



Original article

Functional and clinical results achieved in congenital clubfoot patients treated by Ponseti's technique[☆]



Pedro Augusto Jaqueto*, Guilherme Salgado Martins, Fernando Saddi Mennucci, Cintia Kelly Bittar, José Luís Amim Zabeu

Pontifícia Universidade Católica de Campinas (PUC-Campinas), Hospital e Maternidade Celso Pierro, Campinas, SP, Brazil

ARTICLE INFO

Article history:

Received 16 September 2015

Accepted 6 November 2015

Available online 22 September 2016

Keywords:

Foot deformities

Congenital abnormalities

Clubfoot

Treatment outcome

ABSTRACT

Objectives: To analyze and evaluate functional and clinical results in patients with congenital clubfoot treated with Ponseti's technique.

Methods: This study evaluated 31 patients diagnosed with 51 congenital clubfeet, treated between April 2006 and September 2011 with Ponseti's technique. The patients who did not achieve an equinus correction with manipulation were treated with Achilles tenotomy. An anterior tibial tendon transfer was performed in patients who maintained residual adduction. All plasters were made by fellows and supervised by Ankle and Foot Chiefs. The technique was performed without the need for physical therapists, orthotics, and plaster technicians. Patients were submitted to pre- and post-treatment examination and evaluated under Pirani's classification.

Results: Male patients had an increased incidence and the right side was more affected, while bilateral involvement was observed in 64.5% of the cases. The mean number of cast changes was 5.8, and Achilles tenotomy was necessary in 26 patients. There were significant deformity improvements in 46 of the 51 treated feet (90.2%); Pirani's mean score improved from 5.5 to 3.6 after treatment.

Conclusion: The Ponseti method was effective in both functional and clinical evaluation of patients, with significant statistical relevance ($p=0.0001$), with a success rate of 90.2% and mean improvement in the Pirani's index of 65.5%.

© 2016 Sociedade Brasileira de Ortopedia e Traumatologia. Published by Elsevier Editora Ltda. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

[☆] Study conducted at the Hospital e Maternidade Celso Pierro, Pontifícia Universidade Católica de Campinas (PUC-Campinas), Campinas, SP, Brazil.

* Corresponding author.

E-mail: pajaqueto@hotmail.com (P.A. Jaqueto).

<http://dx.doi.org/10.1016/j.rboe.2016.09.004>

2255-4971/© 2016 Sociedade Brasileira de Ortopedia e Traumatologia. Published by Elsevier Editora Ltda. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

Resultados funcionais e clínicos alcançados em pacientes com pé torto congênito tratados pela técnica de Ponseti

R E S U M O

Palavras-chave:

Deformidades do pé
Anormalidades congênicas
Pé torto
Resultado do tratamento

Objetivos: Analisar e avaliar os resultados funcionais e clínicos em pacientes com pé torto congênito tratados pela técnica de Ponseti.

Métodos: O estudo incluiu 31 pacientes diagnosticados com 51 pés tortos congênicos, tratados entre abril de 2006 a setembro de 2011 pela técnica de Ponseti. Os pacientes que não alcançaram a correção do estado equino com manipulação foram tratados com tenotomia do Aquiles. Uma transposição do tendão tibial anterior foi feita nos pacientes que mantiveram uma adução residual. Todos os gessos foram feitos por residentes e supervisionados pelos chefes de Tornozelo e Pé. A técnica foi aplicada sem a necessidade de fisioterapeutas ou técnicos de gesso. Os pacientes foram submetidos a exame antes e depois do tratamento e avaliados de acordo com a escala de Pirani.

Resultados: Os pacientes do sexo masculino apresentaram um aumento de incidência e o lado direito foi o mais afetado, enquanto que o acometimento bilateral foi observado em 64,5% dos casos. A média de mudanças de gesso foi de 5,8 e a tenotomia do tendão de Aquiles foi necessária em 26 pacientes. Houve melhorias significativas das deformidades em 46 dos 51 dos pés tratados (90,2%), a escala de Pirani pontuou um avanço na média de 5,5 para 3,6 após o tratamento.

