

Comparison of the short-term and long-term results of the Ponseti method in the treatment of idiopathic pes equinovarus

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Abstract

Purpose Congenital club foot is one of the most common birth defects involving the musculoskeletal system. At present two methods are used for the treatment of this deformity: French and Ponseti method. The purpose of this study was to compare the short-term (up to three years) and long-term (three to seven years) results of treatment with the Ponseti method. **Methods** A total of 195 consecutive infants (143 boys and 52 girls) with idiopathic club foot treated with the Ponseti method in the period of 2005–2012 were included in this study; the total number of feet was 303. The severity of the foot deformity was classified according to Diméglio. When relapse occurred up until three years of age, we started with the casting again. If conservative treatment was unsuccessful we proceeded to surgical treatment.

Results Primary correction was attained in all cases. Surgical correction of relapses was performed in 30 % of patients according to the Ponseti method (re-tenotomy of the Achilles tendon and transposition of the tibialis anterior) and in 70 % by alternative techniques. The number of relapses indicated for surgery increased with increasing period of follow-up: whereas in patients where the treatment started already in 2005 relapses occurred in 72 %, in patients included in 2011 the number of recurrences only reached 3 %.

Conclusions It follows from our results that it is impossible to cure all club feet with casting, tenotomy of the Achilles tendon and transposition of the tibialis anterior only.

Keywords Ponseti method · Idiopathic club foot · Foot casting · Tenotomy · Achilles tendon tenotomy · Transposition of tibialis anterior · Congenital club foot

Introduction

Congenital pes equinovarus, also referred to as club foot, occurs in one in 1,000 live births [1] and is one of the most common birth defects involving the musculoskeletal system. It is recognisable at birth and is readily distinguishable from positional foot anomalies because the foot is rigid and does not correct with passive movement. The deformity has five components: equinus, varus, adductus, cavus and supination of the foot. The most severe deformities in a club foot occur in the hind part of the foot. The talus and calcaneus are generally deformed and in severe equinus, the calcaneus is in varus angulation and medially rotated, and the navicular is severely displaced medially and may be in contact with the medial malleolus [2]. These components of the deformity are inextricably interrelated. The ligaments of the posterior aspect of the ankle and of the medial and plantar aspects of the foot are shortened and thickened.

Pathogenic mechanisms of the development of club feet are, unfortunately, not known. It was suggested that an important role is played by the primary defect of the embryonic mesenchyme, induced by an unknown toxic effect before the seventh week of intrauterine development. Most cases of this malformation occur as an isolated birth defect and are considered idiopathic. A genetic component is suggested by the fact that in relatives in the first line the risk of this malformation reaches 2.9 %, in the second line 0.5 % and in the third line 0.2 %. In the case that both parents are carriers of this defect, the risk increases to 10–15 %. Moreover, a 33 % concordance

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in identical twins has been described [14] and familial occurrence in 25 % of cases [15].

When untreated, children with club feet walk on the sides of their feet instead of the soles, resulting in infections, callus formation, arthritis and significant limitations in mobility and employment opportunities. The goal of treatment is to reduce or eliminate the deformities so that the patient has a functional, pain-free, plantigrade foot, with good mobility and without calluses, and does not need to wear modified shoes. There is almost universal agreement that the initial treatment of idiopathic congenital club foot should be non-operative, regardless of the severity of the deformity [3]. The most popular protagonist of the conservative approach—used already at the time of Hippocrates—is without doubt Kite [4]. He treated almost 800 patients during the period 1924–1960; the therapy lasted on average 6 months. This treatment initially consisted of forcible serial manipulations with the patient under anaesthesia, followed by the application of a cast [4]. Among others using a comparable conservative approach, i.e. casting with three-point pressure, we can mention the “Vienna school”. Although all these methods have the potential to be successful when applied correctly, most authors have reported success rates of only 15–50 % [5].

At present two principle methods are mostly used for the treatment of club foot: physiotherapy and continuous motion without immobilisation [6] and the Ponseti method, described almost 50 years ago [7]. It involves serial manipulation, a specific technique of cast application and a possible percutaneous Achilles tenotomy. This method has been reported to have short-term success rates approaching 90 %, and the long-term results have been equally impressive [3]. We believe, however, that the data on the success rate may be significantly influenced by the duration of the period after termination of the treatment.

