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Original Article

ROLE OF ULTRASOUND AS PROGNOSTIC INDICATOR DURING PRONSETI CORRECTION

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ABSTRACT

Objective: Clubfoot ultrasonography is an objective means of determining severity. The purpose of this study is to evaluate the reliability of measuring clubfoot severity by sonographic evaluation of the talonavicular angle (TNA) and the reliability of assessing angle change on simulated Ponseti manipulation.

Methods: Twenty-six infants with unilateral idiopathic clubfoot were evaluated prospectively using clinical scoring and Pirani scoring and sonographic measurements of TNA at the start of treatment, after midfoot correction, and after the complete correction was achieved. The TNA and its change during simulated Ponseti manipulation were recorded.

Results: In static posture, the mean TNA of the clubfoot (66.46°) differed substantially from that of the contralateral normal foot (101.3°). The mean shift in TNA after simulated Ponseti manipulation was 22.54° (5-50°), and it correlated negatively with clinical ratings and the total number of casts required for final correction ($p<0.05$). Linear regression research demonstrated that the change in TNA on simulated Ponseti manipulation was the strongest predictor of treatment outcome in CTEV (with a prediction of 60% compared to 25% for Pirani scores).

Conclusion: The severity of clubfoot in babies can be better accessed via sonographic examination of TNA and change in TNA following simulated Ponseti manipulation. This objective form of assessment is less expensive, more reproducible in clinical settings, and can better predict treatment outcomes.

Keywords: Sonographic, Club foot, Ponseti, Severity

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INTRODUCTION

Congenital talipes equinovarus (CTEV) is a common orthopedic disorder that requires careful management from birth. The main abnormality in CTEV involves the displacement of the talus bone from its socket in the foot (acetabulum pedis) and the subluxation of the talonavicular joint. Additionally, the soft tissues surrounding the foot are abnormally shortened and rigid, especially on the inner and back sides, which affects the flexibility of the foot. Prompt and comprehensive care is crucial in addressing these issues and ensuring proper development and functionality of the affected foot [1].

The current therapeutic consensus for CTEV is nonoperative, with serial manipulation and casting as per Ponseti principles being the preferred technique. Despite the Ponseti method's high success rate, some foot may not attain complete repair and some relapse. Several clinical grading systems have been established by researchers to quantify the severity of clubfoot and predict treatment outcomes. However, the inter and intraobserver differences, as well as the inclusion of several variables, make these rating systems less accurate. Radiographic examination in babies, on the other hand, can be deceptive due to insufficient ossification of the cartilaginous tarsal bones with eccentrically located ossific nucleus [2-6]. MRI's usefulness is severely limited because it is expensive, requires sedation, and is not ideal for serial examination [7]. Ultrasound (US) is a less expensive, noninvasive, and widely available treatment that can be performed both with the foot at rest and during manipulation. US is the best method for locating the position of cartilaginous tarsal bones and can be performed dynamically while correcting the deformity, therefore offering a decent idea of the clubfoot's flexibility/rigidity [8-13].

Recent studies have highlighted the effectiveness and versatility of ultrasonography in simulating Ponseti manipulation for congenital talipes equinovarus (CTEV). Researchers have utilized various measurements, including the median malleolus-navicular distance (MND), the calcaneocuboid angle, and the calcaneal-cuneiform angle. In this context, we propose that assessing the talonavicular angle (TNA) through sonographic measurements (which involves determining the angle between the long axis of the talus and the long axis of the navicular bone in an oblique medial coronal projection on a sonogram) could provide a more accurate evaluation of the severity and rigidity of the clubfoot.

Furthermore, it may indirectly predict the outcome of treatment. In our prospective study, we specifically investigated the TNA as a potential predictor of treatment outcome when utilizing the Ponseti technique to correct clubfeet. By analyzing the TNA both in static conditions and during simulated Ponseti manipulation, we aimed to gain insights into the effectiveness of the treatment and its potential impact on deformity. The ability to predict treatment outcomes would be invaluable for clinicians, allowing them to customize treatment plans and optimize patient care. By incorporating ultrasonography and sonographic measurements, we sought to enhance the understanding of CTEV and its response to the Ponseti technique. This non-invasive imaging modality offers real-time visualization and the ability to assess dynamic changes during manipulations. The findings from our study may contribute to the development of more individualized treatment strategies, ensuring better outcomes for patients with CTEV [10, 11, 13].

