



Clubfoot treatment in China before and after the advent of the Ponseti technique: a historical narrative review

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Abstract: Congenital clubfoot (CF) was first described by Hippocrates in approximately 400 B.C. In ancient China, manipulations were widely used to correct CF, but the outcomes were frequently unsatisfactory with residual deformity even if corrective devices were used. The advent of aseptic surgery and anesthesia has favored the development of different surgical procedures to manage children with CF. Surgical treatment became extremely popular in China during the years 1960–1990 due to the good clinical foot appearance post-surgery. However, the poor mid- to long-term results of surgical treatment facilitated the return of conservative treatment, i.e., the Ponseti technique. Over the past decade, the Ponseti technique has become very popular in China. The Ponseti technique is essentially conservative and it is based on a good understanding of CF pathophysiology. Casts are changed once a week and Achilles tenotomy is performed if equinus persists at the end of treatment. Although highly successful on the short to mid-term, the Ponseti technique is not able to completely eradicate surgery, and recurrence is still possible. As the etiology of CF is still unclear, the first mission for doctors and researchers all over the world is to truly understand the pathogenesis of the deformity. Even though genetics seems to play an important role, successful gene therapy is still a distant goal. This narrative review aims to investigate the history of CF treatment in China, to describe its tortuous process and to potentially inspire new ideas to create new effective methods of treatment.

Keywords: Clubfoot; China; surgery; treatment; Ponseti

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Introduction

Clubfoot deformity (talipes equinovarus, supinatus and adductus) was first described by Hippocrates more than 2000 years ago (about 400 years before Jesus Christ) (1). In China, traditional Chinese medicine (TCM) considers the clubfoot deformity a teratological defect (teratology: the branch of anatomy studying abnormalities of physiological development). In ancient times, TCM professionals mainly used Chinese herbal medicine to treat diseases, so they could not develop any specific technique to manage children with congenital clubfoot (CF). In China, manipulations were usually performed to correct the deformity as the Western practitioners did in ancient times (2). In particular, given that CF was not considered to be a severe illness, as it did not endanger the lives of the patients, nor affect life expectancy (like other congenital malformations such as polydactyly, for example), the Chinese government and TCM professionals did not pay much attention to patients with CF. For this reason, historical data on patients with CF are extremely scarce.

The development of western medicine has contributed to popularize the surgical treatment of CF in China, and several scientific articles about different surgical procedures have been published. However, the principles of CF treatment among Chinese practitioners started gradually to change and switch toward conservative treatment due to the poor functional outcome of operated feet (up to 30% of poor mid- to long-term results). The Ponseti method has become the most popular treatment method of CF worldwide because is inexpensive, reproducible and with good long term outcomes. Cast are changed once a week and Achilles's tenotomy is performed once a week if dorsiflexion is lacking at the end of treatment. Although, more than 90% of clubfoot can be initially corrected, the relapse rate is as high as 50%, according to the literature. In case of recurrence, transfer of the anterior tibialis tendon (TATT) is usually performed. Ponseti method does not completely eliminate the need for surgery.

Chinese medicine represents a large portion of global medicine, and, over the centuries, has developed different treatment concepts compared to western world. Reviewing the history and learning from difference among different treatment philosophies can improve the understanding of the CF pathology.

This narrative review aims to investigate the history of CF treatment in China, to describe its tortuous process and to inspire new ideas to create new effective methods of

treatment. We present the following article in accordance with the Narrative Review reporting checklist (available at <http://dx.doi.org/10.21037/atm-20-8042>).

Search strategy

We extensively search on commonly used biomedical databases, including PubMed, Embase, MedLine (OVID), Web of Science, Cochrane Library, and Sinomed from the inception of relevant database to December 2020. Moreover, additional databases such as The Taiwan Academic Literature Database (<http://www.airitilibrary.cn/>) and The Hong Kong University Theses Collection (HKUTO; <http://hub.hku.hk/>) were screened. We combined subject words and keywords using Boolean operators to search with no limitations on year of publication and language. All articles were reviewed by the two authors of this narrative review (JL and YL). All articles were level IV case series and expert opinion and, hence no systematic assessment of study quality was performed.

The tortuous history of clubfoot treatment in China

In ancient times of China, people used to choose manipulations method to correct the clubfoot deformity as the Western practitioners did. The outcome of treatment in that time was usually not good.