The purpose of this study was, therefore, to compare the short-term (up to three years) and long-term (three to seven years) results of treatment of idiopathic club feet with the Ponseti method and to determine the factors for recurrence. Recognition of important risk factors may eventually result in better patient selection for the currently available treatments of idiopathic club feet and may allow early intervention to improve compliance and outcome.

Patients and method

Patients

A total of 195 consecutive infants (143 boys and 52 girls) with idiopathic club foot who had been treated with the Ponseti method at the Department of Orthopaedics, Bulovka Hospital in Prague in the period of 2005–2012 were included in this study. In 108 children (55 %) the incidence of club foot was bilateral so that the total number of feet treated with the Ponseti method was 303. Included were patients where the

treatment started between birth and six months of age (even if they were originally treated at different medical institutions with another method). Patients were excluded from the study if the club foot was connected with some other congenital malformation. Institutional Review Board approval was obtained for this research and informed consent was obtained from parents. There were 28 patients (14 %) who had a positive family history. The severity of the foot deformity was classified according to the grading system of Diméglio et al. [6] at the time of presentation. In this system, four parameters are assessed in every degree on the basis of their reducibility with gentle manipulation as measured with a handheld goniometer: (1) equinus deviation in the sagittal plane, (2) varus deviation in the frontal plane, (3) derotation of the calcaneopedal block in the horizontal plane and (4) adduction of the forefoot relative to the hindfoot in the horizontal plane.

Treatment regimen

The essential principles of the original Ponseti method were recently summarised elsewhere [3, 8]; at our institution the following regimen is used. Treatment starts as soon as possible after referral, preferably shortly after birth, and consists of gentle manipulation of the foot and the serial application of long leg plaster casts above the knee as described by Ponseti [9, 10]. In all patients, the cavus is corrected first by supinating the forefoot and dorsiflexing the first metatarsal. Failure to supinate the forefoot as the first step ultimately leads to incomplete correction of the club foot. To correct the varus and adduction, the foot in supination is abducted while counter pressure is applied with the thumb against the head of the talus. Three to eleven long leg casts (on average five), changed weekly after proper manipulation of the foot, are usually sufficient to obtain good correction. The essential preconditions for the termination of casting are: (1) palpable distance between medial malleolus and navicular bone, (2) palpable ventral part of the calcaneus, (3) abduction of the foot (70°) without pronation and (4) calcaneus in neutral or slightly valgus position. These four conditions are crucial in obtaining complete correction and in helping to prevent early recurrence.

If residual equinus is observed after the adduction of the foot and the varus deformity of the heel has been corrected, a simple percutaneous tenotomy in the operating room with the patient under general anaesthesia is performed, which allows optimal analgesia for the infant. This setting also provides the surgeon with a controlled environment, which optimises the safety of this procedure. This approach differs from that of Ponseti [9, 11] who prefers that the Achilles tenotomy be done in the clinic with a topical and/or local anaesthetic. We use local anaesthesia only in cases when general anaesthesia is contraindicated for different medical reasons. Tenotomy was performed in 276 of 303 club feet, and it is performed when 15° of dorsiflexion has not been obtained with the use of casts. After the tenotomy, an

additional cast is applied and left in place for three weeks to allow for healing of the tendon. In 2005 we performed only sliding tenotomy instead of complete tenotomy of the Achilles tendon (40 feet).

