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SURGICAL CORRECTION OF FOOT DEFORMITY IN CHILDREN UNDER 3 YEARS OF AGE

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ABSTRACT — **AIM.** The study aimed to improve the outcomes for surgical correction of talipes equinovarus in children using the Ponseti method, as well as vertical talus correction using the Dobbs method combined with massage, physiotherapy and therapeutic exercise. **MATERIAL AND METHODS.** In the period from 2015 to 2020, 109 children were examined and treated at the Filatov City Children's Hospital, Moscow. **RESULTS.** The study has revealed that without timely correction the orthopedic foot pathology in children is often accompanied by pain, functional changes and a high risk of developing disability in a child, which determines a high social significance of this nosology. After a comprehensive assessment and a combination of conservative and surgical correction techniques, the congenital foot deformity in all children was completely eliminated. **CONCLUSION.** The Ponseti method is required to be carefully adhered to in order to achieve a complete pes equino-varus correction. Early start of correction of changes is effective.

KEYWORDS — clubfoot, pes equino-varus, metatarsus varus, vertical talus, congenital foot deformity, the Ponseti method, pes varus, pes planovalgus, pes cavus.

INTRODUCTION

Congenital foot deformities are represented by such nosologies as pes equino-varus (clubfoot), metatarsus varus, vertical talus, pes varus, pes planovalgus, pes cavus, as per ICD-10 code Q66.5. The epidemiology of pes equino-varus is 1 per 1000 newborns [1], while vertical talus and metatarsus varus are met quite rare [2].

The mentioned nosologies are accompanied by severe pain syndrome, functional changes in the foot, thus forcing the patient to use orthopedic shoes. In the absence of proper surgical correction, the risk of disability is high. Functional disorders affect the patient's quality of life and determine the high social significance of the mentioned nosologies [1].

Today, there is a range of congenital foot pathology classifications. According to Zatspepin-Bohm, there are two clinical forms of pes equino-varus:

typical and atypical. According to the literature, the typical deformity accounts for 80% of cases. This type of deformity responds well to such treatment methods as bandaging and plastering.

There are also three types of soft tissue component involvement — soft tissue and bone (rigid). Attributing to a particular type of pathology is distinguished by the possibility and efficacy of a conservative treatment option. The literature describes a number of soft tissue types of deformity as the most common [3].

The aim of the study

was to improve outcomes of pes equino-varus correction using Ponseti method, and vertical talus correction using the Dobbs method in children combining it with massage, physiotherapy and therapeutic exercise.

MATERIAL AND METHODS

In the period from 2015 to 2020, a double prospective cohort study was conducted at the Filatov City Clinical Children's Hospital, Moscow. 109 children with congenital foot deformities were enrolled for the proposed treatment.

During examination of 102 children (93.6%) were diagnosed with the typical form and 7 children (6.4%) were diagnosed the atypical form of pes equino-varus. The soft tissue form was found in 51.4% of cases (in 56 children), and the bone form was found in 48.6% of cases (53 children). We identified the left-sided type in 24 children (22.1% of cases); the right-sided type in 20 children (18.3% of cases) and bilateral type of deformity in 65 children (59.6% of cases).

In terms of the age in which the deformity was diagnosed, the patients were distributed as follows: in 73.4% of cases, the deformity was diagnosed under 3 months (80 children), in 6.4% of cases — from 3 to 6 months (7 children), and in 20.2% of cases — at the age of 6 months and older (22 children).

On average, the clinical observations and treatment began at the age of one month. The surgical intervention period was 3.0 (± 1.25) months, on average.

Surgical correction was performed in all 103 patients with pes equino-varus and in 3 patients with vertical talus. Metatarsus varus was treated conservatively in all patients. Surgical treatment was performed in 106 children (achillotomy was performed in 103 children with pes equino-varus and in 3 children with vertical talus).

The Ponseti method was used in all children with pes equino-varus and in 11 children (91.7%) of 12 children with metatarsus varus. This is a conservative technique for plastering congenital clubfoot, which consists of the stage-by-stage bringing of all the deformity components into the correction position, and is based on the ankle joint biomechanics and supplemented with percutaneous achillotomy.

