

## Original Article

# Transposition of the tibialis anterior muscle as a part of the complex treatment of congenital talipes equinovarus in children

**Kykosh G.V., Korolkov A.I.**

*State Institution “Sytenko Institute of Spine and Joint Pathology of the National Academy of Medical Sciences of Ukraine”*

### Abstract

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#### Transpoziția mușchiului tibial anterior în tratamentul complex al piciorului strâmb congenital la copil

Materialele articolului prezintă rezultatele utilizării transpoziției mușchiului tibial anterior în tratamentul complex al piciorului strâmb la copii cu vârste mai mari de 2 ani. Autorii au dezvoltat și testat clinic sistemul de tratament diferențiat complex al piciorului strâmb congenital la copii pe baza procedurii propuse de I. Ponseti. Pe baza analizei tratamentului a 60 de copii cu vârsta cuprinsă între 2 și 17 ani, în 83,3% au fost obținute rezultate bune și satisfăcătoare, reducând astfel frecvența volumului clasic și a intervențiilor chirurgicale traumatice pentru această patologie cu 78%. Ortezele de corecție, bretele de producție proprie, au fost implementate în practica clinică. Acestea vor reduce costul tratamentului până la 40%.

**Cuvinte cheie:** picior strâmb congenital, procedeul I.Ponseti, transpoziția mușchiului tibial anterior, bretele

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### Abstract

The materials of the article present results of using the transposition of tibialis anterior muscle in the complex treatment of clubfoot in children older than 2 years. The authors have developed and clinically tested the system of differentiated treatment of complex congenital clubfoot in children on the basis of I. Ponseti methodics. Based on the analysis of the treatment of 60 children aged from 2 to 17 years 83.3% of good and satisfactory results received, thus reducing the frequency of the classic volume and traumatic surgery for this pathology by 78%.

Corrective orthoses – braces of own production were implemented in clinical practice. They will reduce the cost of treatment up to 40%.

**Keywords:** congenital talipes equinovarus (clubfoot), I. Ponseti methodics, transposition of tibialis anterior muscle, braces

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**Correspondence to:** e-mail: [korolkovmd@gmail.com](mailto:korolkovmd@gmail.com); mob. +380506347105

## Introduction

The clubfoot or congenital talipes equinovarus (CTEV) is one of the most frequent malformations of the musculoskeletal system in children, it occurs in 1-3 cases per 1,000 newborns (35-40% of all congenital foot deformities) [1, 9, 16]. Techniques which are currently used as a conservative treatment (durable stage plaster cast methodics) do not always lead to complete cure of the patient, and frequent relapses of deformity require subsequent extended and traumatic surgical interventions in most (up to 68%) cases [15]. To date, a large number of CTEV surgical treatment methods, which vary in volume and implementation technique, have been proposed. Analysis of results of methods proposed, of most commonly used surgical procedures also does not add optimism - primary operations relapses reach 54% [10, 13]. Currently, the technique by *I. Ponseti* became the most popular in treatment of CTEV. It is characterized by a number of differences from the "classic" methods – in principles of staged elimination of deformity components, casting technology and duration of the foot deformity correction in a plaster cast, duration of Achilles tenotomy performance and orthosis peculiarities in the rehabilitation period (the brace use). If the early treatment was provided (at the age of 3 months) – feet maintain mobility, severe muscle atrophy is not marked, the full range of motion in ankle joint and joints of the foot is maintained, and the percentage of successful results is 85 - 95% [3, 15, 17]. Works of many authors show that applying the principles of methodics by *I. Ponseti* in children older than 3 years, as the treatment of CTEV, can also give good results in foot deformity correction, on condition of widening indications to certain surgical interventions, particularly, a transposition of m. tibialis anterior tendon on III<sup>rd</sup> cuneiform bone of the foot, the so-called transposition of Anterior tibialis muscle (TTAM) which acquired significant popularity as anti-relapse surgery. It is based on the movement of insertion point outwards from the axis of subtalar joint, which turns this muscle into pronator, and aims to reduce the imbalance between the supinators and pronators. [6, 7, 11, 14].

