

ULTRASOUND EVALUATION OF TALAR DYSPLASIA AS A PROGNOSTIC FACTOR IN TREATMENT OF CLUBFOOT DEFORMITY

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ABSTRACT

Talar dysplasia plays a crucial role in clubfoot deformity. We worked on presumption that talar dysplasia assessed by ultrasonography (US) could be defined as predictive parameter for the outcomes of the Ponseti treatment. 31 patients with unilateral clubfoot deformity were prospectively evaluated and relative talar dysplasia ratio, calculated by the US measurement, categorized the patients into 2 groups – moderate and severe groups. The outcome of the treatment was defined by 3 parameters – number of casts applied, need of percutaneous achillotomy and recurrence of deformity occurrence. Furthermore, Pirani and Dimeglio scores were calculated and complications were observed. Significant differences predicted by the talar dysplasia were observed in terms of number of cast and need of achillotomy and all recurrence were observed in a group with severe dysplasia. Thus, talar dysplasia assessment appeared as promising prognostic factor for predicting the outcomes of the Ponseti technique in treatment of clubfoot deformity.

Key words: Clubfoot, Ponseti method, Ultrasound, Tarsal bone, Dysplasia

INTRODUCTION

Clubfoot (pes equinovarus congenitus, congenital talipes equinovarus) is considered as one of the most common birth defects of the feet, with a prevalence of approximately 1 per 1000 new-borns (6, 22).

In 1950, Ponseti developed a treatment method for clubfoot deformity using manipulation and casting resulting in realignment of navicular bone over talus along with derotation of calcaneo-fore-foot complex (20). Nowadays, it is considered as a gold standard treatment of idiopathic clubfoot and it has achieved the popularity because of its significant efficacy which was reported to produce fully functional feet in 85 – 90% of all cases (17, 18).

There is possible to assess the deformity in a clinical or radiological way. The most often clinical scoring systems used were developed by Pirani (19) and Dimeglio (11). They evaluate the deformity and its components and categorized them into several grades based on the severity of clinical finding. Nevertheless, the usage of the clinical scoring systems in terms of predicting course and outcome of the treatment of clubfoot deformity is of a limited use and it has more descriptive rather than predictive importance (9, 14). On the other hand, not all the authors share this opinion (2, 12).

Radiological evaluation is limited due to cartilaginous part of non-ossified bones in small children.

US has been shown to reliably image the cartilaginous portion of the infant tarsal bones and to demonstrate the differences between normal anatomy and pathological clubfoot anatomy (3, 8). It was already used and described for the Achille's tendon evaluation after Ponseti achillotomy (1) as well as for the evaluation of different dimensions in new-born feet (4, 7, 10).

We worked with the presumption that talar dysplasia plays an important role in predicting the outcomes of the treatment represented by number of cast applied to correct deformity, the necessity of percutaneous tenotomy of Achille tendon – achillotomy or the recurrence of the deformity.

MATERIALS AND METHODS

31 patients (20 boys, 11 girls) were included in the prospective study from January 2014. All patients presented with unilateral clubfoot deformity and all of them were treated using Ponseti method. Only children with idiopathic and unilateral deformity were enrolled in the study regarding to calculate talar dysplasia of the affected foot. Exclusion criteria were as follows: clubfoot deformity of different aetiology than idiopathic, previous therapy in other institution.

Clinical evaluation

Patients were clinically examined and categorized based on the Pirani et al. (19) and Dimeglio et al. (11) scoring systems prior to treatment.

For Pirani scoring, six components were divided into three ones related to the hindfoot (severity of the posterior crease, emptiness of the heel and rigidity of the equinus), and the rest of them were related to the midfoot (curvature of the lateral border of the foot, severity of the medial crease and position of the lateral part of the head of the talus). Each of the components was scored as follows: 0 – no abnormality; 0,5 – mild abnormality and 1 – severe abnormality. Thus, total score could

range from 0 up to 6 and Pirani score of 6 represented clinically the most severe form of clubfoot abnormality.

