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Comparison of the Ponseti method versus early tibialis anterior tendon transfer for idiopathic clubfoot: A prospective randomized study

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ABSTRACT

Objective: The aim of the study was to compare functional and radiological outcomes in clubfoot patients treated by early Tibialis anterior tendon transfer and Ponseti method.

Materials and methods: A prospective, randomized study was conducted. A total of 39 children with a mean age of 17.05 days (55 clubfeet) were randomly allocated into one of two groups: first (conservative Ponseti method) group ($n = 28$) or second (early tibialis anterior tendon transfer [TATT]) group ($n = 27$). Foot function and radiographic measurements were evaluated. The condition of the subjects was observed until they reached the age of 2 years.

Results: The clinical and radiological data did not differ between groups at the age of 6 months. No statistically significant difference regarding Pirani and Dimeglio scale among the groups was observed at the last follow-up. A statistically significant difference was observed in the foot dorsal flexion; it was lower in the second group ($P = 0.03$). Other clinical parameters did not differ between groups. According radiographic data, only the talocalcaneal angle (TCA) was significantly higher in the second group ($P = 0.003$). Children who underwent TATT were 5.00-fold ($P = 0.002$) and 1.67-fold ($P = 0.017$) more likely to have TCA larger than 30° (which reflects the normal range of the TCA) in DP and lateral views, respectively, and 3.40-fold ($P = 0.019$) more likely to have foot dorsal flexion of less than 15° than their counterparts undergoing the conservative Ponseti treatment.

Conclusions: Early TATT allowed a significant reduction in the brace wear duration and resulted in the same outcomes as using the Ponseti method. Additionally, TATT can provide some improvement of hindfoot varus. However, a possible weakening of dorsiflexion should be also taken into account. Our experience has shown the need for a larger sample and longer term studies.

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1. Introduction

Clubfoot is one of the most common and challenging orthopedic deformities in children. Many studies, in particular in short-term studies, demonstrate good clubfoot treatment outcomes, reaching up to 97%, as well as a reduced need for surgery [1–3] using the conservative Ponseti method. However, the relapse rate is also high and reaches 7%–78% [4–7]. The outcomes, especially those recently obtained, are highly dependent on the parent's compliance regarding the wearing of braces. Ponseti as well as other authors argue that the vast majority of relapses significantly depend on the brace wear mode and duration [5,8,9]. Goldstein et al. [10] state that noncompliance with brace wearing increases the need for surgery by 7.9 times. Scholars argue that compliance with brace wear protocol is observed in 47%–81% of cases [6,11,12]. Ponseti also provides a surgical treatment option: tibialis anterior tendon transfer (TATT) in the event of clubfoot relapse and/or noncompliance with brace wear in children older than 2 years. The TATT effect in the treatment of clubfeet in children over 2 years of age is described in retrospective scholarly literature [13–15], as well as in studies with cadavers [16]. Many studies provide favorable outcomes of the TATT procedure on previously operated feet [17–20]. A number of articles evaluating the impact of the foot abduction brace on relapse frequency are available [5,6,9,12]. However, prospective studies are scarce [21]. Meanwhile, no prospective randomized studies evaluating early TATT have been detected in the world literature. Therefore, taking into account a sufficiently serious problem of non-wearing brace and a high relapse rate, this topic is becoming increasingly more relevant; ways are being sought to assure a minimally invasive clubfoot correction, to avoid long-term brace wearing and to protect the feet from relapse at younger age. Our study introduces a modification of the treatment strategy recommended by Ponseti and applies early TATT, with the intention of reducing the relapse rate associated with the noncompliance of brace wear, and, having performed an early surgery and refused brace wearing, to achieve similar outcomes as in the case of the traditional conservative Ponseti method. The aim of this study was to find out whether foot function and radiological measurements of children treated with two different methods differ at the age of 2 years old. It is also important to identify whether this approach is relevant in today's practice, which served as the basis for this study.