Missionaries introduced Western medicine to China around the 16th century. Before that time, children with CF were treated by TCM professionals, with not ideal results. However, at that time, ophthalmology was the only medical specialty involved in the care of Chinese patients; foot and lower extremity deformities were rarely treated by western method. During the 18th century, some Chinese practitioners had the opportunity to receive their education in Western universities and hospitals, and they acquired very good knowledge of Western medicine. However, when they returned to China, they could treat almost exclusively ophthalmological disorders because there was a great deal of reservation toward Western medicine. It was only during the 19th century that the Chinese government realized that Western technology and knowledge could contribute to the advancement of Chinese society and medicine. As a result, the Chinese government decided to send students abroad to learn about Western technologies, including medicine. It was only after World War II that Western medicine was officially recognized in China, and disorders such as CF

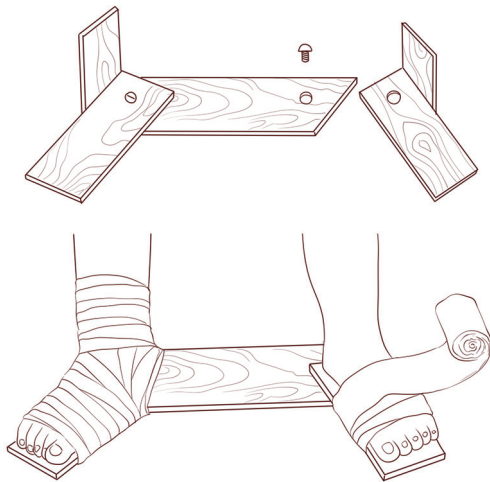


Figure 1 Self-designed brace (Shi JH: Massage therapy for congenital hand and foot deformity in children. *Central Plains Medical Journal*. 1985:30-31).

could be treated accordingly.

Moreover, the advent of anesthesia (at the end of the 19th–beginning of the 20th century) and the introduction of aseptic surgery allowed Western surgeons to develop different surgical techniques that were then introduced gradually to China.

Lambrinudi arthrodesis for severe equinovarus deformities in adults and in children was probably one of the first surgical procedures that was introduced to Chinese practitioners between the 1960s and 1980s. During this period, all children with CF aged less than two years of age were treated by progressive manual reduction and plaster immobilization; however, for some mild cases, soft bands could be used instead of plaster. On the other hand, patients between 2 and 10 years of age, were managed by soft tissue procedures while bony surgery (osteotomies) was reserved for patients older than 10 years of age (3). It is important to note that at that time, most Chinese practitioners preferred surgery to treat patients with CF including infants (4,5); muscle balance surgery was also used to treat children with CF during this same time period (6-8). Because of the good clinical foot appearance post-surgery, surgical treatment of CF became extremely popular in China.

Kite's method was used to treat CF as early as 1965, and it was introduced in China at that time. Zhou *et al.* used the Kite's method to treat children with CF; in particular, they manipulated the foot 5 to 10 minutes prior to casting. The long leg cast was changed every 3 to 4 weeks over a period of 3–9 months, depending on the severity of the deformity.

In particular, at 11 years follow-up, the outcome was good in 28 out of 35 feet (80%) (9).

During the 1960s, manipulations were mostly performed in the TCM hospitals, where the practitioners used soft bands, similar to those used in the French Functional Physical Therapy method, to immobilize the foot in the position obtained with gradual and progressive manipulations (10) (*Figure 1*); results were acceptable in most patients that were able to ambulate without major pain or discomfort.

During the 1980s, early diagnosis and treatment became the gold standard of CF treatment. Conservative treatment aimed for early correction of all components of the deformity even though some feet would still require surgical intervention later to achieve a painless, plantigrade foot. Surgical interventions ranged from a percutaneous heel cord lengthening to a wide release of posterior, medial and lateral structures, with or without TATT. At that time, conservative treatment was recommended to treat infants from birth to 6 months of age; in particular, infants aged less than 3 months were usually managed by manipulations alone, while those over 3 months of age were treated by manipulations and cast immobilization, even though some practitioners preferred to use elastic bandages. To maintain the reduction, some practitioners used a splint or self-designed sheaths instead of a plaster cast (11,12) (*Figure 2*). Patients aged between 6 months and 2 years were treated by conservative means; however, if the deformity could not be corrected, the TATT and/or the Achilles' tendon lengthening was recommended. At that time, extensive soft tissue procedures (posterior and medial release) and arthrodesis were reserved for patients older than 2 years of age (13). On the other hand, patients older than 10 years of age with severe CF deformity were managed by the Lambrinudi arthrodesis; in order to decrease tension on the skin following deformity correction, the use of a dorsal fascial flap was added to the procedure (14); in particular, Zhang *et al.* reported good outcome in 20 severe CF treated with the procedure, and did not report any case of skin flap necrosis nor wound infection. Despite the encouraging results, no further studies were published on the subject at a later time. At that period, surgical treatment (early or late) was still the preferred option to treat CF (15-21).