The Dimeglio classification consists of evaluation of 8 components of clubfoot deformity. Scorings for 4 items (equinus, varus, supination, adductus) range from 0–4 (best to worst). Four items only score zero or one (posterior crease, medial crease, cavus, deviant muscle function). Total score ranges between 20–0 (very severe: 16–20, severe 11–15, moderate 6–10, and postural 0–5).

Ultrasound measurements

All ultrasound measurements were obtained by US machine Aloka Prosound 2 (Aloka Holding Europe, Steinhäuserstrasse, Switzerland) or Mindray (Shenzhen, China) DP-50 using 7,5MHz linear probes. Ultrasound measurement was used before the inner Ponseti treatment was initiated.

Dorsal projection described by Aurel et al. (3) for measurement of maximal talar length was applied. Using this projection, the probe must be placed in the sagittal position on the dorsum of the examined foot following the direction of the talar axis (Fig. 1). The healthy foot was assessed first



Figure 1. Demonstration of dorsal projection when assessing the talus length.

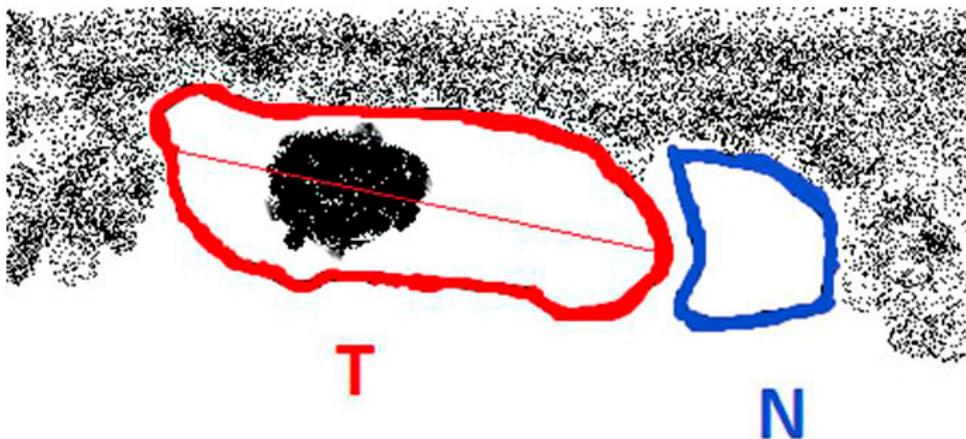
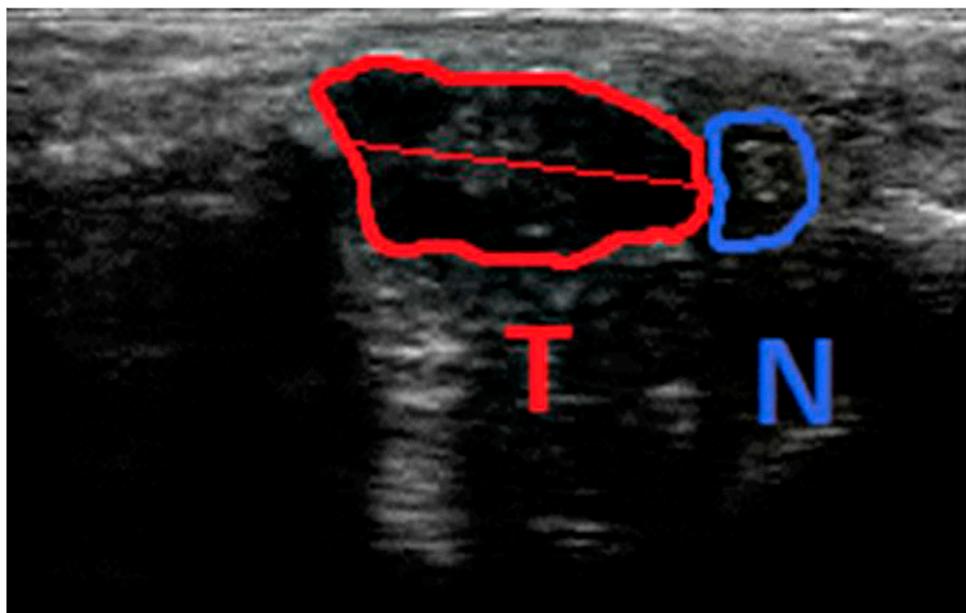