The Dobbs method was used in all children with vertical talus. This is a conservative technique for plastering congenital equinovalgus deformity of feet, which implies a gradual bringing all deformity components to the correct position, and is based on the ankle joint biomechanics, supplemented with percutaneous achillotomy and, in some cases, by fixing the first ray using a Kirschner's wire.

The comprehensive treatment of children with metatarsus varus included massage procedures. Massage was used in five children (83.3%) out of six with vertical talus. A massage was not administered to the children with pes equino-varus. Physiotherapy procedure courses were used in two cases (16.7%) out of twelve in children with metatarsus varus. Comprehensive physical therapy exercises for metatarsus varus were carried out in 70.3% of cases (64 out of 91 children) and in 33.3% of cases for vertical talus (4 out of 6 children). Comprehensive physical therapy exercises were not administered to the children with pes equino-varus.

Treatment outcomes were assessed according to the Pirani scale (1995). The classification includes the analysis of 6 described clinical signs, while their value is determined in the maximum foot correction position.

Each of the signs is assessed based on a point scale: 0, 0.5 and 1 point (depending on the severity).

Statistical assessment of the study results was carried out using a laptop and "Statistica" Software (for Windows, version 6.0).

The study result data were assessed by the variation statistics method.

The study used the following statistical research methods:

1. Wilcoxon's signed rank test (to assess statistically significant differences before and after treatment in each clinical group of patients);
2. Mann-Whitney test (to assess statistically significant differences in inpatient and outpatient groups);
3. Fisher's exact test (to assess statistically significant differences in patients with dorsiflexion $> 15^\circ$ and $< 15^\circ$);
4. Friedman's two-way analysis (to assess statistically significant differences before and after treatment according to the Pirani classification).

RESULTS

The treatment efficacy criteria were the following: heel cavus, degree of cavus rigidity, assessment of the medial fold, shape of the foot lateral arch, foot equinus and dorsiflexion degree. Changes in the foot were determined according to the Pirani classification (1995):

1. The hindfoot condition according to Pirani classification before treatment had more pronounced statistical differences than after correction (according to Wilcoxon test = -8.955, $p < 0.001$);
 2. The cavus rigidity degree according to the Pirani classification before treatment had more pronounced statistical differences than after correction (Wilcoxon test = -9.125; $p < 0.001$);
 3. Assessment of the foot medial fold before treatment had more pronounced statistical differences than after correction (Wilcoxon test = -9.105; $p < 0.001$);
 4. Bend of the foot fibular margin before treatment had more pronounced statistical differences than after correction (Wilcoxon test = -9.364; $p < 0.001$);
 5. Foot equinus before treatment had more pronounced statistical differences than after correction (Wilcoxon test = -8.879; $p < 0.001$);
5. Assessment of the posterior fold of the heel according to the Pirani system before treatment had more pronounced statistical differences than after correction (Wilcoxon test = 8.791; $p < 0.001$).

The total points according to the Pirani criteria before treatment were 4.5 (3.0; 6.0), after correction they amounted to 0 (0; 0) point.

The obtained differences were considered significant at $p < 0.001$ level (Friedman rank analysis of variance was used for related samples).

Among the children enrolled in our study, 61 children underwent surgery on an outpatient basis whereas 45 patients were hospitalized ($n = 106$) and the remaining 3 children were treated as a case follow-up.