The main indication for the transposition of tibialis anterior muscle is the dynamic supination of foot in children over the age of 2.5 years, persisting after the correction of the deformity recurrence; TTAM significantly reduces the need to perform "medial release", also prevents subsequent relapse and normalizes talocalcaneal divergence. However, it should be noted that the isolated TTAM is ineffective in rigid relapse of foot deformities [8, 13, 19].

To present the result of using the transposition of tibialis anterior muscle in the complex treatment of congenital talipes equinovarus in children older than 2 years.

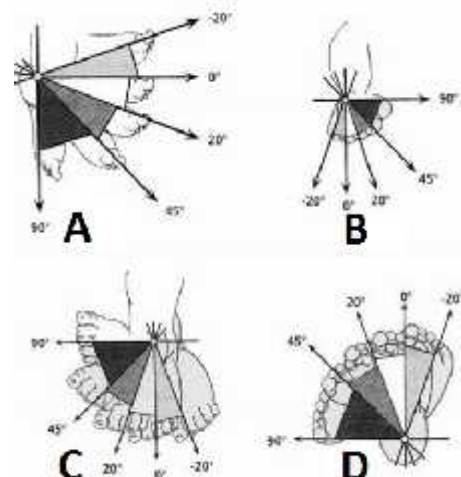
**Materials and Methods.** 60 patients were treated by the *I. Ponseti* methodics in the Clinic of diatric Orthopedics of the State Institution «Sytenko Institute of Spine and Joint Pathology of the National Academy of Medical Sciences of Ukraine», including 41 boys and 19 girls, in which the transposition of bialis anterior muscle was the one of essential elements of treatment (age of patients was from 2 to 17 years (103 feet), the average age of boys - 6.2 years, of girls - 7.5 years, bilateral pathology was present in 72% (43 patients), relapses of deformation were present in 67% of cases analyzed, including 34% - after surgical treatment in other hospitals, and 33% - after conservative treatment (tab. 1). The average period of observation was from 6 months to 6 years. Estimation of foot deformities' severity before and after treatment was conducted using a Dimeglio scale which allows to evaluate the effectiveness of treatment of clubfoot performed by the *I. Ponseti* methodic, and characterizes the condition of the foot in the range between 0 and 20 points (fig. 1): 0 corresponds to the normal foot, the deformity having 5 points or less is classified as a light degree; 6-10 as moderate; 11-15 as heavy; 16-20 as very heavy) [2, 4, 15, 18]. Before the beginning of treatment, during and after it, a comprehensive survey of patients was conducted. It included: ultrasonography of Achilles tendon (surveying its structure and length), electromyography of lower limbs, plantography, pedobarography, podometry, x-ray of foot in three projections, medical examination of neuropathologist and computed tomography or MRI examination (according to indications).

**Table 1. Division of patients according to sex and peculiarities of the previous treatment**

	Division according to the type of previous treatment			One-sided pathology	Bilateral pathology
	Primary treatment	Relapse after conservative treatment	Relapse after surgical treatment		
Boys	12	17	12	13	28
Girls	8	3	8	4	15
<b>Total</b>	<b>20</b>	<b>20</b>	<b>20</b>	<b>17</b>	<b>43</b>

Type of foot (by the Dimeglio scale)	Severity of foot deformities	Points
I	light degree	<5
II	moderate	6-10
III	heavy	11-15
IV	very heavy	16-20

Fig. 1. Estimation of foot deformities' severity by the Dimeglio scale.



## Results and Discussion

We developed and put into practice algorithmic scheme of treatment of children suffering from CTEV, based on the I. Ponseti methodics (fig. 2), in which three age groups of children were allocated: first - from 2 weeks to 2 years old, second - from 2 years old to 10 years old, and third - over 10 years old.