Figure 2. Schematic demonstration of the ultrasonography examination and measurements when the dorsal projection is used (T – talus, N – navicular bone). The length of the talus was used to calculate relative talar dysplasia ratio (RTDR), based on which patients were divided into two groups with different severity of talar dysplasia.

intentionally to keep children calm for further measurements. The talar length was measured in millimetres (mm). The ratio of the maximal talar length of the affected (Taf) and not affected (Tnaf) feet was counted and it was set a criterion of talar dysplasia (relative talar dysplasia ratio (RTDR)= Taf/Tnaf), based on which the patients were divided into 2 groups – mild form of talar dysplasia with RTDR higher than 0.75 (group A) and severe form with RTDR below or equal to 0.75 (group B).

The therapy was carried out according to the principles of Ponseti treatment. Achillotomy (AchT) under general anaesthesia was performed when satisfactory dorsiflexion was not achieved after the last correcting plaster cast. Afterwards, another plaster cast with the correction of dorsiflexion was applied for 3 more weeks. Next, Denis – Brown splints with the plastic AFO splints set to 70 degrees of external rotation for the affected foot and 40 degrees of the external rotation for the healthy foot were applied. Patients were clinically monitored in 3-months intervals.

The effectiveness and the course of the treatment were evaluated by objective criteria as follows: number of cast fixations, number of achillotomies and the recurrence of the deformity during the period of the study.

Statistical analysis

Descriptive statistics for population was expressed as a mean \pm SD (minimal – maximal values) for continuous variables, while categorical variables were reported in percentage (%). Normal distribution of the data was tested by Shapiro-Wilk test.

Fisher's exact test was used to compare gender, laterality, number of achillotomies and recurrence of deformity between groups. Mann-Whitney U test was used to compare age when the therapy was initiated and number of plaster casts applied between the groups.

Independent t-test was used to compare the difference between groups in terms of Pirani and Dimeglio scoring systems results.

All *p* values were 2-sided and a *p* value below 0.05 was considered statistically significant. Data analysis was conducted with SPSS version 20.0 (SPSS INC, Chicago, IL, USA).

RESULTS

31 patients were included in the study. Descriptive statistics of the population is summarized in **Table 1**.

All patients were evaluated and RTDR was calculated. Based on the results, we divided patients as follows: group A (mild form) consisting of 12 patients, group B (severe form) included 19 patients. These two populations didn't show statistically significant difference in terms of gender composition (*p*= .282), laterality of affected foot (*p*= .050) and age when the therapy was initiated (*p*= .438).

	Age (days)	PIRANI	DIMEGLIO	Number of casts	Follow-up (years)
N	31	31	31	31	31
Mean	19	4.581	15.01	07.06	16.35
Median	19	4,5	15	7	15
Modus	19	4	15	4	14
Standard deviation	6.668	0.9138	3.197	2.016	6.755
Minimal	8	3	7	4	7
Maximal	42	6	20	10	32
Gender	20 males			11 females	
Laterality	19 right foot			12 left foot	
Talar dysplasia	12 mild form			19 severe form	
Achilotomy	22 performed			9 not performed	

Table 1. This table demonstrates general population characteristics.

Furthermore, no significant difference was observed between groups when comparing Pirani scores ($p = .554$) and Dimeglio scores ($p = .103$).

The average number of correction casts for group A was 5.2 ± 1.3 (4-8) and for group B 8.3 ± 1.3 (6-10), which revealed significant difference ($p < .001$) between the groups (**Table 2**).

There was necessity for 5 (41%) AchTs in group A but, in contrary, 17 AchTs (90%) were performed in group B. Statistically significant difference ($p > .007$) was between groups using Fisher's exact test (**Table 2**).