Nevertheless, during the 1990s, the high rates of complications associated with extensive surgery and the poor outcomes of conservative treatment prompted doctors to turn to other treatment options (22,23). In particular, split TATT was used to avoid the excessive hind foot

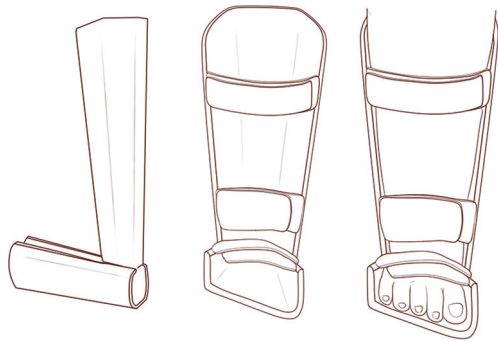


Figure 2 Metal brace (Ling JB: Zheng’s manipulation massage combined with aluminum alloy stent to treat congenital clubfoot in children. *Journal of Chengdu Sport University*. 1994:34-36).

valgus secondary to surgical release (24). Alternatively, the Bridle procedure (posterior tibial tendon, long peroneal tendon and anterior tibial tendon are sutured together) was performed to avoid excessive hind foot valgus (25). All the patients had very good results after the operation according to the report, but the total number of cases was low (13 patients and 21 feet), and the follow up was short (6–18 months). Similarly, the transposition of the flexor longus muscle to the peroneal longus muscle in order to reinforce the strength of the peroneal muscle was also used in patients with CF (26). In particular, Gao *et al.* reported good outcome in 32 patients (34 feet) treated with such procedure. However, the classic surgical procedures, such as the posterior and medial release, and the TATT, were also used by Chinese surgeons (23,27-31).

Extensive posterior and medial release surgery was largely performed throughout China during that time (32,33). In particular, McKay’s procedure was widely used in several Chinese institutions (33-38), where orthopedic and pediatric surgeons used this method to treat infants of approximately 3 months of age (39-41). According to these reports, good correction could be achieved in about 95% of cases; none of the patients developed serious adverse event though the mean follow-up was short (1 year). On the other hand, Ilizarov’s external fixation technique was used to treat some older patients (42-44). However, due to the long period of hospitalization and the high costs, the technique was not widely used. At the same time, Kite’s method and other conservative treatment were still the preferred treatment option by some other doctors (28,45-47). Before the year 2000, the Ponseti method began to be used in a few Chinese institutions although none reported their results (48). In 1994, George Simon’s book, *“The clubfoot.*

The present and a view of the future” (49), granted a limited place to the orthopedic treatment of CF, and Ponseti’s technique is not mentioned at all. That work surfaced in the mid-1990s following the publication of Cooper and Dietz’s article, “Treatment of idiopathic clubfoot. A thirty-year follow-up note” in 1995 (50), and Ponseti’s book, *“Congenital Clubfoot, Fundamentals of treatment”* in 1996 (51). At the same time, many authors reported poor results with extensive surgery according to McKay and Simons (52-57). In this context, reported rates of up to 30% of poor mid- to long-term results facilitated the coming back of conservative management of CF.

Therefore, during the 2000s, the principles of CF treatment among Chinese practitioners started gradually to change and switch toward conservative treatment. Although surgical treatment was still used, increasingly more practitioners started to apply conservative protocols as initial CF treatment. Subsequently, conservative treatment has become the first-line treatment for CF deformity correction, and two main methods of treatment have been developed: the Ponseti technique (Iowa City, USA) and the French functional physiotherapy method (Paris and Montpellier, France). Serial casting and manipulations and gentle manipulations by a skilled physiotherapist are at the core of the Ponseti technique (48,58-63) and the French functional physiotherapy method (64), respectively.

