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Long-term outcomes of atypical clubfoot treated with the Ponseti method

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Abstract

Introduction Congenital clubfoot is the most common congenital malformation of the foot in children. Despite the relatively low birth rate clubfoot shows no tendency to decrease in the population. On the contrary, there is an increased number of foot pathologies associated with central nervous system anomalies and other pathological syndromes. Atypical clubfoot according to Ponseti's classification requires early recognition and continues to challenge the skills of the pediatric orthopedic surgeon. **The objective** was to draw the attention of pediatric orthopedists on the problem of atypical clubfoot. The goals were to discuss common errors in the treatment of atypical clubfoot and assess a recurrence rate that would require a re-operation. **Material and methods** A total of 135 children (184 feet) with atypical clubfoot which amounted to 12.1 % of the total clubfoot cases were treated in hospitals of the city of Yaroslavl between May 2006 and December 2019. The review included 106 children (147 feet) with atypical clubfoot who could benefit from Ponseti treatment. The mean long-term follow-up period was 7.2 years. **Results** Relapses requiring re-operation occurred in 51 children (83 feet) that amounted to 48.1 % of the total atypical clubfoot cases treated in Yaroslavl. Discussion Appropriate bracing is an important component of the Ponseti technique of atypical clubfoot correction in everyday practice of the pediatric orthopedist. Untimely detection of atypical clubfoot and non-compliance with bracing protocol in typical clubfoot can result in an iatrogenic atypical clubfoot with likelihood of major reconstructions and poor prognosis. **Conclusion** The Ponseti method in Russia is the "gold standard" for the treatment of clubfoot.

Keywords: atypical clubfoot, iatrogenic clubfoot, Ponseti method, recurrence

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INTRODUCTION

Clubfoot is the most frequent congenital malformation of the foot in children [1–9]. Despite the relatively low birth rate there is no trend towards a decrease in clubfoot in the population [10–15]. Conversely, we see an increase in the number of foot pathologies associated with malformations of the central nervous system and other pathological syndromes [16–18]. The Ponseti method was first used in Russia in 2004 by G.M. Chochiev in the city of Vladimir. The method gained more active distribution between 2006 and 2008. The Ponseti method is the "gold standard" for newborns in the country and the first-line treatment of clubfoot in most cases [19–25]. The method became more popular in 2006–2008. Now the Ponseti method is the gold standard for newborns in the country and the first-line treatment in most cases [19–25]. Atypical congenital clubfoot is reported to affect 2–3 per 100 children with clubfoot [26–29] and difficult to be identified and adequately treated following the principles of atypical clubfoot management. Ponseti method of plaster casting is a very simple and effective technique that requires strict adherence to Ponseti's principles considering biomechanics of the foot. Non-compliance with the rules of casting in typical clubfoot and inadequate strategy of casting of the atypical feet can lead to a greater number of children to be subjected to major reconstructive surgeries [24–35].

MATERIAL AND METHODS

135 children (184 feet) with atypical clubfoot (ACF) were treated in the hospitals of the city of Yaroslavl between May 2006 and December 2019 that amounted to 12.1 % of the total number of clubfoot cases. The review included 106 children (147 feet) treated with the Ponseti method for ACF. The rest pediatric patients with a history of several operations and initial treatments with a variety of methods were not included in the review. Associated lesions of the nervous system and the skeleton in ACF are presented in Table 1.

The total number of children with neurological deficits, arthrogryposis and various malformations and syndromes associated with ACF amounted to 39 cases (71 feet) or 36.7 % of the total number of ACF children primarily treated with Ponseti method. The age of 89 children (83.9 %) children with ACF who started treatment in the Yaroslavl hospitals ranged between 3 and 12 months. Families normally started manipulations and casting at home and assessing the situation after a few months from the start of therapy

changed the place of treatment. The age of pediatric patients who initiated treatment in Yaroslavl hospitals is presented in Table 2.