Three weeks later, an orthosis is applied to prevent relapse of the deformity. This is best accomplished with the feet in well-fitted, open-toed, high-top straight last shoes attached to an abduction bar of approximately the length between the child's shoulders. The splint maintains the corrected foot in 70° of external rotation to prevent recurrence of the varus deformity of the heel, adduction of the forefoot and toeing-in. The ankle should be in dorsiflexion, in an attempt to prevent equinus, and this is accomplished by bending the bar with the convexity of the bar distally directed. If the deformity is unilateral, the normal foot is placed in 30° of external rotation. The orthosis is worn full-time (23–24 hours a day) for the first three months non-stop and 14–16 hours for the next three years during the night and day sleeping. To help prevent a recurrent equinus contracture, we have introduced—in addition to the original Ponseti method—the exercise of patients with their parents. They are instructed about and given a handout on how to effectively perform range of motion exercises for the ankle when it is out of the brace. The parent uses one hand to stabilise the leg. The other hand is used to grasp the heel and then place the ankle into maximum dorsiflexion followed by plantar flexion. This exercise is performed with the bent as well as extended knee. During the first three months, when the child is in the brace 23 hours a day, the parents perform the exercise only once a day when the brace is removed. When the child is wearing the brace only 14–16 hours a day, the parents perform the exercises several times per day. These exercises have improved our ability to effectively maintain the ankle motion achieved at the time of the tenotomy. The orthosis is removed at the age of three years. The exercise continues until skeletal maturity is reached. In the cases where relapse occurs up until three years of age, we have to start with the above-described casting again. To solve the relapse, however, the number of casts is usually significantly lower. If conservative treatment of the relapse is unsuccessful in this age group, we proceed to surgical treatment. In the relapsing patients older than three years, we only use a surgical approach.

Results

A total of 195 patients (74 % male) were treated with the Ponseti method in the period of 2005–2012. In 108 children (55 %) the incidence of club foot was bilateral so that the total number of feet treated with the Ponseti method was 303 (Table 1). Our group consisted of 16 % patients classified according to Diméglio et al. [6] as grade I (the easiest), 30 % as grade II, 31 % as grade III and 23 % as grade IV (the most severe).

Primary correction was attained in all cases by the conservative approach, i.e. with casting alone (27 feet) or in

Table 1 Total number of treated feet

Years	2005	2006	2007	2008	2009	2010	2011	2012
Feet	55	40	38	34	42	43	34	17

connection with tenotomy of the Achilles tendon (276 feet); all four essential conditions for the termination of casting (see the “Patients and method” section) were accomplished.

The first relapses occurred six weeks after the introduction of the abduction bar. The degree of relapses was, however, in individual patients different: from partial changes (equinus, adduction of the forefoot or varus position of the calcaneus) to complete recurrence of the original status. All relapses were treated initially (up until three years of age) by the conservative approach. If the repeated conservative approach was unsuccessful (four conditions for the termination of casting were not accomplished), surgical treatment was indicated (in 82 patients, 40 %; 111 feet, 37 %). Surgical correction was performed in 30 % by the surgical approach belonging to the Ponseti method (re-tenotomy of the Achilles tendon, transposition of the m. tibialis anterior) and in 70 % by alternative techniques (Table 2). The group of patients with relapses indicated for surgical treatment comprised 5 % classified as grade I according to Diméglio et al. [6], 25 % as grade II, 35 % as grade III and 35 % as grade IV. The average period from the beginning of therapy to the start of surgical treatment was 2.7 years. In some cases, the relapses occurred even after surgical correction: in 13 feet twice, in three feet three times and in one case five times. The number of relapses indicated for surgery increased with the increasing period of the follow-up (Tables 3 and 4). Whereas in patients where the treatment started already in 2005 relapses occurred in 72 %, in patients included in 2011 the number of recurrences only reached 3 %.

Discussion

The major finding of this study is the significant difference between the evaluation of the short-term and long-term results

Table 2 Surgical procedures in relapsed feet

Procedures	
Tenotomy TA	274
Re-tenotomy TA	16
Hindfoot osteotomy	40
Dorsal release	21
Dorsomedial release	14
Peritalar release	34
Supramalleolar osteotomy	1
Forefoot osteotomy	6
MTA transposition	47

TA tendo Achilles, MTA m. tibialis anterior

Table 3 Total number of relapsed feet indicated for surgery

Start of treatment	2005	2006	2007	2008	2009	2010	2011	2012
Patients	28	19	15	8	7	1	2	0
Feet	40	26	21	11	8	2	3	0

of the Ponseti method in the treatment of idiopathic pes equinovarus. The number of relapses during the first three years of treatment, indicated for surgical intervention, was markedly less (5 %) as compared with patients where the treatment started six to eight years ago (65 %). For an explanation of this finding it is necessary to take into consideration—particularly for the oldest group (year 2005)—the learning curve as well as the fact that we performed only sliding tenotomy instead of complete tenotomy of the Achilles tendon. On the other hand, the results from the year 2007 and onwards were significantly better: the number of relapses only reached 44 %. It may be assumed, therefore, that primary correction of pes equinovarus is possible in almost 100 % of patients, but for the subsequent solution of relapses it is necessary to use surgical intervention.

