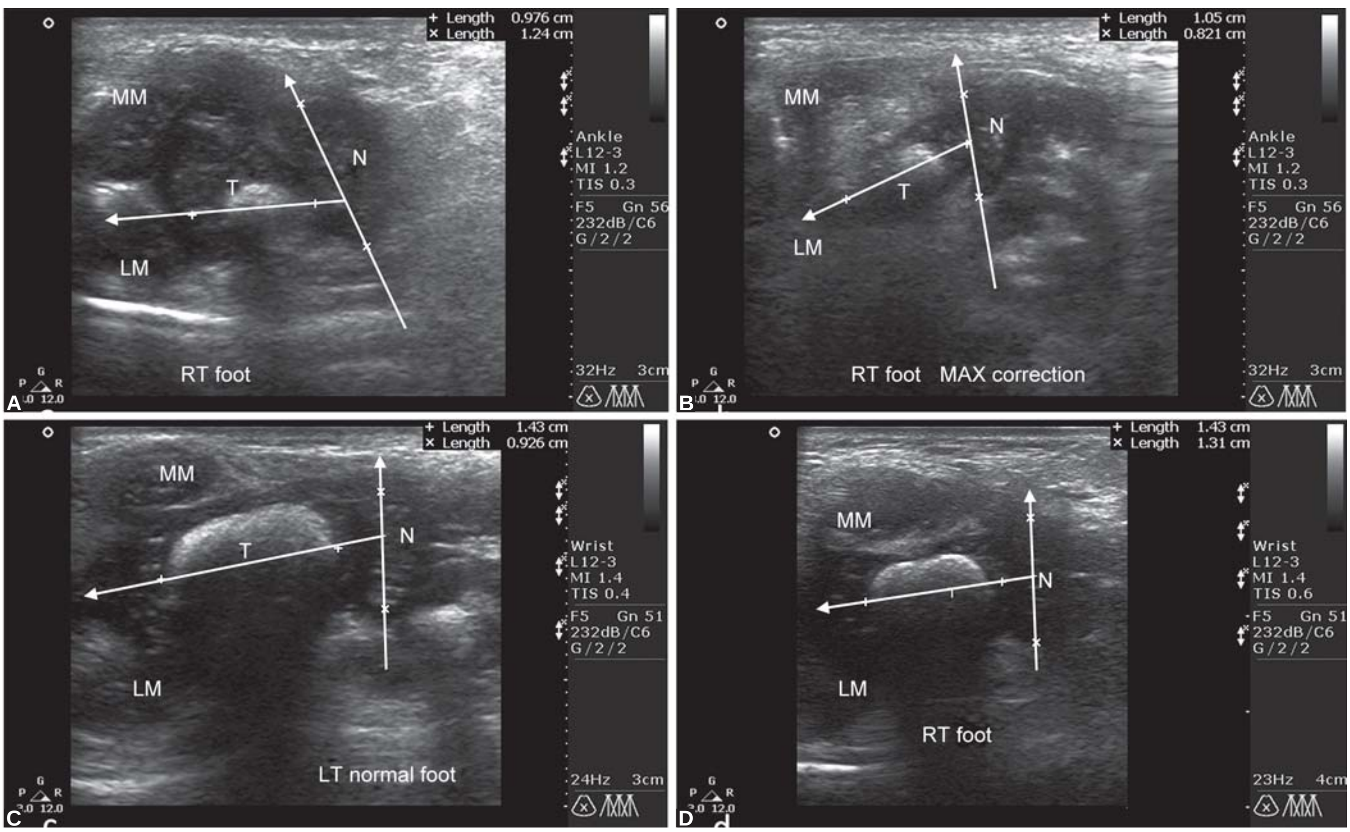
Fig. 2: Ultrasonographic probe placement on oblique medial coronal plane of the foot

The initial TNA ($p < 0.008$) as well as change in angle on simulated Ponseti manipulation ($p < 0.001$) showed statistically significant negative correlation with total number of casts applied to achieve final correction. This correlation was better than the correlation between the calculated clinical scores and total number of casts applied. ($p = 0.024$ for Dimeglio score and $p = 0.008$ for Pirani score).

