# The Treatment of Clubfoot with the Ponseti Method: A Systematic Review

# Ponseti Metodu ile Clubfoot Tedavisi: Derleme

Clubfoot Tedavisi / The Treatment of Clubfoot

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**Özet**

Talipes equinovarus (Çarpık ayak) bin doğumda bir görülen ve kesin etyolojisi bilinmeyen doğumsal bir bozukluktur. Genetik nedenler, bağ dokusu hastalıkları ve hamilelik sırasında geçirilen problemler altta yatan sebep olarak düşünülmekle beraber muhtemelen bir çok etkenin bir arada bulunması bu anomaliye sebep olmaktadır. Güncel tedavi seçenekleri arasında, girişimsel olmayan maniplasyonlardan oluşan Ponseti methodu, ilk tarif edildiği günden bu yana hızla yaygınlaşmıştır. Günümüzde, tüm dünyada en çok uygulanan tedavi yöntemidir. Her ne kadar bu teknik hem klinisyenin hem de ailenin katkısını gerektiren ve sabır isteyen bir süreç gerektirse de düşük maliyeti ve yüksek başarı oranları nedeniyle tüm ortopedistlerin iyi bilmesi ve ilk sırada uygulaması gereken bir yöntemdir.

**Anahtar Kelimeler**

Çarpık Ayak; Konjenital Talipes Equinovarus; Ponseti Methodu

**Abstract**

Though talipes equinovarus, or “clubfoot,” is a fairly common birth defect occurring once out of every 1,000 live births, its precise etiology is still poorly understood. Genetics, connective tissue disorders, and problems during pregnancy have been proposed as causes but it is likely that several pathways contribute to this particular dysmelia. Among the current treatment options available, the Ponseti method, which is a noninvasive manipulative technique, rapidly spread since its first description. Today it is the most widely adopted treatment method in the world. Although the manipulative technique is a drawn-out process that requires patience and effort on the part of both the clinician and the family, the Ponseti method should be upheld as the conventional treatment option orthopedists practice due to relatively low costs and positive success rates.

**Keywords**

Clubfoot; Congenital Talipes Equinovarus; Ponseti Method

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## Introduction

Though not regarded as idiopathic, the specific etiology for clubfoot (talipes equinovarus) is still uncertain and remains a matter of disputation. Studies that have investigated this type of birth deformity so far have indicated several contributing factors such as hereditary and intrauterine mechanical complications, neuromuscular defects, arrest of fetal development, primary germ cell defects, muscular imbalance, local dysplasia, vascular defects, malnutrition, hormonal imbalances and infections [1-7]. The incidence of clubfoot has a genetic component and can be linked to the ethnic background of the parents. For people of Caucasian/European descent, clubfoot occurs 1.2 times per every 1,000 live births [8]. In the United States, the incidence of the disorder is 13.30 per every 10,000 live births, [9] whereas in Turkey, Biri et al. found a much higher rate of 634 per every 10,000 live births [10]. Lochmiller et al. conducted an epidemiological study and found that clubfoot occurs in a male/female ratio of 2.5 to 1, that generally 52.6% of the time there is bilateral involvement and 30.6% of the time there is first, second or third degree family history. Furthermore, they found that when the disease affected only one foot, the right foot was much more likely to have the disorder than the left [11]. A more recent study by Cardy et al. asserted that the male/female ratio is 2.3 to 1, that 58% of the time there is bilateral involvement and that 11% of the time first and second degree family history is associated [12]. Yet these findings indicate a similar set of trends in the demographics correlated with the disease.

Although the origination of the Ponseti method began more than 60 years ago, it has only become the world's principal treatment for clubfoot for no more than last two decades due to emerging information on its successes in long-term correction.