	Group A	Group B	Sig.
Gender (male/female)	9/3	11/8	.282
Laterality (right/left)	10/2	9/10	.050
Age (days)	19.3±5.5 (8-32)	18.8±7.5 (11-42)	.438
Pirani score	4.5±0.9 (3-6)	4.7±1.0 (3-6)	.554
Dimeglio score	13.9±3.8 (7-18)	15.8±2.6 (10-20)	.103
Number of casts	5.2±1.3 (4-8)	8.3±1.3 (6-10)	.000
Achillotomy	5/12 (41%)	17/19 (90%)	.007
Recurrence	0/12 (0%)	3/19 (0%)	.216

Table 2. Patients were divided into two groups based on the relative talar dysplasia ratio (RTDR). These groups were compared in terms of gender, laterality, age of initiation of the therapy, Pirani score, Dimeglio score, number of casts applied to correct the deformity, need of percutaneous tenotomy of Achille tendon and the occurrence of the recurrence of deformity using appropriate statistical test.

	Mild dysplasia			Severe dysplasia		
	Tnaf (mm)	Taf (mm)	RTDR	Tnaf (mm)	Taf (mm)	RTDR
Mean	18,42	14,68	0,80	18,26	12,99	0,71
Standard deviation	1,17	1,31	0,03	1,26	0,86	0,02
Minimum	16	13	0,76	15,5	11,5	0,68
Maximum	20,5	17,5	0,88	21	15,5	0,75
Maximal	42	6	6	20	10	32

Table 3. This table demonstrates measurement of talar dysplasia and calculation of RTDR. (Taf – maximal talar length of the affected foot; Tnaf – maximal talar length of the not-affected foot; RTDR – relative talar dysplasia ratio).

During the study, the recurrence of the deformity appeared in 3 cases, all of them were present in the group B and the process of plaster casting with AchTs had to be repeated (2 patient in 9th month and 1 patient in 10th month of life). Nevertheless, the difference between groups A and B was not statistically significant ($p = 0.216$).

No complications were observed during treatment.

DISCUSSION

Idiopathic clubfoot deformity could present with different levels of resistance to the Ponseti treatment, so identifying parameters which could predict the course and outcomes of the treatment would be beneficial when planning treatment strategy.

Throughout the literature, numbers of plaster casts required for the deformity correction, need of percutaneous tenotomy of Achilles tendon or recurrence of the deformity are considered as the parameters assessing the course of Ponseti therapy. Some authors (2, 12) use clinical classification systems developed by Pirani (19) or Dimeglio (11) for prediction of the outcomes of the Ponseti treatment, although their predictive value is controversial. Gao et al. (14) presented study in which low correlation was identified when Dimeglio score was compared with the number of casts and no correlation was found between the Pirani score and the number of casts. Moreover, Chu et al. (9) found only low correlation for both Dimeglio and Pirani score and the number of required Ponseti casts. On the other hand, high Pirani score was identified by Goriainov et al. (15) as statistically significant predictor of potential relapse. Similar conclusion was presented also in the study published by Dyer et al. (12). In our study, there were not seen any statistically significant differences between the groups in terms of Dimeglio and Pirani scores, although severity talar dysplasia proved to be reliable predictive factor as it is advocated further in the text.

There are several possibilities how to assess the deformity using imaging methods. Because of cartilaginous parts of the bone, X-ray imaging is of a limited use. Furthermore, radiation dose in repeated radiographic examinations in children must be considered. The radiation dose issue needs to be considered even more in CT examination, which, additionally, needs to be performed

under general anaesthesia in new-born patients. Although magnetic resonance imaging (MRI) is the option of examination without exposing the patient to radiation, there is also the necessity of general anaesthesia to obtain the images of satisfactory quality.