2. Materials and methods

2.1. Study participants

A total of 44 children (63 feet) treated for idiopathic clubfoot at the Clinic of Paediatric Surgery, Hospital of the Lithuanian University of Health Sciences, from 2011 to 2013, who complied with the inclusion criteria and gave consent to participate in a prospective randomized study. After the dropouts of 5 children (8 feet) (12.7%), the data of 39 children (55 feet) were used for a functional and radiological analysis. The study involved 27 (69.23%) boys and 12 (30.77%) girls. Right clubfoot was diagnosed in 17 children (43.59%), left in 6 (15.38%), and bilateral in 16 (41.03%). The inclusion criteria were as follows: (1) patients with idiopathic clubfoot; (2) patients up to 3 months of age; (3) written consent to participate in the study; and (4) patients who underwent no other treatment. The exclusion criteria were as follows: (1) patients who refused to participate in the study; and (2) severe concurrent genetic or neurological pathology that is likely to affect the child's physical development and/or the function of the foot. At baseline patients were allocated randomly by the sealed envelope technique to one of two groups: (1) first group: treatment following the traditional conservative Ponseti method; (2) second group: early TATT into the cuboid bone. The condition of the subjects was observed until they reached the age of 2 years. Figure shows the flowchart of the study. The study was carried out under the permission of the Regional Biomedical Research Ethics Committee (No. BE-2-13).

2.2. Study design

First group patients, at the initial stage, underwent a traditional casting as recommended by the Ponseti method [22]. In the case of persistent equinus deformity after a casting course, percutaneous Achilles tenotomy was performed. After Achilles tenotomy, the feet were immobilized for 3 weeks. After removing the last plaster cast, the foot abduction brace was applied, to be worn 23 h a day for up to 6 months of age. The 6 month-old patients continued to be treated with the brace for 14–16 h a day throughout the study period up to 2 years of age, in accordance with the Ponseti method's recommendations.

The patients in the second group, up to 6 months of age, underwent the same treatment as the patients of the first group, as described above. The 6 month-old patients underwent TATT under the extensor retinaculum into the cuboid bone. The surgery was performed under general anesthesia, using a tourniquet and X-rays. After the surgery, the foot was immobilized in the plaster cast for 5 weeks. After removing the plaster cast, the patients did not wear the abduction brace anymore. The last follow-up was 1.5 years after surgery, until they reached the age of 2 years.

2.3. Measurements

At baseline, each patient underwent a thorough detailed orthopedic and pediatric examination. The severity of the clubfoot was estimated by the Pirani and Dimeglio scales at baseline, at 6 months of age and 2 years of age. Additionally, at 6 months of age and at the last follow-up (aged 2 years), the foot range of motion (ROM) (dorsal flexion, plantar flexion, supination, pronation) was rated using a goniometer, and a radiological examination was performed by obtaining the standard dorsoplantar (DP) and lateral foot X-ray. Talocalcaneal (TCA), tibiocalcaneal (TBCA), talo-first metatarsal and cuboid abduction angles, reflecting the main clubfoot components, were measured.

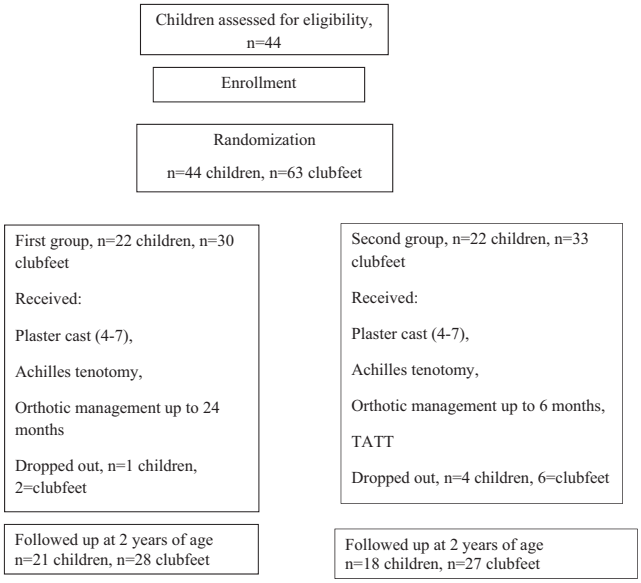

Figure – Flowchart of the study.