Conclusão: O método de Ponseti foi eficaz nas avaliações funcionais e clínicas dos pacientes, com uma relevância estatística significativa ($p = 0,0001$), com uma taxa de sucesso de 90,2% e um avanço na escala de Pirani de 65,5%.

© 2016 Sociedade Brasileira de Ortopedia e Traumatologia. Publicado por Elsevier Editora Ltda. Este é um artigo Open Access sob uma licença CC BY-NC-ND (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

Introduction

Congenital clubfoot (CCF) is a deformity characterized by a complex misalignment of the feet, involving both soft and bony parts, with varus and equinus deformity of the hindfoot (talipes equinovarus), as well as cavus and adduction of the midfoot and forefoot.¹⁻⁵ Its incidence is approximately one in every 1000 live births, with a predominance of males at the ratio of 2:1, and with bilateral involvement in 50% of cases.^{6,7}

CCF has a wide variety of clinical expressions; some classifications consider only the clinical aspects, while others also take radiographic features into account. To date, no classification has prevailed. Nonetheless, the literature indicates that the most used classification is the Pirani⁸ scale, which is simpler and more recent.

The first reference to CCF treatment was described by Hippocrates (400 BC), who mentioned repeated and gentle manipulations, followed by immobilizations. Guerin is known as the first physician to use plaster in 1836. Around the 20th century, new technologies were developed to support these corrections, such as the Thomas device. In 1932, Kite⁹ advocated smooth and repeated manipulations followed by plaster immobilization, in an attempt to prevent forced and prolonged corrections. This combination became known as the Kite method for CCF treatment.¹⁰

Around 1940, Ponseti, after several in-depth studies of the pathological and functional anatomy of the CCF, developed and perfected his treatment technique. Ponseti described details about maneuvers and plaster immobilization, as well as follow-up after Achilles tendon resection, guided by the

patient's age. He also identified and published the most common errors in treatment management at the time.¹¹ The most important advantage of the Ponseti method is the degree of mobility achieved at the end of treatment when compared with other techniques.¹⁰

His method is based on gentle manipulations and serial plaster changes, percutaneous resection of the Achilles tendon, and the use of a foot abduction brace.^{1,4,12} It has become the preferred method for treating idiopathic CCF in many countries.^{5,13,14} In the past decade, with its wide acceptance, this method has been extended to be used in older children^{15,16}; complex and refractory feet¹⁷; recurrent feet,¹⁸ including recurrence after extensive surgical decompression¹⁹; relapsed feet, without taking into account non-idiopathic cases such as myelomeningocele,^{20,21} and distal arthrogryposis.^{22,23} The foundation of the manipulation technique consists of correcting deformities through plastic change of contracted and shortened elements, which have a high elastic capacity in children, especially in the first year of life. Ponseti advocated that clinical and physical examinations are paramount; he did not value imaging exams in his assessments. Other authors, such as Pirani et al.,²⁴ used magnetic resonance imaging (MRI) to confirm that the Ponseti method, in addition to correcting the relationship between the foot bones, also promoted mechanical stimuli that were important and played a role in bone remodeling.

CCF treatment with the Ponseti technique is widely used in many countries due to its good results, close to 90%.^{4,13,14,25,26} In turn, approximately 50% of patients treated with Kites' technique require surgical intervention and 40% present residual deformity.²⁷ Another interesting factor to support the

Ponseti technique is that the treatment lasts between two and four months, and manipulations with orthoses for four years,²⁸ while Kites' technique lasts for approximately 22 months. Herzenberg et al.²⁹ have reported that, with the Ponseti method, only 3% of cases needed posteromedial decompression surgery, vs. 94% of cases in other contemporary techniques.

This study was designed to evaluate the functional and clinical outcome of patients with CCF who were treated by the Ponseti technique.

Methods

A retrospective study in a university hospital diagnosed 31 patients with idiopathic CCF treated with the Ponseti technique in the Orthopedics Clinic between April 2006 and September 2011. Patients presenting rigid feet were excluded, and those with flexible feet were included.