According to this algorithm, children aged between 2 and 10 years, after the complex examination, passed a compulsory preparatory step before surgery – stage plaster cast with performance of 4-6 corrective bandaging according to the I. Ponseti methodics (during 4-6 weeks).

The obtained data give coincides with the literature [5, 6, 12, 14] that the stage of preliminary plaster casting in children suffering from CTEV is necessary in the age of 2-10 years - it reduces the deformation of the foot and prepares tissues to a subsequent operation, and consequently significantly reduces the severity and duration of subsequent surgical intervention, but, at the same time, provides the complete correction of residual deformation of the foot, and often even both feet at the same time, in one stage. It should be emphasized that, after a preparatory plaster cast stage, in 100% of cases the stable equinus and the residual adduction of the forefoot remained.

**Surgical technology** consists of several elements:

- the surgical intervention is performed on the rear part of foot - either the percutaneous achillotomy (it was performed in 65% of cases) or achilloplasty (in 31,6% of cases). The posterior release of foot with incising the capsule of the ankle and subtalar joints performed in 28,3% (volume of intervention on the rear part of foot depended on the severity of the residual equinus and ultrasound results (results which indicated the presence of pathologically changed Achilles tendon and the spread of cicatricial process in the rear part of

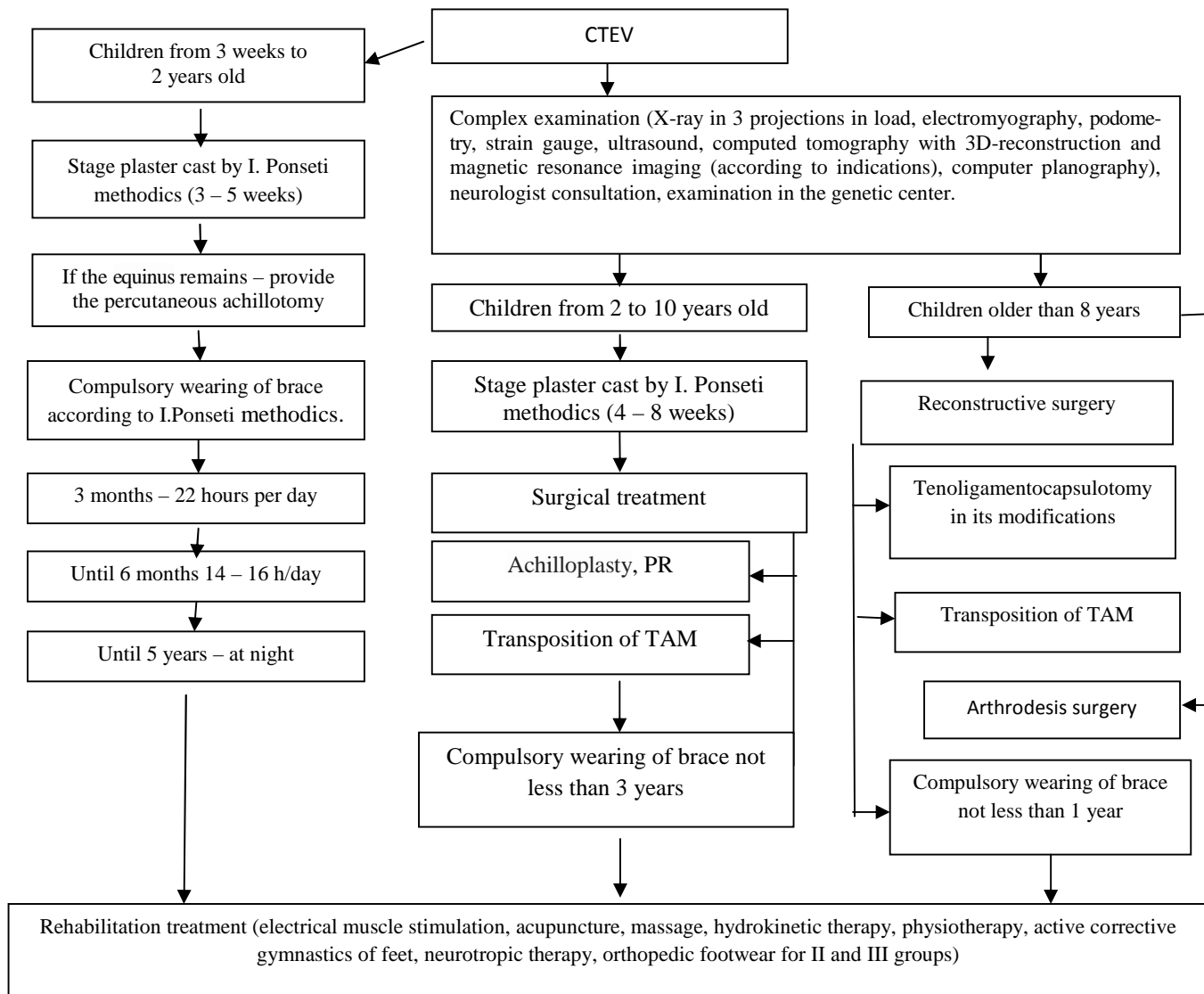
foot served as indications to undertake an extended surgical intervention));