2.4. *Statistical analysis*

Statistical data analysis was performed using standard software package SPSS v. 20. The sample volume was calculated during a pilot study. The power of the study (β) was selected to be 0.8 (80%), and the confidence levels (α) 0.05. The findings are expressed as means (standard deviation). The data of normality were expressed by a Kolmogorov–Smirnov test. When the sample size was sufficient and the distribution normal, the differences between the mean values of the groups for independent samples were compared by applying Student's *t* test and a nonparametric test (the Mann–Whitney *U* test). The Wilcoxon signed-rank test was used when comparing two related samples or repeated measurements. The hypothesis of difference between the two groups was made using chi-square test for discrete variables. Odds ratios (ORs) and their 95% confidence intervals were determined. We calculated ORs using a 2 × 2 frequency table. A *P* value of <0.05 was considered statistically significant.

3. Results

The demographic characteristics of both groups of patients are shown in Table 1. At the beginning of treatment (at baseline) (Table 1) and at 6 months of age (when the TATT was performed in second group patients) (Table 2), both groups were homogeneous according to the main criteria. An Achilles tenotomy was necessary for 52 feet (94.55%): 25 feet (89.29%) in the first group and 27 feet (100%) in the second group. The average age at surgery (TATT) was 27.17 weeks (SD = 0.79, min: 26, max: 28). The average age at the last follow-up was 24.33 months (SD = 0.53, min: 24, max: 26). No difference between the groups was observed according to the Pirani or Dimeglio scales that reflect the severity of the deformity at baseline and the treatment effect at the age of 6 months and 2 years (Table 2). An increase of Dimeglio total score (mean difference: −1.11, $P = 0.004$) and Dimeglio varus score (mean difference: −0.48, $P = 0.002$) was observed between 6 months and 2 years in the first group. No changes in both the Pirani and Dimeglio scale were visible in the second group from the age of 6 months to the last follow-up.

Foot ROM measured by a goniometer (dorsal flexion, plantar flexion, supination and pronation) did not differ between the groups at the age of 6 months. During the last follow-up, a statistically significant difference between the two groups was observed only in the foot dorsal flexion: it was lower in the second group ($P = 0.03$) (Table 2), although the dorsal flexion changes that occurred over the period from 6

Table 1 – Baseline patients' characteristics.

Characteristics		First group $n = 28$	Second group $n = 27$	*P*
Gender, *n* (%)	Boys	13 (61.90)	14 (77.78)	0.28
	Girls	8 (38.10)	4 (22.22)	
Foot, *n* (%)	Right	16 (57.14)	17 (62.96)	0.66
	Left	12 (42.86)	10 (37.04)*	
Number of casts		5.36 (1.06)	5.52 (0.75)	0.52
Age before casting, days		19.04 (9.46)	15.00 (17.21)	0.42
Pirani score				
Total		5.05 (0.66)	5.09 (0.75)	0.84
Midfoot		2.45 (0.46)	2.48 (0.49)	0.79
Hindfoot		2.60 (0.48)	2.61 (0.45)	0.97
Dimeglio score				
Total		11.93 (2.72)	12.63 (2.34)	0.31
Varus		2.40 (0.57)	2.56 (0.58)	0.29
Equinus		2.64 (0.56)	2.81 (0.79)	0.35

Values are mean (standard deviation) unless stated otherwise.
* $\chi^2 = 0.6243$; $df = 1$; $P = 0.25$.

Table 2 – Clinical measurements.