MATERIALS AND METHODS

In a 2 y prospective study, 26 babies (23 boys and 3 females) with idiopathic unilateral clubfoot were included for sonographic examination of the foot deformity. Systemic disorders, arthrogryposis multiplex congenita, spina bifida, and other concomitant congenital defects were not considered. The infants were enrolled once their parents gave their permission to participate in this study. The clubfeet were treated using Ponseti methods of weekly serial manipulation and casting. The degree of the foot deformity was clinically measured (using Pirani score) at initial presentation (fig. 1A), midfoot correction, and finally, complete correction (fig. 1B).

An experienced radiologist performed sonographic examination of the feet during the treatment period in the oblique medial coronal plane on a Phillips H11 machine (Phillips Electronics Ltd, Saronno, Italy) with a 3 to 12 MHz linear probe (fig. 2).

The radiologist was unaware of the clinical significance of the foot. Depending on the size of the foot, two linear probes of 26 and 45 mm were employed. The talonavicular angle of the deformed foot (Test, fig. 3A) and contralateral normal foot (Control, fig. 3C) was measured by drawing lines down the long axis of the talus and navicular bone on sonographic images. TNA changed during simulated Ponseti manipulation with the greatest possible foot abduction (fig. 3B).

If two of the following three conditions were met, the feet were labelled as plantigrade: (1) Dimeglio/Bensahel score of 6; (2) Catterall/Pirani score of 1.5; (3) Functional foot score of greater than 30. The total number of POP casts needed for full correction was recorded. After complete correction, the youngsters were fitted with Denis Brown splints and CTEV shoes until they were one year old. They were observed every month for the first year, then every three months for the next 12 mo (minimum 3 mo and maximum 15 mo). Statistical analysis was performed using SPSS software (SPSS Inc., Chicago IL, version 15.0 for Windows) to determine a relationship between the initial TNA, the change in TNA, and the total number of casts necessary.

RESULTS

The average age of presentation was 50.46 d (range 7-130 d), with the left side (14 feet) being the most involved. After complete correction, the mean Pirani score dropped from 4.54 at presentation to 0.692. The Wilcoxon signed ranks test revealed that the improvement in Pirani scores was fairly significant ($p<0.05$).

For complete correction, the average number of casts required was 8 (minimum 6, maximum 14). Except for one foot, which required additional surgical soft tissue release, all feet were entirely repaired with this form of casting. One foot relapsed after 6 mo and required remanipulation and casting, with correction achieved after the insertion of 5 more casts. On simulated Ponseti manipulation, the mean change in TNA was 22.54° (angle change range 5o-50o). The Pearson correlation coefficient test revealed that the initial clinical evaluation score (Pirani score) had negative associations with both the original TNA and the change in TNA ($p<0.05$). This can be translated as follows: The greater the initial clinical rating of the foot, the less the talonavicular angle will alter on simulated Ponseti manipulation.

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

The difference between the mean value of TNA at the beginning of therapy (66.4°) and the mean value at the end of treatment (98.19°) (fig. 3D) was shown to be statistically significant ($p<0.001$), as determined by the paired t-test. The mean talonavicular angle of the normal control feet at the conclusion of therapy was 101.3°, and the mean talonavicular angle of the deformed foot was 98.19°; the difference between these two angles was judged to be statistically insignificant ($p>0.072$). Two feet were eliminated from this research (one that required surgery and the other with relapse) because the end TNA was significantly different from the normal foot. The relapsing foot looked to be clinically correctible after 6 mo, but the end TNA (85°) was different from the normal contralateral foot.

The initial TNA ($p<0.008$) and angle change on simulated Ponseti manipulation ($p<0.001$) had a statistically significant negative connection with the total number of casts used to achieve final correction. This link was stronger than the one found between estimated clinical scores and the total number of casts used. ($p = 0.008$ for the Pirani score).

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

The average TNA on first sonography was 66.46° (range 48°-78°), compared to 101.3° in the normal. The linear regression method revealed that the change in TNA on simulated Ponseti manipulation was the best predictor of the total number of casts used to achieve final correction (predictability of Dimeglio score (19%), Pirani score (25%), initial TNA (25%), and change in TNA (60%).

DISCUSSION

Several clinical assessment approaches have been proposed over the years. Harold and Walker [14] were among the first to establish a simple grading system for CTEV basic deformity evaluation. This, however, was not sensitive enough to detect minor improvements in outcome. Despite the development of the Dimeglio and Bensahel [3] scoring system, the CatterallPirani system [4], and the modified hospital for joint disease functional rating system [15], there is still no agreement on a standard reproducible technique of deformity assessment and outcome. Among these clinical scores, Dimeglio [3] and Pirani [4] have been verified and shown to be the most reliable in precisely quantifying the severity of clubfoot deformity.