- the tendinous portion m. abd. hallucis longus is released all along its length through a linear incision along the medial surface of the foot, followed by its Z-shaped elongation (fig. 3, 4). Then, the tendon of tibialis anterior muscle is exposed all along its length (fig. 3b) with a cut-off from the attachment site, followed by stitching by . Cuneo (fig. 5a). Next, after the preliminary X-ray visualization of III<sup>rd</sup> cuneiform bone (fig. 5b), the stitched tendon of tibialis anterior muscle is carried on the dorsal surface of the foot, and, using straight bone needles, the stitching of tibialis anterior muscle across the III<sup>rd</sup> cuneiform bone, with moving the suture knot to the plantar surface of the foot with simultaneous bringing the foot in the position of maximum dorsiflexion, is performed (fig. 5, 6).

TTAM to III<sup>rd</sup> cuneiform bone in combination with the extension of abductor hallucis muscle held at 100% of children in investigated groups and, according to indications (in 62% of cases), the plantar aponeurotomy performed. "Classic", Zatselin-like, type of surgical interference with expanded volume of surgery was performed in none of cases on that group of children.

The 2<sup>nd</sup> surgery stage supplemented to 16 children (26,6%) by the medial release with performing the dissection of capsule of cuneometatarsal, naviculocuneiform and talonavicular joints on the medial surface. The main indicator of surgery efficiency, except of all clinical deformation elements removal, was the normalization of interactions in the talonavicular joint, which was verified at the anterior-posterior X-rays of foot.

In addition to the elements listed above, cuneiform "+ -" osteotomies of cuneiform and cuboid bone using fixation by spokes (wires) or U-shaped staples were performed to 4 children.



**Fig. 2.** Algorithm for the treatment of children with CTEV. (CTEV - congenital talipes equinovarus; PR - posterior release; TAM - tibialis anterior muscle)

When performing TTAM, in 64% of cases we detected the deviation (dystopia) at location of m. tibialis anterior - the place of its attachment was located from 0.5 to 2 cm distally than it is described for the normal foot. According to the "Atlas of Human Anatomy", this muscle "originates from the lateral condyle and the lateral surface of tibia and the interosseous membrane of leg, in the lower third of shin it goes into a long flat tendon, which lies in the tendon channel under retinaculum mm. extensorum inferius and, first, heads to the medial edge of foot and then on the plantar surface of foot where it is attached to the medial cuneiform bone and to the base of I<sup>st</sup> metatarsal bone." However, studies conducted show a significant

diversity of locations of tibialis anterior muscle insertion - see fig. 7 a, b [7, 13].