Characteristic	At 6 months		P	At 2 years		P
	First group, $n = 28$	Second group, $n = 27$		First group, $n = 28$	Second group, $n = 27$	
Pirani score						
Total	0.14 (0.30)	0.22 (0.38)	0.39	0.27 (0.40)	0.33 (0.44)	0.56
Midfoot	0.07 (0.18)	0.07 (0.23)	0.96	0.14 (0.23)	0.19 (0.34)	0.59
Hindfoot	0.07 (0.18)	0.15 (0.23)	0.18	0.11 (0.21)	0.15 (0.33)	0.59
Dimeglio score						
Total	2.40 (1.31)	3.22 (1.78)	0.05	3.50 (1.77)	3.04 (1.68)	0.33
Varus	0.45 (0.63)	0.7 (0.67)	0.15	0.93 (0.72)	0.67 (0.73)	0.19
Equinus	0.46 (0.69)	0.7 (0.61)	0.18	0.61 (0.50)	0.81 (0.40)	0.09
ROM (°)						
Dorsal flexion	18.00 (4.59)	16.07 (6.51)	0.21	18.21 (4.26)	15.56 (4.78)	0.03
Plantar flexion	34.71 (4.29)	33.48 (4.06)	0.28	35.21 (4.12)	34.67 (2.66)	0.56
Pronation	15.29 (4.04)	16.59 (3.23)	0.19	14.71 (4.01)	15.78 (3.94)	0.32
Supination	24.36 (4.04)	24.96 (4.48)	0.60	24.50 (4.06)	25.56 (4.20)	0.35

Values are mean (standard deviation). ROM, range of motion.

months to 2 years of age were not statistically significant in either group.

The radiological data of the subjects at the age of 6 months did not differ between the groups. During the last follow-up, only the TCA on the DP view was significantly higher in the second group ($P = 0.003$) (Table 3). The TBCA in lateral view showed a statistically significant increase in the first group (mean difference: −4.18, $P < 0.001$) from 6 months up to the last follow-up, yet no difference was observed between the 2-year age groups.

Varus and equinus are the most expressed components in clubfoot and it require the most attention. The TCA on the DP and lateral view reflects varus/valgus deformity as well as tibiocalcaneal angle on lateral view – equinus deformity. It is known that when a TCA is larger than 30° in both DP and lateral view it reflects good varus correction and tibiocalcaneal angle, when it is less than 80°, good equinus correction. Taking everything into account, the OR of the TCA in the DP and lateral views, tibiocalcaneal angle and foot dorsal flexion were estimated. Children who underwent TATT were 5.00-fold ($P = 0.002$) and 1.67-fold ($P = 0.017$) more likely to have TCA larger than 30° (which reflects the normal range of the TCA) in DP and lateral views, respectively, and 3.40-fold ($P = 0.019$) more likely to have foot dorsal flexion of less than 15° than their counterparts undergoing the conservative Ponseti treatment (Table 4).

The children of the first group started to walk at the mean age of 13.29 months (SD = 0.78) and those of the second group at the mean age of 12.78 months (SD = 1.40) ($P = 0.16$). During the course of treatment up to 6 months of age, calluses in the heel area from the abduction brace were observed in 3 feet (5.45%) which healed without residual effects. In the first group, the recurrence was recorded in 4 feet (14.29%). Clinical relapses in 3 feet resulted in dynamic supination, and 1 resulted in dynamic supination alongside the varus type of deformity. We noticed the severity of the deformation according to the Pirani scale in all of these patients was 5 or more points, and on the Dimeglio scale 11 points or more, which corresponds to a severe or extremely severe foot deformity. In the second group, neither hypercorrection nor dynamic supination occurred in any of the patients after surgery. In all cases, normal muscle activity was clinically recorded.

4. Discussion

On average the deformities were corrected after application of 5.44 casts (min: 3, max: 8). These findings correspond the data presented in other studies [2,9]. According to the scientific literature, Achilles tenotomy is common in 72%–96.8% cases [2,8,22,23]. These were comparable to values in our study 52

Table 3 – Radiographic measurements.