Among several scoring methods developed to assess the foot before, during, and after treatment, Dimeglio and Pirani are the most commonly used scoring systems. Dimeglio and his colleagues divided the clubfoot deformity into four measurable anatomical features, or subgroups, which were scored on a scale of 20 points. These subgroups were: equinus in the sagittal plane, varus deviation in the frontal plane, derotation around the talus of the calcaneo-forefoot block, and adduction of the forefoot on the hindfoot in the horizontal plane. Each subgroup is assessed in severity from one to four points. In the presence of a posterior or medial fold, extreme cavus and/or muscle weakness, another point is added to each category for a possible total of 5 [13]. The second scale, the Pirani scoring system, evaluates six parameters of the foot separately as normal (which is 0 points), moderate to severe (0.5 point) or severe (1 point). These anatomical parameters are the bending of lateral border of foot, degree of medial skin fold, covering of the head of talus, degree of posterior skin fold, equinus or extreme plantarflexion at the ankle joint and the presence of a free heel [14]. These scoring systems are useful in evaluating the degree of correction of the foot as well as the possibility for recurrence of the disease.

In the following review, we will examine the components of the Ponseti method and review published researchs on the deformity in the literature.

## Understanding the Deformity

The benefits of non-surgical manipulative techniques such as the Ponseti method make intuitive sense when we consider the underlying physiological conditions in newborns with talipes equinovarus. The clubfoot deformity is localized in the somewhat irregular, articulating tarsal bones and the muscles that pull the joints where they meet out of alignment (Figure 1,2). Furthermore, the majority of the tarsal bones consist of relatively soft cartilage tissue at birth. In the case of the clubfoot dysmelia, these tarsal bones adopt a particular pattern of misalignment. The talus is severely plantarflexed. The navicula is significantly displaced medially, towards the medial malleolus and often articulates with the medial talar head. The calcaneus is significantly adducted and inverted under the talus. While the talus does not have a singular axis with which to rotate in a patient with clubfoot nor in normal foot, all the tarsal bones are associated functionally with each other [15]. It is therefore necessary to understand the functional anatomy of the foot in order to correct the severe displacement of tarsal bones in clubfoot. The deformity is essentially a three-dimensional rotational and torsional deformity. Rotation refers to the changes in the joints and torsion refers to the changes in the bones themselves. Motion of a single tarsal bone leads to simultaneous movements of the adjacent bones. It follows then, that when one of the tarsal bones is hindered from moving, the other tarsals experience interference due to their inter-articulation. Huson gave this phenomenon the name "closed kinematic chain movement" [16]. Templeton demonstrated that the varus-valgus movement of the foot originates from the anterior subtalar joint and that the talonavicular, calcaneocuboid and posterior subtalar joints play minimal roles in these movements [17]. The Ponseti method has been so successful because it considers these kinematic, biomechanical and anatomical features of the foot (Figure 3).

## Initiation of the treatment

The Ponseti method is not free of contentions and controversies, especially regarding the proper time to begin treatments. Although Dr. Ponseti recommended starting the treatment within the first days of life due to the "malleable" properties of the fibro-elastic connective tissue present in the tendons, ligaments and joint capsules. Iltar and colleagues proposed to start one month after the birth or when the foot length grew to a minimum of 8 cm or more [18]. Alves and colleagues investigated what effect, if any, an earlier versus later initiation of the Ponseti method had on overall treatment. When they examined cases treated before and after six months of birth, they found no significant difference in the correction rates, number of casts, recurrence rates, need for tenotomy or any other additional surgical interventions [19]. However in another study, Yagmurlu et al. conveyed that starting the Ponseti treatments after 20 months resulted in a lesser degree of improvement in the varus, adductus and medial rotation of calcaneopedal block [20]. However, the Ponseti method has had positive corrective results in overlooked patients that were not treated until much later as well [21].

## The Role of Radiology

Formerly, radiological imaging tests were used in the standard treatment and follow-ups for clubfoot patients. Yet according to Kite, radiographic images only showed the morphology of the foot in the transitory position it was being held in for the tests. Therefore, Kite argued close inspection and physical examination gave a more realistic impression on the foot's condition [22]. Nevertheless, radiological imaging does not become wholly unnecessary in correcting clubfoot deformities. In the more resistant cases, radiological assessment can be done to

Figure 1. The feet of a newborn with congenital talipes equinovarus deformity

Figure 2. The feet of a newborn with congenital talipes equinovarus deformity

Figure 3. Casting by using the Ponseti Method

evaluate bone anomalies. Staheli argued that radiographic images of the foot could be used effectively in treatment after six months of age [23]. According to a study by Miyagi et al., the navicular tarsal ossified on average in about 3 years and 10 months for males and about 2 years 11 months for females in a normally developing foot. In a clubfooted patient, this same bone is ossified in about 5 years and 2 months for males and about 3 years 2 months for females [24].