Retrospectively evaluating the performance of the muscles by the electromyography results, we found that bioelectric activity (BEA) of m. tibialis anterior was higher by 30-45% compared with adjacent muscles of the foot (m. tibialis posterior, m. flexor digitorum longus and m. flexor hallucis longus). More detailed analysis of the obtained data concerning muscles' changes in clubfoot will be presented in subsequent publications.

The complete foot correction was achieved intraoperatively in 85% of cases. That allowed us to exclude the use of spokes (in other cases, the Transsossal fixation of corrected position of the talonavicular and talocalcaneal

joints using Kirschner wires was performed). After suturing the wounds, a circular plaster cast was applied for 5 to 5.5 weeks according to I. Ponseti methodics. By plaster casts' removal, braces own design (fig. 8) with a fixed orthopedic shoe were used. They have crossbeam which has same distance as shoulders width, setting the foot at 45-55° for corrected foot and at 30° for a healthy foot, with dorsiflexion of foot – at 10-20°. Against the background of fixing feet in the brace, the rehabilitation treatment – regular courses of electrical stimulation of

tibia and fibula, acupuncture, ozokerite therapy, electrophoresis of foot; massage, hydro-massage; daily corrective gymnastics (held at least 3 times a day by parents) was performed.

Bracing is also an integral part of the treatment of CTEV also for children older than 2 years, wherein the compliance with their wearing is very important: the first 1.5 months after removal of the plaster cast immobilization - at least 22 hours/day, then - at bedtime, for, at least, 1 - 1,5 years.

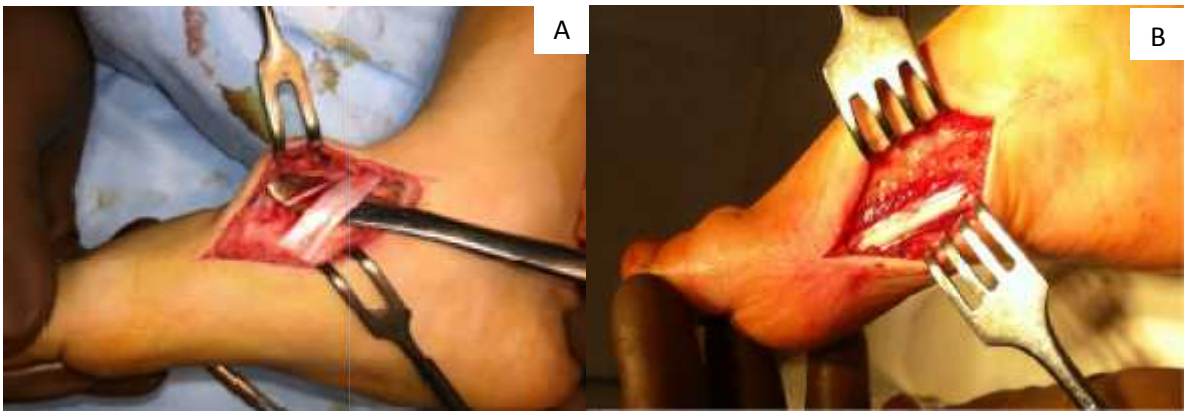


Fig. 3. Dystopic tendon of tibialis anterior muscle (A); B - contracted m. abd. hallucis longus