Table 1

Associated lesions of the musculoskeletal and nervous systems

Lesions of the musculoskeletal and nervous systems	Children/feet	%
Idiopathic	67/76	63.3
Arthrogryposis	14/28	13.2
Combined pathology of CNS and peripheral NS	10/18	9.4
Amniotic bands	5/8	4.7
Hemimelia and coalition	3/4	2.8
Skeletal dysplasia	2/4	1.9
Others	5/9	4.7
Total	106/147	100

Table 2

Age of pediatric patients with ACF who initiated treatment in Yaroslavl

Age at initiation of treatment	Number of pediatric patients	%
0–3 mos	9	8.5
3–6 mos	24	22.6
6–12 mos	65	61.3
12–36 mos	8	7.6
Total	106	100

The long-term follow-up period averaged 7.2 years. The families of children we treated were offered (on-/off-site) pediatric examinations at the decreed dates (Table 3). Braces, angular adjustments were checked and the time of use adjusted during on-/off-site examinations of the first year. Three 100-point international scales: two scales of the American Society of Foot and Ankle Surgeons (AOFAS) for the hindfoot and midfoot (Midfoot Scale AO, Hindfoot Scale AO) and the Laaveg-Ponseti scale were used to assess the effectiveness of the treatment strategy. ACF children were advised to use bracing up to 5 years to be followed by stretching the Achilles tendon using the DorsiRamp device. Children with arthrogryposis and contractures of the overlying joints usually did not use traditional braces. Individual turbocast splints were employed for their feet fixation. ACF children treated with a course of casting were examined at 2 weeks, 2 months, 4 months, then once every 3 months up to 1 year, twice a year from 1 year to 5 years of age, once a year after 5 years of age until the end of growth.

Table 3

Treatment performed	Number of pediatric patients	
	абс.	%
Repeat achillotomy	11	13.1
Tibialis anterior tendon transfer. Repeat achillotomy	16	19.2
Tibialis anterior tendon transfer. Release	44	52.2
Tibialis anterior tendon transfer. Fusion	10	12.1
Tibialis anterior tendon transfer. CDA	1	1.1
Anterior hemiepiphysiodesis of the ankle joint	2	2.3
Total	84	100

We report the most common causes of errors in the treatment of ACF encountered in our practice and encouraging parents to change the place of treatment for the child.

The rarity of the pathology among clubfoot cases, impaired casting technology (poor modeling of the plaster cast, lack of knee flexion and resultant slipping casts), failure to perform or too early performance of achillotomy, discrepancy between adjustment or brace model, etc were common causes of failures. The above reasons led to a greater number of children with ACF who received treatment in historical clubfoot centers. Every tenth child we treated required atypical casting strategy. The above factors led to a large number of children suffering iatrogenic and congenital atypical feet.

RESULTS

Recurrences that required repeat surgical treatment occurred in 51 children (83 feet) that accounted for 48.1 % of the total number of children with ACF treated in Yaroslavl. Questionnaires were sent to all children with ACF to evaluate outcomes at a long term. Children who developed recurrences (n = 84, 79.3 %) underwent surgical treatment (Table 3).

Recurrences of ACF were treated with re-casting and achillotomy up to 3 years of age. Transposition of the distal insertion of the tibialis anterior tendon was produced at the age of 2.5 years and over with the ossification nucleus of the 3rd sphenoid bone being more than 5 mm on the radiograph. Relapses between the ages of 3 and 6 years after recasting were treated using various combinations of releases (medial, plantar, posterior and sometimes lateral). Children aged 6 years and over were treated with simultaneous correction and foot reconstruction including calcaneocuboid arthrodesis or wedge-shaped closing osteotomy of the cuboid bone. External fixation device was used for equinus correction in a growing child, and anterior hemiepiphysiodesis of the ankle joint resulted in a good outcome in two adolescents. Combinations of the above methods were also used. Of the total number of children with ACF we treated, 87 patients (82 %) were

reviewed. The mean follow-up period was 7.2 years. As mentioned above, we used three 100-point international scales – two scales of the American Society of Foot and Ankle Surgeons (AO FAS) for the hind and middle sections of the foot to evaluate the effectiveness of the treatment strategy. The mean Midfoot Scale AO scored 61.2, the Hindfoot Scale AO scored 58.3 and the Laaveg-Ponseti scale scored 65.1.

DISCUSSION

A small number of ACF cases reported in the literature does not seem real for practical pediatric surgeon. From our experience, about 10 percent of clubfoot cases require casting and correction of the cavus and then equinus at the hospital. The Ponseti method remains highly effective in ACF children aged up to 3 years and major operations can be avoided in most cases. Releases and, sometimes, arthrodesis would be added to Ponseti method in children with arthrogrypotic involvement of the feet at the age of 1.5 years or over.

Multiple lesions of the lower limbs are associated with difficulties in the use of the classic Ponseti method leading to loss of correction and the need for recasting and reoperations.