Characteristics	At 6 months		P	At 2 years		P
	First group, $n = 28$	Second group, $n = 27$		First group, $n = 28$	Second group, $n = 27$	
Radiographic angles (°)						
Talocalcaneal (DP)	30.36 (5.29)	29.48 (4.15)	0.5	28.61 (5.48)	33 (4.85)	0.003
Talo first metatarsal (DP)	−3.00 (3.81)	−2.96 (3.88)	0.97	−3.32 (5.03)	−3.70 (3.58)	0.75
Cuboid abduction (DP)	2.18 (2.58)	1.63 (1.98)	0.38	2.25 (1.94)	2.07 (2.00)	0.74
Talocalcaneal (L)	29.54 (7.97)	30.96 (4.78)	0.43	29.43 (5.73)	31.78 (6.33)	0.16
Tibiocalcaneal (L)	75.93 (6.50)	76.96 (5.41)	0.53	80.11 (2.28)	79.59 (6.13)	0.68

Values are mean (standard deviation). DP, dorsoplantar, L, lateral.

Table 4 – The odds ratio of second versus first group of the clinical and radiographic measurements.

Characteristics	OR	95% CI	2-Tailed P value
Dorsal flexion <15°	3.40	2.62–4.44	0.019
Talocalcaneal angle >30° (DP)	5.00	3.84–6.52	0.002
Talocalcaneal angle >30° (L)	1.67	1.28–2.18	0.017
Tibiocalcaneal angle >80° (L)	1.24	0.96–1.62	0.347

DP, dorsoplantar; L, lateral.

(94.55%). We performed tenotomies under sedation, for better precision and safety, as did Dobs et al. [12] and Zwick et al. [24]. Similar data were published in a joint Israeli-American study [25], which indicated that the conditions for safe Achilles tenotomy under local anesthesia can be challenging in the case of a disturbed child, and that it is difficult to palpate an Achilles tendon because of injected local anesthetic.

It is known that conservative Ponseti treatment is a golden standard in the treatment of clubfoot. However, because of some reasons, the continuity of treatment is not equally and fully ensured in all families. It is not possible to know which foot are tend to relapse and which are not. Also, it is important to appreciate the aspect that any easy relapse of deformation, which is not treated, can turn into serious rigid deformation in the future and require major surgery. Hence, a big percent of noncompliance with brace wearing and subsequent relapses stimulated us to look for other measures in order to minimally and invasively protect foot from future deformations and provide children with an ability to have strong and mobile foot. As TATT is extra-articular and minimally invasive surgery, we decided to do this operation in early age, before a child begins to walk. Taking into account that collagen accretion is the greatest a few months after the birth and then it is better not to do surgery, we performed TATT at mean 27.17 weeks of age. We performed TATT into the cuboid bone, which is already sufficiently well visualized on X-ray and is big enough so that we could safely make a canal in the bone without damaging the cartilage layer in patients 6 months of age, because the lateral cuneiform, where the standard TATT is performed [13–15,17,19–21], is usually not visible at this age and/or is very small. Although Ponseti recommends avoiding TATT laterally to the lateral cuneiform due to hyperpronation and the risk of heel valgus deformation [4], in his study, where 94 clubfoot treatment results were evaluated, transposition to lateral cuneiform was performed in 33% of the cases and to the cuboid, in 8.5%. At the follow-up of 5–12 years, there were no cases of over-correction, while varus deformity was observed in 23.1% of cases after TATT. It is probable that in some cases transfer should have been performed to the cuboid in order to avoid varus relapse [26].

No evidence in scholarly publications was found with regard to the negative impact of the transposition on the cuboid bone. In addition, we used the full tendon transfer in our patients, as recommended by Ponseti and other authors, seeking not to reduce the tibialis anterior muscle eversion force. The tendon was transferred under the extensor retinaculum to avoid a possible ‘‘bowstring’’ phenomenon [19,20] and fixed with a button of the plantar surface of the foot.