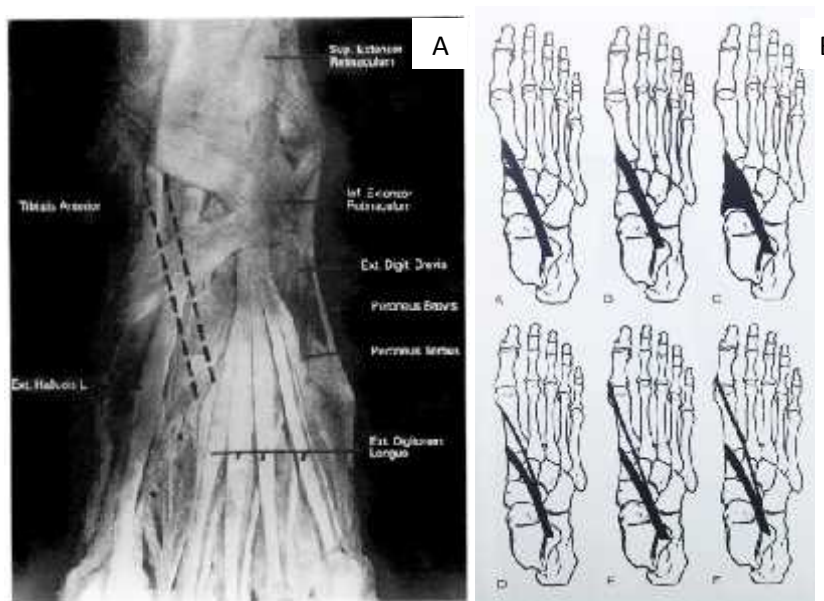
Fig. 4. Z-shaped elongation of the tendon portion of m. abd. hallucis longus



**Fig. 5.** Transposition of tibialis anterior muscle on III<sup>rd</sup> cuneiform bone: **a.** The bringing of tendon of tibialis anterior muscle stitched by .Cuneo to the dorsal surface of the foot; **b.** X-ray visualization of III<sup>rd</sup> cuneiform bone; **c.** The bringing of tibialis anterior muscle across the III<sup>rd</sup> cuneiform bone.



**Fig. 6.** Feet appearance after wounds' suturing.



**Fig. 7.** A - anatomical preparation - scheme of transposition of the tibialis anterior muscle tendon to the III<sup>rd</sup> cuneiform bone (Congenital Clubfoot Fundamentals of treatment Ignacio V. Ponseti, 1996.); B - variants of TAM tendon attachment (Hallisy JE. The muscular variations in the human foot: A quantitative study Am J.Anat. 1930).

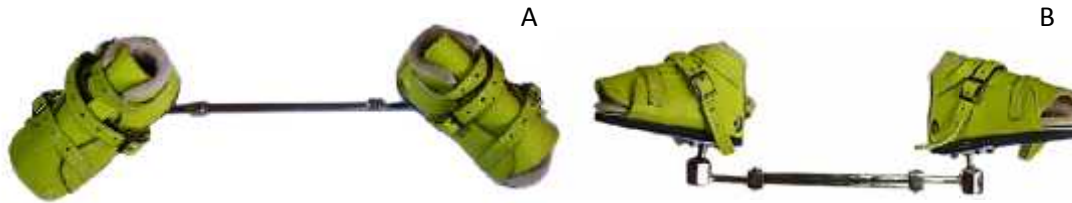


Fig. 8. Braces of own design (patent of Ukraine 95542)

We want to remind that the main purpose of bracing is to prevent relapses. According to data cited in the article by I. Ponseti "Clubfoot" in cases when parents adhered to the wearing mode of fixator, there has been a relapse in only 5 to 10% of children [13].

The results of clubfoot treatment were estimated as good (supporting foot, reached both with the help of subcutaneous tenotomy, and without it); satisfactory (foot requiring the limited rear release, transposition of the tibialis anterior muscle and the shortening of lateral support, or these operations were planned); or bad (a foot requiring a full posterior-medial release, or which was executed as planned).

To confirm the effectiveness of this technology we give an example of its use.

**Clinical example.** Child V., 5 years old, with a diagnosis: "Severe degree of bilateral congenital talipes equinovarus" (10 points by Dimeglio scale). Relapse of deformations of both feet long conservative treatment (plaster cast by "classical methodics" during 7 months) (fig. 9, 10).

The staged correction of feet deformities was done by I. Ponseti methodics for 6 weeks with changing 5 plaster casts. After their removal, subject to stable equinus of foot, residual adduction of anterior part, the surgical intervention was performed in the following volume: Partial percutaneous achillotomy, transposition of TAM to III<sup>rd</sup> cuneiform bone of both feet, the m. abductor hallucis lengthening on both feet, right-sided plantar partial fasciotomy.