Figure 4. Using of the Dennis Browne orthesis

Figure 5. The overview of the feet after the treatment by using the Ponseti Method

**Casting Materials and Co-Treatment**

In addition to the Ponseti method, other variations in treatment have been examined such as the specific casting materials and injections of botulinum toxin before casts are set. Pittner et al. reported that fiberglass casting materials were more comfortable for patients but the plaster of Paris casts provided significantly more correction [25]. Cummings found no significant difference in the rates of correction with or without the use of botulinum-A toxin before the casting [26].

**Re-casting**

The old casts should be removed at the clinic just before the new one applied. According to Lafargue and Morcuende's findings, removing the cast at the clinic reduces the total number of casts, the duration of the correction procedure and the number of recurrent cases [27]. Although the Ponseti method indicates once-weekly casting intervals, some authors including Ponseti himself, reported two or three casting per week displayed the same effectiveness [28]. These findings supported that two or three casting in a week could safely be used for patients who live nearby the clinic or for families traveling long distances that stay in or near the hospital during the treatment.

**Achillotenotomy**

Typically the last stage of the Ponseti method before use of orthoses is an achillotenotomy, though not all patients require this surgical procedure. Before an achillotenotomy is performed, all other deformities besides equinus must be corrected. The percutaneous achillotenotomy is a rather small intervention compared to other major surgical techniques used in the treatment of the clubfoot deformity. Several achillotenotomy techniques have been refined and researched so far. Dogan et al. compared the percutaneous achillotenotomy with incision lengthening Z-plasty in rats and found no clear biomechanical difference [29]. Many surgeons prefer to perform a tenotomy under local anesthesia. This is generally because they want to avoid any possible adverse effects associated with general anesthesia. However, in a retrospective study by Prada et al., no apnea or general anesthesia-related complications were reported in a series of 182 patients' tenotomies [30]. Perhaps the most serious potential complication of percutaneous achillotenotomy is neurovascular injury. Dobbs et al. published a study of 200 patients that underwent the tenotomy, in which 2% experienced serious bleeding complications that were eventually controlled solely with compression [31]. Any delays in the tenotomy may adversely cause the development of a more advanced rocker bottom deformity. The possibility of rocker bottom deformity occurring in patients treated with non-invasive, manipulative techniques was reported as 3.2% in a study conducted by Koureas et al [32].

**Orthosis**

The use of orthoses equipment after the corrections plays an integral role in the Ponseti method (Figure 4). The success of the method decreases significantly without proper and extensive use of orthoses [33]. It has been demonstrated that using the correct othosis is just as important as using one at all. A study that compared the Dennis Browne orthoses with the ankle foot orthoses revealed that Dennis Browne orthoses led to significantly far fewer recurrences of the disease [34]. There is currently no scientific consensus regarding the timing of when to stop using orthoses. Generally they are used for 3 years on patients with mild deformity and can be used for up to 4 years on patients with severe deformity.

The time commitment correlated with proper use of orthoses therefore underscores the critical importance of cooperation from the family in the course of treatment. As stated earlier, it has found that greater compliance follows extensive and healthy communication between the family and the physician. Hence the family must be provided with detailed information about the use of an orthosis, why it is beneficial, as well as the consequences of improper use [35].