We used both the scoring systems suggested by Pirani and Dimeglio to identify the severity of the deformity at baseline and over the subsequent follow-up period. To assess whether any of the clubfoot components is expressed more clearly than another, we highlighted varus and equinus signs on the Pirani and Dimeglio scales. However, no significant difference between the groups was observed in the measurements obtained on both scales at baseline and at 6 months of age, when we performed the TATT. This shows that both groups were homogenous according their severity scoring. In assessing the mean of both the Pirani and Dimeglio scales at baseline, a prevailing severe-degree clubfoot was found, as observed in the study by Cosma and Vasilescu [27]. We found a tendency of worse outcomes, measured by Dimeglio equinus score in the second group and Dimeglio varus score in the first group, yet no statistically significant difference was recorded. We believe that both classifications are quick and easy to use and can be used to evaluate the correction of the deformity.

Foot dorsal flexion is one of the key clinical signs in assessing the equinus component correction. A very important aspect is the changes occurring in foot dorsal flexion after the TATT. As muscle tibialis anterior is considered one of the main extensors of the foot, there is a risk that after the transposition, the muscle activity may be reduced, but none of the studies have registered a negative transposition impact on the dorsal flexion of the foot [13,14,20,21]. Like many other authors, we agree that at the initial treatment stage, before an Achilles tenotomy is carried out, 15° dorsal flexion is the critical limit [4,28], but in assessing the subsequent treatment outcomes as well as the fact that dorsal flexion physiologically decreases when the child is growing up, dorsal flexion is considered sufficient when it is larger than 5° [9,29,30]. In the study by Bor et al. [9], dorsal flexion of more than 5° was observed in 89% of feet; in the study by Radler et al. [30], it was observed in 97%. No dorsal flexion of lower than 5° was found by our study, but dorsal flexion of less than 10° was observed in 3.57% in the first group and in 11.11% of cases in the second group, which is superior compared to the study by Radler et al. [30], with 9% of cases presenting dorsal flexion of less than 10°. The mean value of dorsal flexion, 13.9° [29] and 15.9° [30], was consistent with the data obtained by our study (a mean of 18.21° in the first group and 15.56° in the second group). Gray et al. [21] also reported a statistically significant difference ($P = 0.02$) in dorsal flexion between the patients of the conservative and TATT groups, observed 12 months after surgery. Notwithstanding the fact that the final outcomes obtained in both the groups are consistent with the findings presented in the literature and fall within the normal range,

the dorsal flexion downward trend was observed in the second group, which is also shown by the OR calculations. In terms of the surgery to be performed at an early age or the impact of the brace refusal on the decrease in dorsal flexion during a longer follow-up period, no unambiguous answer can be provided yet, as more continuous studies are required. The ROM of the passive plantar flexion, supination and pronation in both groups corresponded to the data given in the literature [31]. This fact shows that the application of both approaches results in the feet remaining mobile and functional.

The analysis of radiological changes revealed that all of the angles evaluated by us in both the groups, either at the age of 6 months or 2 years, were in line with the normal range of radiological angles [31–34] and were similar to the data published by other authors [24,35]. One of the most important radiological measurements is the TCA reflecting varus deformity. Our study showed that, over the study period, the TCA in the DP view in the second group increased by 3.5° and in the first group only 1.7°, and differed between the two groups at 2 years of age. The likelihood that the TCA in the DP and lateral view will be larger than 30° after performing a TATT was 5.00 and 1.67-fold higher, respectively. We presume these findings were triggered by the decrease of inversion and the increase in the eversion force as a result of the TATT, yet no signs of pronation characteristic to hypercorrection or valgus radiological features were observed. Beatson and Pearson referred to slightly wider boundaries of this angle (15°–55°) [34], but we agree with the opinion presented by other authors and assume that a TCA of less than 30° in both projections reflects the varus type of deformity already [33,35]. Apart from that, it should be taken into account that during the growth period, due to shape changes in the anatomical talus ossification nucleus, the TCA decreases physiologically by 10% [36], thus it may already be insufficient in older children. Various studies present rather contradictory radiological angles changes as a result of TATT. Similar to our study, the radiological data reflecting the varus component, improved in the study by Kuo et al. [17] too; however, completely contradictory findings are presented in 2 long-term retrospective studies assessing adult patients previously treated by TATT. Holt et al. showed that during the follow-up period, at the age of 37–55 years, the TCA in the DP view was less in the TATT group than in the Ponseti group, but it did not affect clinical signs [15], while Lampasi et al. determined that TATT impacted the decrease of only the talo-first metatarsal angle, but also that no significant difference was detected between the TCA and supination [19]. However, we believe that in terms of function, the elastic child foot is incomparable to the adult foot. The mean lateral TCA in our study was comparable to the values presented in the study by Prasad et al. [35] (31.4° in the case of very good outcomes and 27.3° in the case of good outcomes), while in the study by Laaveg and Ponseti [37], these values were 22.4° and 20.5°, respectively. We think that the lateral TCA as well as the TCA in the DP view is a good indicator of hindfoot deformity.