Conservative management of intractable relapses by casting in patients older than three years is according to our experience very difficult because of maturation and decreased compliance of the fibrotic tissue. It is, however, necessary to mention that the strict age limitation for tenotomy of the Achilles tendon was not specified. We have not observed any defects in the healing of the Achilles tendon: the palpable rigid band of the tendon appeared already three weeks after tenotomy, suggesting its successful regeneration. Despite the knowledge of some rare complications [12], Achilles tenotomy should be taken as a more conservative method than trying to aggressively treat with casts [13]. We are convinced, therefore, that the complex treatment of this defect requires not only exact knowledge of the conservative approach but also the set of different surgical interventions, like dorsal and peritalar release, osteotomy of the hindfoot and forefoot as well as supramalleolar osteotomy, particularly in the treatment of neurogenic club feet, where the per cent of relapses is much higher.

Most club feet develop in otherwise normal children toward the middle of pregnancy. Exceptionally, the first signs of this deformity can be observed on ultrasonography already by the end of the 16th week of gravidity. Some transient muscular and collagen dysfunction localised in the posterior and medial aspects of the foot and leg appear to induce deformity in a

Table 4 Total number of relapsed feet indicated for re-tenotomy or transposition of the m. tibialis anterior

Years	2005	2006	2007	2008	2009	2010	2011	2012
Feet	16	4	6	3	2	0	1	0

normally developed foot [10]. The presence of vimentin and myofibroblast-like cells in the thick, tight and shortened medial and posterior tarsal ligaments seems to play an important role in the pathogenesis and relapses of the club foot deformity [16]. Some shortening and fibrosis are also observed in the m. gastrocnemius and its tendon as well as in the posterior tibial muscle and its tendon. These ligaments and tendons firmly hold the foot in equinus and the navicular, cuboid and calcaneus in severe adduction and inversion. This causes the heel varus and foot supination. The resistance of these ligaments varies significantly. The ligaments in the forefoot are normal. Also adducted, the forefoot is not as supinated as the hindfoot. This causes the cavus [9].

Data on the sex differences in the incidence of club foot are not concise. Iltar et al. [13] have found that at the beginning of treatment male patients had more severe deformities than did female patients, as measured by Diméglio scores. However, final Diméglio scores for both sexes were comparable. In general, we can find in the literature the ratio between boys and girls of 2:1. In our group of patients the male to female ratio was 3:1. Morcuende et al. [17] indicated even the ratio of 4:1. We agree with the opinion of Radler et al. [18] that radiographic measurements of infant feet are not fully reliable. They stated that there is bias when drawing lines representing the axes of the ossific nuclei, which often appear circular at very young ages.

There are a lot of studies reporting that recurrence after correction is related to patients' compliance with bracing [19, 20]. When the parents of patients do not comply with the bracing protocol, many major and minor recurrences should be expected. Morcuende et al. [17] found that relapses occur in only 6 % of compliant families and in more than 80 % in non-compliant families. We encountered relapses in patients in which the family had curtailed brace application. Dobbs et al. [3] reported that the educational level of the parents was another significant risk factor for recurrence, and our results are consistent with this observation.

According to Gibbons and Gray [21] most recurrences occur during the period of the foot abduction brace. This is in contradiction to our observation that relapses occur mostly after removal of the foot abduction bar in children above three years age.

In conclusion, the goal of any club foot surgery is to obtain a cosmetically acceptable, pliable, functional, painless, plantigrade foot. Even the Ponseti method is unable to correct the whole deformity, but it causes a significant improvement. It is clear that this improvement supplies a much better basis for the surgery even when it is not sufficient to achieve a fully corrected foot. We agree with the statement of Yagmurlu et al. [20] that whatever the presenting age of the patient with club foot, the Ponseti method should be applied, at least to achieve some improvement of the deformity. However, it follows from our results that it is impossible to cure all club feet with

casting, tenotomy of the Achilles tendon and transposition of the m. tibialis anterior only.

Conflict of interest The authors declare that they have no conflict of interest.

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