Although these two techniques revolve around different clinical approaches, both protocols have shown good efficacy, reliability, and lasting outcomes and are reported to perform comparably with initial correction rates of up to 90%. Both protocols aim to achieve a pain-free supple plantigrade foot with as little surgery as practicably possible, as long-term studies on outcomes of surgical releases have reported high rates of painful and stiff feet with poor functional outcomes. However, these protocols are not able to eliminate the need for surgery completely (65). Surgical treatment is only needed when the orthopedic treatment is no longer effective and/or when the foot shows no additional improvement. Minimally invasive surgical procedures such as Carroll’s technique were introduced in China (66,67). In particular, the selective release of the tendon of the abductor hallucis tendon and of the plantar fascia reduced the total time of cast treatment. However, many practitioners felt it was not worth doing the surgery because such technique could only decrease the cast by 1–2 weeks.

During this period, the majority of Chinese practitioners switched to conservative treatment, while very few are still

using surgery even though surgery is mostly reserved for recurrent and resistant cases.

Since the year 2010, treatment of CF in China has matched international guidelines, and conservative treatment has also become the gold standard in older children (68); very few hospital are still performing surgical treatment as the initial CF treatment. Over the years, the Ponseti technique has become very popular in China. The Ponseti technique is essentially conservative, and it is based on serial castings that are changed on a weekly basis.

Correction starts in the horizontal plane. The first couple casts of are applied with the forefoot supinated, to bring it into alignment with the hind foot. Ponseti pointed out not to correct the supination by lowering the first metatarsal bone, which results in a worsening of the cavus. Subsequent casts are made with the forefoot progressively abducted with simultaneous counter pressure over the head of talus. Prior to the last cast, the degree of dorsiflexion is assessed, and if dorsiflexion is limited, a percutaneous Achilles tenotomy is required. Following full correction, the feet are placed in a Denis-Browne bar or in a Foot Abduction Orthosis (FAO), which is used for 23 hours a day in the initial 4 to 6 months and then subsequently at nighttime for three to five years.

Indisputably, the Ponseti method is effective although it does not completely eliminate the need for surgery. It is obvious that the more severe the CF deformity is, the higher the risk of surgery is. Following the return of conservative treatment, a new surgery—limited, thrifty, and kind—has born: the surgery “à la carte”, which joins the French philosophy. CF has multiple clinical facets and regardless of the method of treatment, the goals are the same, to achieve a plantigrade, painless and supple foot, to diminish the frequency and extent of surgery as much as possible and to decrease the risk of relapse.

TCM and clubfoot

TCM has played an important role in Chinese medical history as it has been successfully involved in the treatment of several disorders. Although TCM usually pays attention to the whole body rather than to a single organ (i.e., the foot), massage therapy has been used to treat CF deformity (28,69-72). However, because of the limited understanding of the underlying pathogenic mechanisms of CF deformity, the outcome of TCM massage therapy is not fully positive, especially in patients with severe and stiff deformity. Following the introduction of the Ponseti technique, massage therapy per TCM guidelines has been used to keep

the foot supple and the ankle mobile during brace treatment (72,73). Acupuncture and moxibustion anesthesia have also been used to assist surgery (74). TCM is different from Western medicine as it aims to support the human body to self-repair itself. Currently, several Chinese practitioners are treating patients with CF by integrating TCM principles with Western medicine concepts (75-77). Unfortunately, the studies reporting on these treatment protocols do not have the methodological standards required by modern science, and the results are not known outside China. Future studies that are methodologically sound are needed to prove the efficacy of combining TCM with Western treatment protocols.

Discussion

The Ponseti method has revolutionized the approach to treating CF. The Ponseti method is based on conservative means, i.e., serial casting and manipulations, however, the use of manipulations to correct the deformity had been introduced by Hippocrates more than 2000 years ago (2). One of the reasons why the Ponseti technique has gained popularity all over the world and has achieved excellent correction rates is that Dr. Ponseti understood the pathoanatomy of the disease (thanks to his anatomical dissections of fetuses) and, subsequently, on the basis of his observations set up his treatment protocol (78).

The etiology of CF is still unknown although several theories have been formulated to explain it. In particular, CF can be caused by vascular deficiencies, position in utero, abnormal congenital muscle insertions as well as genetic factors. The future treatment of CF will involve understanding of the pathogenetic mechanisms of the CF deformity.