Three newborns were diagnosed at another hospital before screening in this hospital; six newborns abandoned treatment.

Patients were identified and selected from the database of the orthopedics department; after selection, their medical information and records were collected. Data were thoroughly analyzed using the Pirani scale to detect progress in the use of the Ponseti technique.

Patients were clinically diagnosed and treated by the foot and ankle group, which also analyzed the results using the Pirani scale. The diagnosis is based on clinical deformities presented by patients at the time of evaluation. Characteristics of the deformities are cavus, adductus, varus, and equinus.

Several variables were included: gender, age, family history, affected foot, early diagnosis, treatment onset and duration, associated deformities, number of plaster changes, need for tenotomy and type of anesthesia, Pirani scores before and after treatment, as well as recurrence and follow-up time.

Clubfoot has different expressions. There are classifications that consider only clinical aspects and others that also take into account the radiographic characteristics. To date, no severity classification system has prevailed. However, the main classification is the Pirani scale, which is simpler and more recent, but is still in the validation phase. It is based on a simple classification system, consisting of three variables in the hindfoot and three in the midfoot. Each variable can be marked from zero to one.

In order to assess the results obtained with the Ponseti technique, the Pirani scale was applied before and after the proposed treatment.⁹ Statistical analysis was done by a qualified practitioner in the field. The Wilcoxon test for paired samples (p -value ≤ 0.0001) was used.

Results

Of the 31 patients evaluated, 20 (64.5%) were male and 11 (35.5%) were female. Twenty patients (64.5%) had bilateral involvement and 11 (35.5%), unilateral. The right side was affected in 25 patients (80.6%), and the left side, in six (19.4%). Thirty patients (96.8%) had not previously received treatment, while one had undergone previous treatment (3.2%). Twenty-eight patients (90.3%) had no associated deformity, and three

Table 1 – General characteristics of patients.

Qualitative variables	n	%
<i>Side</i>		
Right	25	80.6
Left	6	19.4
<i>Sex</i>		
Female	11	35.5
Male	20	64.5
<i>Previous treatment</i>		
No	30	96.8
Yes	1	3.2
<i>History of congenital clubfoot</i>		
No	28	90.3
Yes	3	9.7
<i>Diagnosis by ultrasound</i>		
No	28	90.3
Yes	3	9.7
<i>Anesthesia</i>		
General	1	3.4
Sedation (in the operating room)	25	86.2
No	3	10.3
<i>Recurrence</i>		
No	20	76.9
Yes	6	23.1
<i>Recurrence period</i>		
Six months after ankle-foot orthosis	1	16.7
11 months after orthosis	1	16.7
Two years after orthosis	1	16.7
Two months after orthosis	1	16.7
Six months after orthosis	1	16.7
Initial period of ankle-foot orthosis	1	16.7
<i>Return to plaster casts</i>		
Yes and abandonment of treatment	1	16.6
Yes	3	50.0
No	2	33.3
<i>Transposition of the anterior tibialis tendon</i>		
No	17	68.0
Yes	8	32.0
<i>Correct use of the orthosis</i>		
No	9	36.0
Yes	16	64.0
<i>Duration of orthosis use</i>		
Three years	8	32.0
Four years	14	68.0

(9.7%) had a positive family history of CCF. Previous diagnoses were made by ultrasound in three patients. Due to the socioeconomic status of patients, many did not receive adequate explanation for an early diagnosis. Many of them were from

Table 2 – Age of the patient and follow-up duration.

	n	Medium	Minimum	Maximum
Age at first consultation (in months)	31	17.9	2.9	144.0
Follow-up period (in months)	31	30.2	40.1	50.0

Table 3 – Results.