Statistical analysis by linear regression method revealed that the change in TNA on simulated Ponseti manipulation was the best predictor of total number of casts applied to achieve final correction (predictability of Dimeglio score (19%), Pirani score (25%), initial TNA (25%) and change in TNA (60%).

DISCUSSION

Lloyd Roberts[14] in 1964 very rightly stated that clubfoot will doubtlessly continue to challenge the skill and ingenuity of orthopedic surgeons, and difficulties will continue in predicting treatment outcomes. Though the Ponseti method of serial manipulation and casting has a high success rate (90%)[15,16] some feet fail to achieve correction and require



Figs 3A to D: (A) Initial TNA in static position as measured sonographically, (B) change in TNA on simulated Ponseti manipulation (by abducting the forefoot). The reducibility of navicular bone indicates about the flexibility of clubfoot, (C) TNA of contralateral normal foot and (D) TNA at final correction showing sonographic correction as well surgery and some feet get relapses. Both the parents and the surgeon are highly concerned about the prognosis and length of treatment.

Over the years, several clinical methods of assessment have been proposed.[17,18] Harold and Walker[19] were among the first to describe a simple grading system for evaluation of the basic deformity in CTEV. However, this was not sensitive enough to evaluate subtle improvement in outcome. Dimeglio and Bensahel[3] scoring system, Catterall-Pirani system[4] and the modified hospital for joint disease functional rating system[20] were subsequently developed, but there is still little agreement on a standard reproducible method of deformity assessment and outcome. Among these clinical scores, Dimeglio[3] and Pirani[4] scores have been validated and proven most reliable to accurately quantify the severity of clubfoot deformity.

These clinical severity assessment scores are based on subjective clinical criteria and have a high index of inter-observer and intraobserver variations.[13] It is important to note that the chances of 'interobserver variation' as well as 'spurious correction' cannot be avoided while grading the foot on a clinical basis. The primary abnormality of CTEV is navicular subluxation over the talar head; as the foot deformity gets corrected, the navicular bone gets reduced over the talus. A 'spurious correction' occurs when the foot appears to be plantigrade clinically, but actually the navicular remains subluxated.[13,21] The long-term effect of these spurious corrections remains unknown; it thus, becomes doubly important to have an objective method of assessment, which focuses on the primary abnormality and its correction and USG seems to fit the bill.

Various studies on the utility of USG, ranging from its role in clubfoot pathoanatomy, severity assessment, monitoring of treatment and evaluation of final outcome have been published. Several authors[8-13] have described the pathoanatomy of clubfoot using ultrasound in different projections. These studies reveal that the talus is smaller than normal with a less convex talar dome. The anterior end of the talus is also deviated medially and planter ward[9] and its medial surface is also deformed and smaller in size, the navicular is displaced medially and may even touch the medial malleolus. Accordingly the typical feature of the navicular displacement over the head of the talus is well-visualized on sonography in medial oblique coronal projections. Most authors[10,12,13] consider the talonavicular malalignment to be most important component of the deformity, and normalization of this talonavicular alignment is perhaps the primary goal in orthopedic management of clubfoot. Despite the fact that ultrasound has been used by numerous authors to assess the clubfoot in neonates and infants, there has been no consistency in the measured variables. Hamel and Becker[21] and Suda et al[22] used certain angles like the talo-cuneiform (TnCe) angle, talo-1st metatarsal angle (TnMT1) on medial projection and tibial tuber (TTde) angle on posterior projection; Aurell et al[8] used distances between the medial malleolus and navicular (MM-N). On the other hand Desai et al[13] used a combination of an angle and distance to measure the severity of clubfoot.