Although the Ponseti technique is performed all around the world, it has not been adopted everywhere; in particular, some institutions do manage patients with CF with manipulations and physiotherapy (French method). The same trend is observed in China, where other techniques for CF correction are used, for example, the so-called polyaxial fixation metal braces have been successfully used to treat CF in China (79) (Figure 3A,B). Presently, the general principle of early diagnosis and treatment is widely accepted, however, some treatment modalities may vary. Similarly, although the principles of the Ponseti technique are accepted, the type of cast material used may vary. In particular, some surgeons use the traditional plaster as suggested by Dr. Ponseti while others use semirigid or rigid

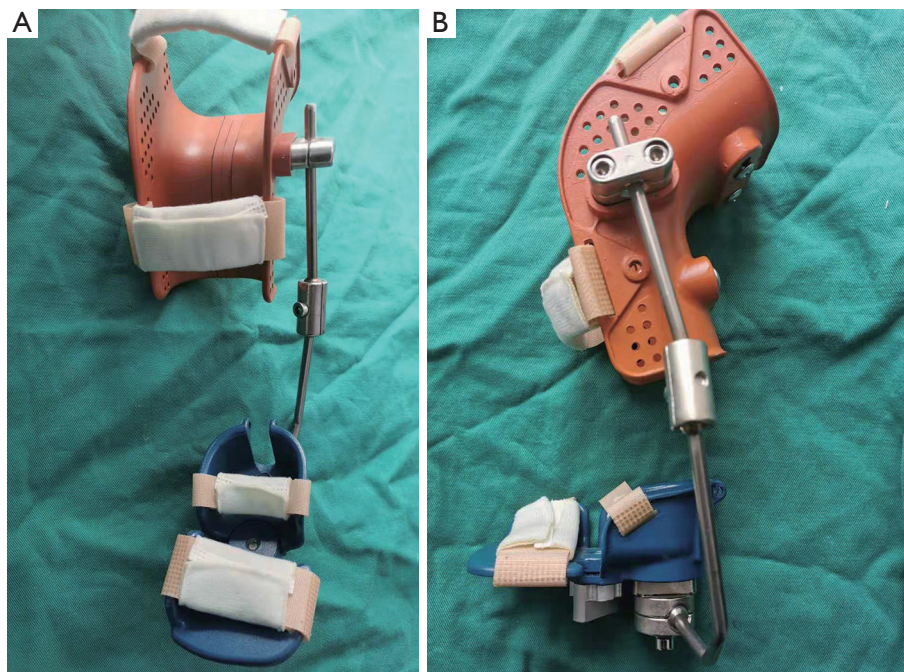


Figure 3 Polyaxial fixation brace for treating congenital clubfoot. (A) Frontal view; (B) lateral view (Su Y, Xie Y, Kang X, Nan G: A polyaxial fixation brace for the treatment of idiopathic congenital talipes equinovarus in newborns. *J Orthop Surg Res.* 2019, 14:211).

fiberglass casts. Hui *et al.* found that there was no significant difference in the number of casts required for correction of clubfoot between the traditional plaster and semirigid fiberglass cast (80).

According to Ponseti, about half of the relapses have a tendency to occur between 10 months and five years of age, regardless of the degree of correction obtained with conservative treatment. The primary reason for relapses is the inability of families to maintain the correction initially achieved with conservative treatment. Therefore, substantial follow-up is necessary to evaluate the effect of treatment as deteriorations can be observed around and after two years of age (81,82). For this reason, many Chinese institutions have developed specific sessions to explain to parents and caregivers the necessity of wearing braces (to improve the parents' compliance) in order to avoid recurrence of the deformity (83,84); these sessions are also available online (85). The type of brace varies among different Chinese institutions; some centers prescribe Denis-Browne shoes and others the Ponseti-Mitchell or Dobbs shoes. Selecting the type of brace is mainly dependent on the doctor's suggestion. For example, Ponseti-Mitchell shoes are generally selected because silicone is better tolerated than leather while Dobbs shoes allow the children

to move more. However, it is important to note that in some situations, parents want to select the shoes for their children by themselves.

Currently, the treatment of CF in China is carried out as in Western countries, and the trend is to favor conservative treatment. The best method to treat CF must be simple, effective and inexpensive. The Ponseti method meets these criteria, and therefore, it has been accepted worldwide. However, the Ponseti technique cannot treat all CF deformities as the recurrence rate is not negligible. For this reason, a new treatment method based on the understanding of the pathogenetic factors of the disease is needed to improve the care of children with CF. For this reason, basic research studies on the etiology of CF are rapidly expanding in China (86-92) and around the world (93-95). Although there is still a long way to go, only continuous exchanges between caregivers and researchers as well as international and interregional cooperation will guide the medical community towards the best possible care for children with CF.

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