In fig. 11 and 12 - in the long term, after 12 months after surgery, feet are mobile, dorsal flexion of feet is sufficient, there was no tendency to relapse observed. No complaints of the patient on pain in feet. Fixing the feet in the braces is continued at the time of sleep against the background of regular courses of conservative rehabilitation treatment. In fig. 13 (a, b, c), confirming the effectiveness of the correction provided, the static and dynamic barometric data is presented, that shows the normalization of the load on feet, for both the posterior and anterior parts.



Fig. 9. The child V., 5 years old, feet appearance before treatment begins



Fig. 10. X-ray images of feet of the child V., 5 years old, standing with the load before treatment

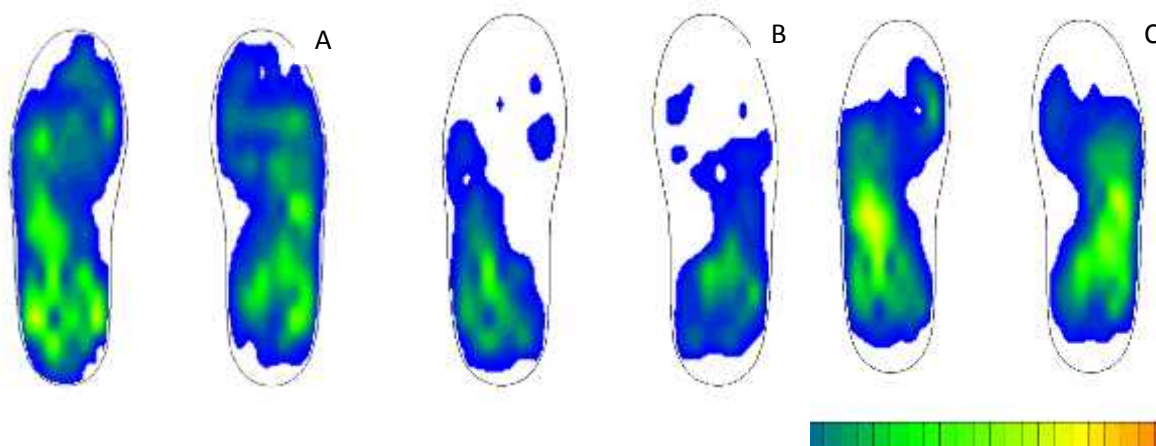


Fig. 11. Feet appearance – the child V. stands, 6 years (12 months after treatment)



Fig. 12. X-ray images of feet of the child V., 6 years old, standing with the load (12 months after treatment)





**Fig. 13.** Dynamic barometry of the feet of child V., 6 years, 12 months after surgical treatment: A - average value; B - standing without movement; C - biggest load for the longest period of time during a roll-over)

## Conclusions

1. The system of differentiated treatment of complex congenital talipes equinovarus in children based on the I. Ponseti methodics, which is developed and clinically tested, allows the individual approach in solving the problem of this disease's treatment, and the frequency of the "classic" voluminous and the traumatic surgical interventions is reduced by 78% for given pathology. The use of staged plaster cast methodics by I. Ponseti on the preoperative preparation of children in the age between 2 to 10 years is an effective way of significant reducing the severity and duration of the surgery, allowing simultaneous correction of residual deformities of both feet at one surgical stage.

2. Transposition of the tibialis anterior muscle is an essential element in anti-relapse complex treatment of congenital talipes equinovarus by I. Ponseti methodics in children aged from 2 to 17 years, but its performance allowed to obtain 3,3% of good and satisfactory results while respecting the technology, peculiarities of treatment and terms using fixation brace.

3. Using domestically produced brace reduces individuals treatment cost by 40%, excludes durable plaster casting of child's foot, does not lead to severe muscle hypotrophy and neurological complications, and allows child to start stages of a comprehensive rehabilitation treatment earlier, resulting in persistent good anatomical and functional results.

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