**The Kite and the French Physical Therapy Methods**

Two other techniques have been applied in the non-surgical treatment of clubfoot deformities. These are the Kite and the French physical therapy methods. Sanghvi and Mittal compared the Kite and Ponseti methods and found similar successful correction rates, yet the Ponseti method required fewer casts, provided better ankle dorsiflexion, less residual deformity, shorter overall correction time and lower recurrence rates [36]. In a meta-analysis by Matos and de Oliveira, statistically combined evidence pointed to the Ponseti method as being a superior treatment technique to the Kite method [37]. Faulks and Richards conducted a study comparing the success rates of the Ponseti method with the French functional method and found no significant difference between the two [38]. In a study that compared the Ponseti and French functional methods based on effectiveness by Dimeglio score, the authors found no significant difference in the success rate for Dimeglio grade 2 clubfeet, but claimed that the Ponseti method was far more effective in Dimeglio grade 3 and 4 clubfeet [39]. Research by Rodriguez, Martinez-Cañavete and Casares, investigated the efficacy of a modified form of the Copenhagen physical therapy method and found 64% of patients required posterior release surgeries [40]. The literature so far has clearly pointed to the Ponseti method as being the gold standard in clubfoot treatment. We therefore feel that the efficacy of new methodologies should be compared with the Ponseti method in order to evaluate their benefit. Since these cross-studies have been conducted, the Kite method has dropped off in common use while the French functional method has been employed more frequently.

**Gross Motor Development and the Gait Analysis**

Despite correction via the methods described, gait analysis after treatment of clubfoot deformities typically reveals that even plantigrade, functionally perfect feet are different when compared with the feet of normal peers [41]. Often times, the specific treatment method has an effect on the results obtained from a gait analysis [42]. Garcia et al. led a study that indicated that babies with clubfoot deformities have delayed attainment of gross motor development in the feet and begin to walk at later ages when compared to normal babies [43]. In order to offer the family full disclosure, they should be told that the development of their baby's feet might differ from that of normal feet even if the patient has a full recovery (Figure 5).

**Surgical Treatment**

Before the Ponseti method became such an effective and widespread tool, clubfoot deformities were corrected entirely with invasive surgical procedures. Schlegel and his colleagues performed these invasive, corrective surgeries on 131 feet from 98 patients and despite their proficiency, divulged that 53 feet from 47 patients still needed revision surgeries [44]. Deniz et al. reported only 5 fair corrective results from a study involving 47 feet from 30 patients who underwent extensive surgical dissection. This rather low success rate was significantly contrasted with the advantage, they indicated, of correcting all the deformities in one session [45]. Halanski et al. compared the Ponseti method with surgical treatments and found that feet treated with the Ponseti method ultimately required less operative intervention and less revision surgery [46].

**Recurrences**

It is essential that one have a strong understanding of the anatomy and the biomechanics of foot in order to apply the Ponseti method correctly. The foot consists of tightly connected bones supported by soft tissue structures. Therefore older methodologies or the misapplication of the Ponseti method may cause recurrence of the deformity. Perhaps one of the most important benefits of the Ponseti method is the near elimination of recurrences of clubfoot deformities. Nagaraju et al. published that they treated 18 feet from 13 patients via the Ponseti method and they achieved well-formed plantigrade feet where previously they had used the Kite method and experienced recurrences of the disease [47]. Nogueira reported that in patients who had been unsuccessfully treated surgically, they corrected 71 out of 83 feet (86%) with the Ponseti method and that the

patients developed plantigrade, fully corrected feet [48]. The recurrences of the deformity are characterized as metatarsus adductus, abduction of foot, loss of dorsiflexion and dynamic supination, which appears during gait analysis when the patient is walking. Dynamic supination is due to weakness in the peroneal muscles and over contraction compensation by the tibialis anterior muscle. If recurrence of the deformity is detected, the patient's foot should be placed in a cast as soon as possible because it essentially has not yet been treated. In most cases, the Achilles tenotomy procedure can be repeated as necessary until the patient has regained the motility for dorsiflexion. In order to successfully complete treatment, an orthosis must be used to maintain the foot in corrected alignment. Although a number of studies have supported that surgical treatments have good results after recurrences, [49,50] the Ponseti method should be tried first, before the surgery to avoid fibrosis, scar tissue and possible anesthetic complications. The success rate of the Ponseti method has been corroborated after recurrences of the deformities. This is the case even if the primary treatment technique was the Ponseti method itself.

### *Competing interests*

The authors declare that they have no competing interests.

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