Despite the fact that the Ponseti method of serial manipulation and casting has a high success rate (90%) some feet do not correct and require surgery, and other feet relapse. Both the parents and the surgeon are anxious about the prognosis and treatment duration [16, 17]. Lloyd Roberts [18] correctly noted in 1964 that clubfoot will undoubtedly continue to test the expertise and ingenuity of orthopaedic surgeons and that forecasting treatment outcomes will be challenging.

These clinical severity rating scores are subjective clinical criteria with a high level of interobserver and intraobserver variability. It is vital to highlight that the possibility of 'interobserver variation' and' spurious correction' cannot be avoided while grading the foot clinically. CTEV is characterised by navicular subluxation over the talar head; once the foot deformity is repaired, the navicular bone shrinks over the talus. A spurious correction' occurs when the foot clinically appears to be plantigrade yet the navicular remains subluxated [13, 19]. The long-term impact of these erroneous adjustments is unknown; consequently, it is critical to have an objective technique of assessment that focuses on the original anomaly and its correction, and USG appears to suit the bill.

Several research on the utility of USG have been published, spanning from its involvement in clubfoot pathoanatomy, severity assessment, treatment monitoring, and final outcome evaluation. Several authors have used ultrasonography in various projections to explain the pathoanatomy of clubfoot. According to these research, the talus is smaller than normal, with a less convex talar dome. The anterior end of the talus is likewise deviated medially and planter ward 9, and its medial surface is distorted and reduced in size, as is the navicular, which is moved medially and may even touch the medial malleolus. As a result, the usual feature of navicular displacement above the head of the talus on sonography is well visualised in medial oblique coronal projections. Most authors [8-13] believe that the talonavicular malalignment is the most essential component of the deformity and that normalising this talonavicular alignment is arguably the primary target in clubfoot orthopaedic therapy. Despite the fact that multiple authors have employed ultrasound to assess clubfoot in neonates and babies, there has been little uniformity in the measured factors. Hamel and Becker [20] and Suda *et al.* [21] employed angles such as the talo-cuneiform (TnCe) angle on medial projection and the talo-1st metatarsal (TnMT1) angle on posterior projection; Aurell *et al.* [8] used distances between the medial malleolus and navicular (MM-N). Desai *et al.* [13], on the other hand, employed a combination of an angle and distance to assess the severity of clubfoot.

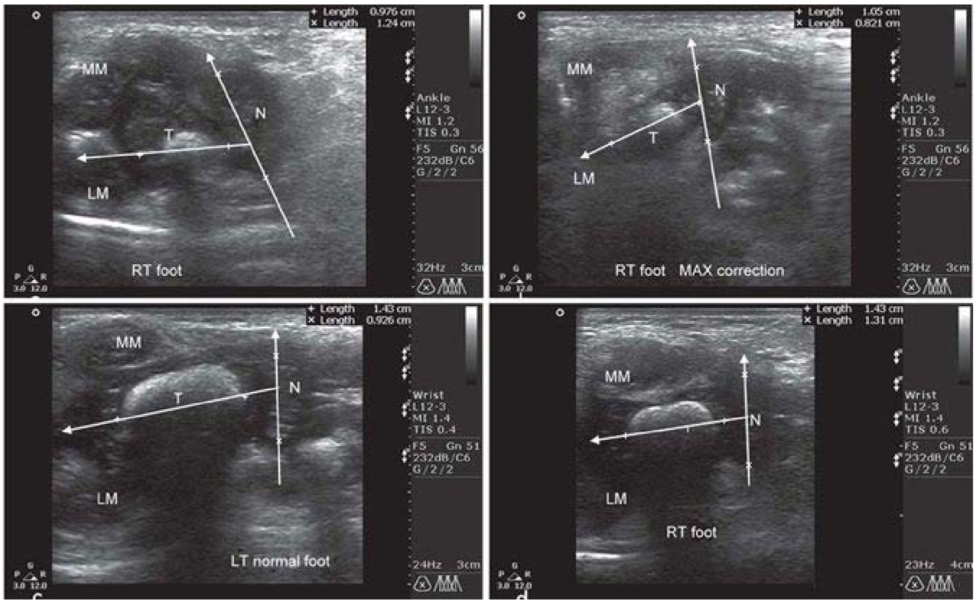

Fig. 3: (A) Initial TNA in static position as measured sonographically, (B) change in TNA on simulated Ponseti manipulation by abducting the forefoot). The reducibility of navicular bone indicates about the flexibility of clubfoot, (C) TNA of the contralateral normal foot and (D) TNA at final correction showing sonographic correction as well