As an expression of fore foot adduction, the talo-first metatarsal angle in the DP view was measured. Prasad et al. [35] found that talo-first metatarsal angle in the DP view in normal feet ranged from −23° to 5°; in the case of corrected clubfoot, the mean value of this angle in very good feet was −12.8° and 0° in good feet. These were comparable to the values in our study in both groups. Our study found the talo-first metatarsal angle to be larger than 0° in 3 children of the first group, who were clinically observed for dynamic supination.

Although the decrease in foot dorsal flexion was significant in the second group, the radiological lateral TBCA, which reflects this sign, did not differ between the groups at the last follow-up. Over the treatment course, the lateral TBCA in the first group increased by 4.2°, whereas in the second it increased only 2.6°; at the age of 2 years, the values were similar (mean: 80.11° and 79.59°, respectively), which corresponds to Zwick's data (median: 79° [24] at the age of 3.5 years) and Prasad's data, where lateral TBCA was 58.1°–81° which reflects very good-to-satisfactory clubfoot correction outcomes [35]. Our study and other studies suggest that lateral TBCA even in the case of corrected clubfoot, treated either by the conservative Ponseti method or surgically, reaches the upper boundary of the normal range. Thus, in assessing radiological parameters, it is worth paying attention to the increased risk of equinus relapse in the presence of an angle larger than 80° [38]. We believe that the TATT did not affect the occurrence of the lateral TBCA changes during the course of treatment, which is in line with the data reported by other studies [15,19].

Although the cuboid abduction angle in the case of clubfoot is not assessed routinely, it is quite commonly applied in evaluating the outcomes of flatfoot treatment [39]. As the increase of the angle reflects the pronation at the midtarsal joint and abduction of the midfoot, we measured it seeking to evaluate the potential inclination of the foot to hyperpronation after an early TATT into the cuboid bone [4]. No radiological signs of pronation were observed in any of the groups nor was any statistically significant difference found between the groups.

A small number of patients and a short follow-up in duration of up to 2 years are among the main shortcomings of the study. The literature provides a number of prospective studies assessing the outcomes of clubfoot on the basis of 42 [21] and 28 feet [24] as well; however, a larger sample of subjects and a longer follow-up, in our opinion, can influence the outcomes. Our study assessed the outcomes at the age of 2 when the first group patients still wore braces. Of course longer term follow-up is needed to draw conclusions about the use of early TATT in clubfoot. The highest frequency of relapses occurs until 3–4 years of age; thus it would be appropriate to continue the study until this age.

5. Conclusions

Early TATT in the patients of the second group allowed a significant reduction in brace wear duration and resulted in the same outcomes as using the conservative Ponseti method. Additionally, TATT can provide some improvement of hindfoot varus, the most important component of clubfoot. However, a possible weakening of dorsal flexion should be also taken into account. Our experience has shown the need for larger sample and longer term studies to more accurately assess these parameters.

Conflict of interest

The authors have no conflict of interest to declare.

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