	n	Mean	Medium	Minimum	Maximum
Number of cast changes until tenotomy	31	5.8	6.0	3.0	9.0
Individual measurement by affected foot	n	Mean	Medium	Minimum	Maximum
Initial Pirani scale	51	5.5	5.5	3.5	6.0
Final Pirani scale	51	3.6	3.5	3.0	5.0

other states, which have low-quality ultrasound machines and inexperienced examiners. Tenotomy of the Achilles tendon was necessary in 26 patients (84%). The mean number of plaster changes to tenotomy was 5.8 (range between 4 and 9). Recurrence was observed in six (23.1%) of the 26 patients. During follow-up, six patients abandoned treatment (19.4%, Table 1). Mean age at initial evaluation was 17.9 months (range: 7 days to 12 years). The mean follow-up time was 30.2 months (range: 4–50), as shown in Table 2. Improvements of the deformities were observed in 46 of the 51 treated feet (90.2%). The initial Pirani score individualized by side ($n = 51$) was 5.5 (range: 4–6); after treatment, the mean was 3.6 (range: 3–5). These results had p -values <0.0001 (Table 3).

Discussion

Although the study, the research of medical records, clinical diagnosis, and treatment were conducted in an orderly manner, the number of patients at the presentation of the results was still low, representing only a small portion of all cases of clubfoot treated in this service.

Nonetheless, family understanding of the treatment and its difficulties, whether physical or psychological, were strongly emphasized through guidance to parents and illustrated booklets. It was observed that some families had difficulties in understanding the importance of treatment and its goals. In these cases, more careful monitoring was necessary, aiming to complete the treatment at the desired levels.

Idiopathic clubfoot was defined as those that did not have a defined etiology, and neurological clubfoot as those with a central, spinal, or peripheral disease. These patients were newborns and presented the hormone relaxin. There was improvement in the standing position, but with partial recurrence.

Gender and the predominance of the affected side were in agreement with the literature, in the ratio of 2:1 between men and women,^{6,7} and the right side was the most affected.^{6,7,30} However, the present study observed a higher bilateral incidence (64.5%) than that reported in the literature (50%).^{6,7}

Tenotomy of the Achilles tendon was necessary in 26 patients (84%), which is in agreement with the current literature (between 70% and 90%).^{1,4,13,15,30} In the present study, the mean number of plaster changes before tenotomy^{5,8} was six, which is also in agreement with the literature.^{1,4,12,13,15,25,26}

Recurrence was observed in six patients. Four cases were idiopathic recurrences, and two recurrences were associated with incorrect use of the orthosis.

In all four idiopathic recurrence cases, a transposition of the anterior tibial tendon to the third cuneiform and percutaneous transposition of the Achilles tendon was performed. Six

weeks after surgery, the ankle and foot orthosis was applied, being used for six months.

Eight relapsed feet without prior treatment were observed in patients older than 4 years. In such cases, transposition of the anterior tibial tendon was performed after the plaster changes, followed by six months of ankle and foot orthosis instead of the Denis Browne bar, as these patients were already walking. Recurrence of deformity occurred in one case, and an external circular fixator was used.

The success rate of the present study was 90.2%, very close to those cited in the literature and in Ponseti's original article.^{4,13,15,25,26} Functional and clinical advances were also observed in the present treated patients, with a 90.2% success rate (46 of the 51 feet treated) and a mean improvement in the Pirani scale of 65.5% (a decrease from 5.5 to 3.6).

Conclusion

The Ponseti method was effective in the treatment of CCF regarding functional and clinical outcomes. Furthermore, its effectiveness was proven and measured by the statistically significant Pirani scale improvements described in the present study.

Conflicts of interest

The authors declare no conflicts of interest.

REFERENCES

1. Ponseti IV. *Congenital clubfoot: fundamentals of treatment*. Oxford: Oxford University Press; 1996.
2. Song HR, Carroll NC, Neyt J, Carter JM, Han J, D'Amato CR. Clubfoot analysis with three-dimensional foot models. *J Pediatr Orthop B*. 1999;8(1):5–11.
3. Cahuzac JP, Baunin C, Luu S, Estivalezes E, Sales de Gauzy J, Hobatho MC. Assessment of hindfoot deformity by three-dimensional MRI in infant club foot. *J Bone Joint Surg Br*. 1999;81(1):97–101.
4. Ponseti IV. Treatment of congenital club foot. *J Bone Joint Surg Am*. 1992;74(3):448–54.
5. Dobbs MB, Gurnett CA. Update on clubfoot: etiology and treatment. *Clin Orthop Relat Res*. 2009;467(5):1146–53.
6. Lochmiller C, Johnston D, Scott A, Risman M, Hecht JT. Genetic epidemiology study of idiopathic talipes equinovarus. *Am J Med Genet*. 1998;79(2):90–6.
7. Stewart SF. Club-foot: its incidence, cause, and treatment. *An anatomical-physiological study*. *J Bone Joint Surg Am*. 1951;33(3):577–90.
8. Pirani S, Naddumba E. Ponseti clubfoot management: teaching manual for healthcare providers in Uganda.