OUTPATIENT SURGICAL TREATMENT RESULTS

According to the Pirani classification, changes in the foot were distributed as follows: 1. Heel cavus according to Pirani classification before treatment revealed statistically significant differences at $p < 0.001$ than after correction (Wilcoxon test = -6.705, 1.0 (0.5; 1.0) before treatment versus 0.0 (0.0; 0.0) after correction); 2. Cavus rigidity according to Pirani classification before treatment had more pronounced statistical differences than after correction (Wilcoxon test = -6.628; $p < 0.001$, 1.0 (0.5, 1.0) before treatment versus 0.0 (0.0; 0.0) after correction); 3. Assessment of the foot medial fold before treatment had more

pronounced statistical differences than after correction (Wilcoxon test = -6.628; $p < 0.001$, 1.0 (0.5, 1.0) before treatment versus 0.0 (0.0; 0, 0) after correction); 4. Bend of the foot fibular margin before treatment had more pronounced statistical differences than after correction (Wilcoxon test = -6.683; $p < 0.001$, 1.0 (0.5, 1.0) before treatment versus 0.0 (0.0; 0, 0) after correction); 5. The foot equinus before treatment had more pronounced statistical differences than after correction (Wilcoxon test = -6.753; $p < 0.001$, 1.0 (0.5, 1.0) before treatment versus 0.0 (0.0; 0, 0) after correction); 6. Assessment of the posterior fold of the heel according to the Pirani classification before treatment had more pronounced statistical differences than after correction (Wilcoxon test = -6.662; $p < 0.001$, 1.0 (0.5, 1.0) before treatment versus 0.0 (0, 0; 0.0) after correction).

Thus, the total point according to the Pirani classification before treatment was 5.0 (4.0; 6.0), after correction it was 0 (0; 0). The obtained differences were considered significant at $p < 0.001$ (according to Friedman rank analysis of variance).

RESULTS OF INPATIENT SURGICAL TREATMENT

According to the Pirani classification, changes in the foot were distributed as follows: 1. Heel cavus according to the Pirani classification before treatment had more pronounced statistical differences than after correction (Wilcoxon test = -5.665, $p < 0.001$, 1.0 (0.5; 1.0) before treatment versus 0.0 (0.0; 0.0) after correction); 2. Cavus rigidity according to Pirani classification before treatment had more pronounced statistical differences than after correction (Wilcoxon test = -5.557; $p < 0.001$, 1.0 (0.5, 1.0) before treatment versus 0.0 (0.0; 0.0) after correction); 3. Assessment of the foot medial fold before treatment had more pronounced statistical differences than after correction (Wilcoxon test = -5.516; $p < 0.001$, 1.0 (0.5, 1.0) before treatment versus 0.0 (0.0; 0, 0) after correction); 4. Bend of the foot fibular margin before treatment had more pronounced statistical differences than after correction (Wilcoxon test = -5.631; $p < 0.001$, 1.0 (0.5, 1.0) before treatment versus 0.0 (0.0; 0, 0) after correction); 5. The foot equinus before treatment had more pronounced statistical differences than after correction (Wilcoxon test = -5.674; $p < 0.001$, 1.0 (0.5, 1.0) before treatment versus 0.0 (0.0; 0, 0) after correction); 6. Assessment of the posterior fold of the heel according to the Pirani classification before treatment had more pronounced statistical differences than after correction (Wilcoxon test = -5.631; $p < 0.001$, 1.0 (0.5, 1.0) before treatment versus 0.0 (0, 0; 0.0) after correction).

Thus, the total point according to the Pirani classification before correction was 5.5 (4.0; 6.0), after

correction it was 0 (0; 0). Differences were considered statistically significant at $p < 0.001$ (according to Friedman's two-way analysis).

COMPARISON OF INPATIENT AND OUTPATIENT GROUPS

Before treatment, the inpatient and outpatient treatment groups were comparable in all Pirani classification criteria: 1. Heel cavus (Mann-Whitney test, $p = 0.466$); 2. Cavus rigidity (Mann-Whitney test, $p = 0.611$); 3. Medial fold of the foot (Mann-Whitney test, $p = 0.986$); 4. Bend of the foot fibular margin (Mann-Whitney test, $p = 0.978$); 5. Foot equinus (Mann-Whitney test, $p = 0.663$); 6. Posterior fold of the heel (Mann-Whitney test, $p = 0.671$).

Based on the treatment efficacy criteria according to the Pirani classification, it is possible to compare the clinical comparison groups according to the achieved dorsiflexion degree.