Failures in the treatment of ACF with Ponseti methods were as follows:

1) atypical clubfoot is not common for daily practice of a pediatric orthopedic surgeon being subject to an average workload providing services for the region and the condition is not encountered every year. This can lead to higher probability of failures in Ponseti serial casting. The pediatric orthopedic surgeon is less likely to see ACF children at the doctor's office, so this leads to the need to change the doctor;

2) with the Ponseti method being introduced into the daily orthopaedic practice the congenital clubfoot classification changed. And what used to be called atypical clubfoot no longer coincided with Ponseti treatment. I. Ponseti described the atypical clubfoot as a rigid, relatively small foot with a pronounced equinus of the hindfoot and the cavus. The first and second conditions were seen in 56 children / 67 feet of our series;

3) prior to introduction of the Ponseti treatment traditional casting in our country suggested the knee flexion of 120–130 degrees. A change in the treatment strategy according to Ponseti principles with knee flexion up to 90 degrees was subjectively difficult and, according to some orthopaedists, could be unsafe with vascular complications. Poor casting modeling and lack of knee flexion up to 90 degrees often led to slipping of the cast and the development of an iatrogenic atypical foot with pronounced cavus and rigid equinus. The more the child walks with a slipping cast on, the more rigid the deformity becomes (18 children – 24 feet).

The assessment was performed retrospectively using photos of lower limbs with cast on applied at the place of residence. Children with atypical clubfoot often demonstrated excess weight and a short cavus foot. The knee flexed to 80–70 degrees and careful cast modeling from the upper third of the femur to the toes were meant for good fixation of the foot after the third cast, in particular (Fig. 1);

4) performing a cast of an atypical clubfoot with resultant incomplete correction, a pediatric orthopaedic surgeon was prone to early achillotomy (after 3–4 casts) and could get a good dorsal flexion and a calcaneal foot in some cases (Fig. 2). But the cavus correction did not occur. The feet were short with a vague hindfoot and poorly fixed with brace. This led to the negative family attitude towards braces and the treatment technology.

In addition to that, absence of a countersupport of the stretched Achilles tendon following achillotomy according to the principle of a crane did not allow casting the cavus until the Achilles was well fused and the tibial length changed with growth in relation to the Achilles tendon (13 children – 19 feet);

5) by contrast, achillotomy that was not performed during equinus correction resulted in a foot with an oblique talus (Fig. 3). The return and repeat casting did not always led to correction of the iatrogenic deformity. Asymptomatic flat feet often remained unaddressed (9 children – 14 feet);

Fig. 1 Examples of casting: (a-c) performed at home without proper knee flexion leading to slippage of the cast and iatrogenic atypical clubfoot; (d) the knee flexed for appropriate casting of atypical clubfoot

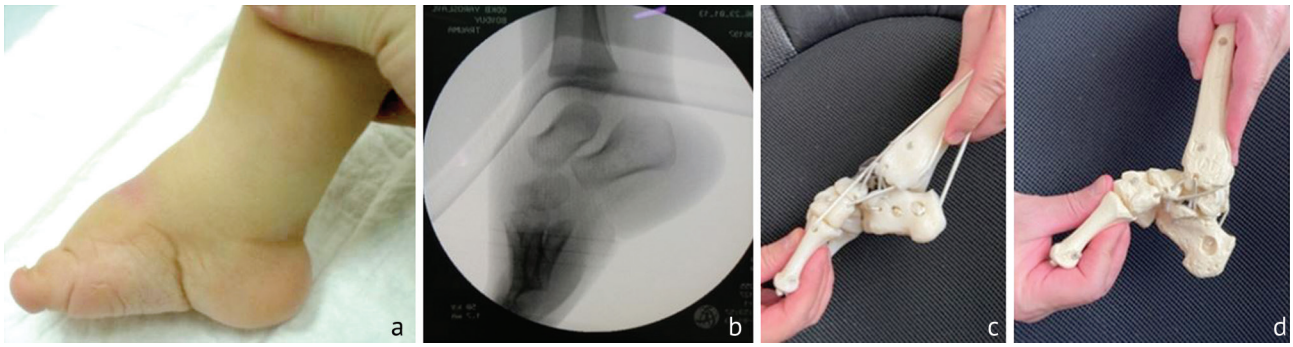

Fig. 2 (a) preoperative equinus and cavus of the foot; (b) preoperative image intensifier demonstrating cavus and equinus; (c) remodeling of the foot bones after early achillotomy before cavus correction; (d) appearance of the foot after achillotomy without cavus correction. A pronounced hindfoot is visible with a deep transverse plantar crease