Kuhn *et al.* [10] investigated a sonographic method of assessing clubfoot by measuring the MM-N distance at rest and during simulated Ponseti manipulation. They concluded that the Ponseti manoeuvre leads the subluxated navicular to shift significantly closer to its natural position. They did, however, include children at various stages of manipulation and cast application, which could be a source of inaccuracy. Aurell *et al.* [9] discovered that all clubfeet had a shorter MM-N distance than the normal reference group; they also discovered a slight association between the MM-N distance and the subjectively assessed navicular displacement. This limited link can be explained by the fact that the MM-N distance has numerous components; it could be shortened by increased medial deviation of the talus neck, a short talar body, or a smaller foot size and forced adduction of the forefoot.

For the first time, we used the TNA as a predictor of severity assessment in CTEV, expanding the importance of US measurement. We define TNA change as a measure of talonavicular mobility, which is more objective than the subjective assessment of navicular mobility defined by Aurell *et al.* [9]. This angle change is plainly visible during dynamic sonography and can be quantified in oblique medial coronal projection. In our investigation, the initial TNA and the change in TNA on manipulation were positively connected, implying that the lower the original TNA, the greater the angle shift on manipulation.

Previous research has linked US measurements to clinical score factors. Suda *et al.* [21] and Aurell *et al.* employed the Pirani classification [9], whereas Desai *et al.* [13] employed the Dimeglio score [10], with the latter two investigations focusing on post-treatment outcomes. However, no consistency was identified in the measured US factors, and none of the writers discovered a correlation between the clinical and US variables. In contrast, El-Adwar et al., [22] linked the different sonographic variables with the Pirani score [4] once before and once after treatment. They discovered a significant negative connection between the midfoot Pirani score (MS) and the MM-N distance before beginning treatment. As a result, they supported the use of the Pirani score in determining the initial severity of the deformity. They discovered a link between the midfoot Pirani score and the total number of casts used to achieve correction, but they failed to find a link between the sonographic variables and the total number of casts.

The current study links static TNA and change in TNA with Dimeglio and Pirani's clinical severity levels. The dynamic nature of USG is an extra benefit, as the change in TNA during simulated Ponseti manipulation has a negative connection with clinical scores ($p<0.05$) and the total number of casts necessary for full correction. In our investigation, only unilateral clubfeet were compared to the contralateral normal foot.

Another significant advantage of USG is its ability to detect spurious corrections that appear to be clinically corrected. Ponseti [23] discovered that ligaments in the front of the navicular bone facilitate passive abduction, allowing lateral displacement/angulation of cuneiform bones and bringing the forefoot into alignment with the hindfoot despite the navicular being only partially shortened. He discovered that relapses were more common in these bogus corrections. We also discovered that the falsely repaired foot in this series relapsed within 6 mo. The original Dimeglio score in this foot indicated a severe kind, and the change in TNA following manipulation was minor. Despite the fact that the foot seemed plantigrade following the final correction, the TNA at the conclusion of treatment was significantly different from the contralateral normal foot, emphasizing the importance of ultrasonographic TNA measurement.

To avoid the issues associated with various sonographic variables, the current study was limited to one US measure TNA in one plane (medial oblique coronal plane). In an unwilling youngster, including several factors is impractical and less clinically useful. Furthermore, the number of casts used during Ponseti manipulation is primarily determined by the severity of the adduction deformity. El-Adwar et al., [22] established a positive association between the midfoot Pirani score (but not the hindfoot score) and the number of casts required to repair the deformity.

The current study has two important limitations: a limited sample size and a short follow-up period. Another drawback is the lack of automated software, as all of the lines for TNA computation in this work were drawn by hand; hence, interobserver variance cannot be ruled out. However, based on our preliminary findings, we believe that sonographic evaluation of TNA can be a good means of assessing severity in CTEV, because angle change during manipulation is an objective marker of the flexibility/rigidity of clubfoot deformity. This can be a useful tool in predicting treatment outcomes. More research on the sonographic evaluation of TNA is required to overcome the limitations of our study and make it practical and practically applicable.

CONCLUSION

Sonographic study of TNA and change in TNA following simulated Ponseti manipulation can be used to better diagnose the severity of clubfoot in newborns. This objective type of evaluation is less costly, more repeatable in clinical settings, and can more accurately anticipate treatment effects.

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AUTHORS CONTRIBUTIONS

All the authors have contributed equally.

CONFLICT OF INTERESTS

Declared none

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