Achieved dorsiflexion exceeding 15° was observed in 57 cases of surgical treatment ($93.4 \pm 10.9\%$) in hospital environment and in 39 cases ($86.6 \pm 11.2\%$) of surgical treatment in the inpatient setting (Table 1).

From the above table it follows that the differences between the groups are statistically insignificant (Fisher's exact test, exact significance (2-sided) = 0.139). By the overall point — Mann-Whitney test, $p = 0.917$. Thus, the groups are comparable with each other in terms of these indicators.

UNFAVORABLE OUTCOMES OF INPATIENT AND OUTPATIENT TREATMENT

After surgical correction in hospital environment, one child required a second surgical intervention due to relapse (an additional achillotomy was performed).

Based on the accumulated experience, early detection of the recurrent pathology is the key to successful elimination of recurrent deformities. They are usually caused by a failure to follow the rules of using rehabilitation orthoses, braces and orthopedic shoes at the end of the main surgical correction stage. Relapse, as a rule, is detected during the period of the foot intensive growth — before 10–13 years of age. Therefore, at the juvenile onset, such children should be regularly followed up by an orthopedist [4].

In 6 (9.8%) of 61 children who were undergoing outpatient treatment, the limited motion range was observed in the distal part of the lower leg, while the same complication in the hospital was observed in 3 (6.6%) of 45 patients. There were no statistical differences in the compared groups (Fisher's test, exact significance (2-sided) = 0.387).

Table 1. Achieved dorsiflexion in comparison groups

			Comparison groups		p1	p2
			Outpatient n=61	Inpatient n=45		
Achieved dorsiflexion	< 15°	Number, people	4	6	0.178	0.664
		Incidences, %	6.5±7.5%	13.3±6.2%		
	> 15°	Number, people	57	39	0.038	0.120
		Incidences, %	93.4±10.9%	86.6±11.2%		

Note: p1 is the level of statistical significance of differences in pairwise comparison of outpatient and inpatient groups of patients; p2 — the level of statistical significance of differences in pairwise comparison of groups of patients, depending on the degree of achieved dorsiflexion.

Thus, both outpatient and inpatient treatment options for children with foot pathology had the same effect on the evaluation criteria for treatment success. Satisfactory results were achieved in 100% of cases of surgical correction. When choosing a treatment method (outpatient or inpatient), not only the degree of social adaptation of the patient should be considered as the principal criteria, but also economic factors, since the clinical effectiveness of these treatment approaches was the same.

DISCUSSION

In the modern pediatric orthopedic practice, pes equinovarus treatment according to the Ponseti method is the *gold standard* correction

To achieve a successful pes equino-varus correction with the prevention of relapses or other deformities, careful adherence to the Ponseti protocol is required. Initially, the Ponseti procedure was used only in the children under two years of age, but modern studies demonstrate the success of pes equino-varus correction in the older age groups [5].

According to the authors, the proposed protocol employment for treating foot deformity is effective and consistent with the data obtained by other authors. The Ponseti procedure is successful and relapse-free in 94–96% [6].

In our opinion, the most preferred age for deformity correction is an early age and we adhere to the position of early treatment of deformities (immediately after diagnosis). Based on the studied literature available to us, the late correction start is directly proportional to the likelihood of relapse and treatment duration [1].

CONCLUSION

Based on the obtained data we recommend treating pes equino-varus as early as possible after birth (3–5 months) to prevent recurrence and ensure the complete deformity correction. In addition, a strict adherence to the Ponseti protocol is required for such patients.

In cases of vertical talus correction, conservative correction in combination with minimally invasive surgical tech-

niques can prevent the development of complications previously observed during extensive surgical procedures.

The Dobbs correction method used by us is simpler and more effective in infants. Our data are consistent with reports of other authors' excellent results. The Dobbs correction method is less invasive and allows avoiding the risks associated with more extensive surgeries [7].

We have not found significant differences in the choice of an outpatient or inpatient treatment regimen. Considering the economic factor, in conditions of statistically significant similar clinical outcomes, the outpatient treatment regimen is most preferable.

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