The US examination was already presented as a potential modality when searching for predictive parameters of the clubfoot deformity (**4, 7, 13**). Nevertheless, there is no consensus about the validity of US assessment of measured parameters among different authors

Some authors tried to find objective US parameters and their relationship to the severity of the deformity when measuring the angles of the tarsal bones or the bones of the lower leg (**16, 21**). Different dimensions were described to evaluate the severity of the deformity. El-Adwar et al. (**13**) presented set of complex measurements using medial malleolus and navicular bone distance (MMN), calcaneocuboid distance (CC) or shift of the navicular bone against talus and correlated the variables with the Pirani score before and after treatment. However, no consistent opinion was seen concerning CC as a reliable parameter throughout the literature. Aurell et al. (**4**) concluded that CC distance is of limited use because of its small range. Although negative correlation between MMN and midfoot score was found before treatment in El-Adwar et al. study (**13**). This finding doesn't lead us to the prediction of the response of the affected feet to the Ponseti technique treatment.

Chandrakanth et al. (**7**) focused on US measurements of the dysplasia of tarsal bones occurring in clubfoot deformity. They reported significant correlation between talar dysplasia and the number of casts needed to correct the deformity, no significant correlation was found between dysplasia of navicular or calcaneus and number of plaster casts. Although in their study were categorized into 3 groups based on the relative talar dysplasia ratio: mild dysplasia (RTDR = 0.9 to 1.0), moderate dysplasia (RTDR = 0.8 to 0.89), and severe dysplasia (RTDR < 0.8), we divided patients into 2 groups with the threshold of RTDR of 0.75 because we wanted to avoid influence of interobserver variability resulting from small dimensions of talus. Furthermore, we believed that categorizing patients into 2 groups based on the talar dysplasia would be more suitable for daily routine clinical practice. For talus, Chandrakanth et al. (**7**) found statistically significant correlation between the severity of the deformity and number of casts applied during treatment and no correlation between severity of the deformity and AchT. On contrary, we found significant difference in need of performing percutaneous achilotomy between groups.

In contrast to our study, Chandrakanth et al. (**7**) didn't observe any recurrence of deformity. Although statistically significant difference between the groups wasn't proved in terms of recurrence of the deformity, we reported 3 patients with relapses all of them belonging to group B. These discrepancies between our studies could be explained by the fact, that our patients were followed for significantly longer time (mean 16 months) compared to 6 months follow-up period of their study. At this point, we would like to emphasize the need to follow patients with clubfoot deformity regularly for at least 12 months, especially patients with severe forms of the deformity. The other important fact is that our study population was bigger than the population in Chandrakanth et al. (**7**) study, but still not big enough to found statistically significant difference.

In our study, only dorsal projection was chosen to be used because it offers the most accurate information about real length of the talus and it helps to obtain its maximal possible values compared to other projections. Furthermore, we tried to simplify the measurements by choosing only one projection in regard to implement the US measurement in daily routine practice for experienced orthopaedic surgeon.

We encounter some limitation for the study. The study population was relatively small, although comparable to other studies, which was seen when we analysed the recurrence of the deformity. Although the results were obvious, statistical significance wasn't proved. Thus, further data collections and patients' inclusion are necessary to confirm achieved results and presumptions. We did not assess interobserver variability as the measurements and evaluations were run by only one senior paediatric orthopaedic surgeon (JJ) with sufficient experiences in musculoskeletal US imaging. Because of absent second observer the measurements could be influenced by individual error, but, on the other hand, one-observer measurement provided unified and standard approach.

CONCLUSION

Talar dysplasia proved to be interesting parameter in assessment of clubfoot deformity which provides different dimensions in clubfoot analysis. Furthermore, in comparison to standard clinical evaluation described by Pirani and Dimeglio, talar dysplasia appeared to be more reliable parameter when predicting the course and outcome of the Ponseti treatment. For daily clinical practise, it could be necessary to distinguish between severe and mild forms of talar dysplasia, because based on our findings, patients with severe form need significantly more plaster casts to correct deformity, the frequency of achillotomy is significantly higher as well and the recurrence of the deformity can occur in this group of patients. Because of results we reach in the study, we recommend to follow patients with severe forms of clubfoot deformity regularly for at least 12 months.

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