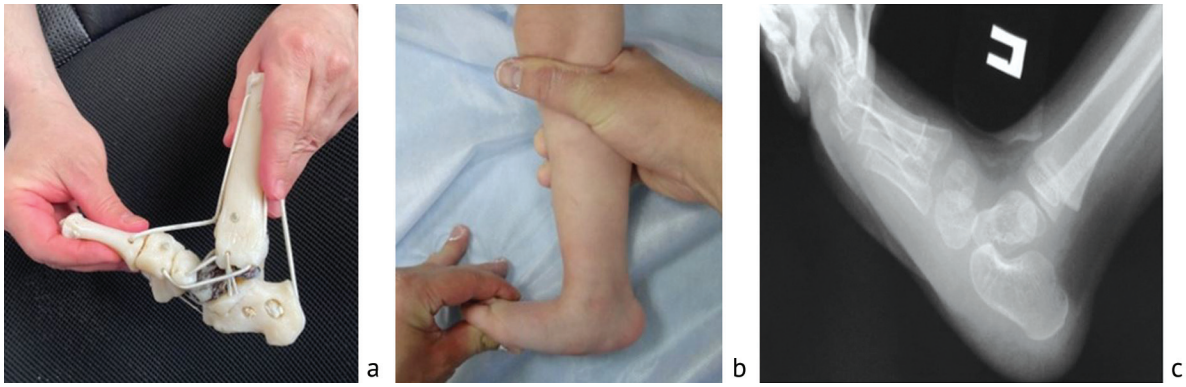

Fig 3 An attempt to correct the foot deformity without achillotomy: (a) using a dummy; (b) appearance of the foot; (c) radiological appearance

6) incomplete equinus correction during cast modeling (the foot was neutral with respect to the tibia, and 15–20 degrees of dorsal flexion was required) after achillotomy led to the absence of dorsal flexion, and subsequently to poor foot fixation with brace. Frequent slipping of the shoe led to a recurrence and discredit of the Ponseti method;

7) primary Ponseti treatment of clubfoot started at the age of 1 month. With immature nervous system we saw no developmental impairment except for severe malformations. With growth children could be diagnosed with cerebral palsy, paresis of the peripheral nervous system, amniotic bands, hemimelia, different tarsal coalitions, various syndromes being not verified in some cases (20 children - 43 feet out of the total number of children);

8) inconsistency of the brace or the adjustment to the feet shape was seen after good correction of ACF with casting. Brace had to be abducted at 40 degrees in atypical clubfoot and not at 60–70 as in typical clubfoot. A boot designed to fix atypical clubfoot should have had a silicone inset ideally fitting the foot after a course of casting. A “pressure saddle” could be used to facilitate even distribution the pressure of the middle strap on the skin at the anterior aspect of the ankle joint. Macerates, naminas and bedsores could appear on the skin of the foot with insufficient quality fixation. This could lead to impaired mode of wearing braces and finally to a relapse (9 children / 16 feet);

9) there was a group of patients with arthrogrypotic clubfoot – 14 children (28 feet). The deformity of the feet was rigid with a pronounced cavus and equinus and quickly recurred in the process of growth. Correction of knee contractures interfered with equinus correction in multiple lesions of lower limbs, and the surgical reduction of teratogenic dislocations of the femoral head followed by prolonged immobilization could lead to the loss of correction and the need for repeated correction at a shorter time.

International rating scales including Midfoot Scale AO, Hindfoot Scale AO and Laaveg-Ponseti allow the analysis of long-term outcomes of atypical clubfoot treated with the Ponseti method and objective characterization of the effectiveness of the casting technique. Long-term follow-ups of children with atypical clubfoot evaluated with international AO and Laaveg-Ponseti rating scales indicated the effectiveness of the Ponseti method at a short term and loss of correction at growth that would require a repeat surgery.

CONCLUSION

The Ponseti method in Russia is the "gold standard" for the treatment of clubfoot. Correction of congenital clubfoot with casting is highly effective but the technique requires careful attention from the pediatric orthopaedic surgeon in case of ACF to be timely detected among children with foot deformities. Compliance with the strategy of casting correction and using appropriate braces facilitates effective treatment and monitoring of children with atypical clubfoot. Repeated treatments using the methods available to the surgeon may be required for half of the cases with concomitant pathology.

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