Kuhn et al[10] evaluated a sonographic method of evaluation of clubfoot by measuring the MM-N distance during rest and during simulated Ponseti manipulation. They concluded that Ponseti maneuver causes a significant movement of the subluxated navicular toward its normal position. However, they included children in different phases of manipulation and cast application, which could be a source of error. Aurell et al[9] observed that all clubfeet had an MM-N distance shorter than the normal reference group; they also observed weak correlation between the MM-N distance and the subjectively scored displacement of the navicular. This weak correlation can be explained on the basis of the fact that MM-N distance includes several components; it could be shortened by an increased medial deviation of the neck of the talus, or a short talar body, or shorter size of a foot and a forced adduction of the forefoot.

We have expanded the role of US measurement and used the TNA as a predictor of severity assessment in CTEV for the first time. We describe the change in TNA on manipulation as a measure of talo-navicular mobility, which is more objective than the subjective assessment of navicular mobility described by Aurell et al[9] and Loutfy et al.[23] This change in angle is easily visualized during dynamic sonographic examination and could be easily measured in oblique medial coronal projection. Initial TNA and change in TNA on manipulation were positively correlated in our study, i.e. lesser the initial TNA less will be the angle change on manipulation.

Some of the previous studies correlated US measures with clinical score variables. Suda et al[22] and Aurell et al[9] used the Pirani classification,[9] whereas Desai et al[13] used the Dimeglio score,[10] with the latter two studies looking at post-treatment results. However, there was no consistency in the measured US variables and none of the authors found correlation between the clinical and US variables. In contrast, Loutfy et al[23] correlated the different sonographic variables with the Pirani score,[4] first at the start of treatment and one after treatment was completed. One important negative correlation observed by them was between the midfoot Pirani score (MS) and MM-N distance before starting the treatment. By virtue of this, they justified use of the Pirani score in assessment of the initial severity of the deformity. They derived correlation between midfoot Pirani score and total number of casts applied to achieve correction, but failed to correlate the sonographic variables with the total number of casts.

The present study correlates the static TNA and change in TNA with the clinical severity scores of Dimeglio and Pirani. The dynamicity of USG is an added advantage as the change in TNA on simulated Ponseti manipulation shows negative correlation with clinical scores ($p < 0.05$) and also to the total number of casts required for complete correction. Focus on only unilateral clubfeet in our study resulted in comparison with the contralateral normal foot.

Another major advantage of USG is its usefulness in the identification of spurious correction that appears to be corrected clinically. Ponseti[24] noted that ligaments in front of the navicular bone yield to passive abduction, which allows lateral displacement/angulation of cuneiform bones and brings the forefoot in alignment to the hindfoot even though the navicular is only partially reduced. He found that the relapses were more frequent in these spurious corrections. We also observed that the spuriously corrected foot in this series got a relapse within 6 months. The initial Dimeglio score in this foot reflected a very severe type and the change in TNA on manipulation was minimal. Even though the foot appeared plantigrade after final correction, The TNA at the end of treatment was very different from the contralateral normal foot, which further underlines the value of ultrasonographic TNA assessment.

The present study was restricted to one US measure TNA in one plane (medial oblique coronal plane) to overcome the problems of multiple sonographic variables. Inclusions of multiple variables seem to be impractical and less clinically applicable in an uncooperative child. Moreover, the number of casts applied during Ponseti manipulation mainly depends upon the severity of adduction deformity. This fact has been substantiated by Loutfy,[23] who observed a positive correlation between the midfoot Pirani score (but not the hindfoot score) and the number of casts needed to correct the deformity.

The small sample size and short-term follow-up are two major limitations of the present study. Another limitation is the lack of automated software as all the lines for calculation of TNA in this study were drawn manually; the chances of interobserver variation also thus not be ruled out. However, as a result of our preliminary study, we can propose that sonographic evaluation of TNA can emerge as a good method of severity assessment in CTEV, and angle change during manipulation is an objective measure of flexibility/rigidity of clubfoot deformity. This can be a good tool in the prediction of treatment outcome. Further research on the sonographic evaluation of TNA is needed to overcome the shortcomings of our study and to make it practical and clinically applicable.

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