- Kampala: Global-HELP Organization; 2008. Available in: https://global-help.org/publications/books/help_ponsetiuganda.pdf.
9. Kite JH. Principles involved in the treatment of congenital clubfoot. *J Bone Joint Surg Am.* 1939;21(3):595-606.
 10. Sizinio HK, Barros Filho TEP, Xavier R, Pardini Júnior A. *Ortopedia e traumatologia: princípios e prática.* Porto Alegre: Artmed; 2009.
 11. Kite JH. Principles involved in the treatment of congenital clubfoot. *Clin Orthop Relat Res.* 1972;(84):4-8.
 12. Ponseti IV. Common errors in the treatment of congenital clubfoot. *Int Orthop.* 1997;21(2):137-41.
 13. Ponseti IV, Smoley EN. Congenital club foot: the results of treatment. *J Bone Joint Surg Am.* 1963;45(2):261-344.
 14. Bor N, Coplan JA, Herzenberg JE. Ponseti treatment for idiopathic clubfoot: minimum 5-year followup. *Clin Orthop Relat Res.* 2009;467(5):1263-70.
 15. Dobbs MB, Gordon JE, Schoenecker PL. Absent posterior tibial artery associated with idiopathic clubfoot. A report of two cases. *J Bone Joint Surg Am.* 2004;86(3):599-602.
 16. Morcuende JA, Dolan LA, Dietz FR, Ponseti IV. Radical reduction in the rate of extensive corrective surgery for clubfoot using the Ponseti method. *Pediatrics.* 2004;113(2):376-80.
 17. Spiegel DA, Shrestha OP, Sitoula P, Rajbhandary T, Bijukachhe B, Banskota AK. Ponseti method for untreated idiopathic clubfeet in Nepalese patients from 1 to 6 years of age. *Clin Orthop Relat Res.* 2009;467(5):1164-70.
 18. Ponseti IV, Zhivkov M, Davis N, Sinclair M, Dobbs MB, Morcuende JA. Treatment of the complex idiopathic clubfoot. *Clin Orthop Relat Res.* 2006;451:171-6.
 19. Bor N, Herzenberg JE, Frick SL. Ponseti management of clubfoot in older infants. *Clin Orthop Relat Res.* 2006;444:224-8.
 20. Nogueira MP, Ey Batlle AM, Alves CG. Is it possible to treat recurrent clubfoot with the Ponseti technique after posteromedial release? A preliminary study. *Clin Orthop Relat Res.* 2009;467(5):1298-305.
 21. Chen RC, Gordon JE, Luhmann SJ, Schoenecker PL, Dobbs MB. A new dynamic foot abduction orthosis for clubfoot treatment. *J Pediatr Orthop.* 2007;27(5):522-8.
 22. Gerlach DJ, Gurnett CA, Limpaphayom N, Alaei F, Zhang Z, Porter K, et al. Early results of the Ponseti method for the treatment of clubfoot associated with myelomeningocele. *J Bone Joint Surg Am.* 2009;91(6):1350-9.
 23. van Bosse HJ, Marangoz S, Lehman WB, Sala DA. Correction of arthrogryptic clubfoot with a modified Ponseti technique. *Clin Orthop Relat Res.* 2009;467(5):1283-93.
 24. Pirani S, Zeznik L, Hodges D. Magnetic resonance imaging study of the congenital clubfoot treated with the Ponseti method. *J Pediatr Orthop.* 2001;21(6):719-26.
 25. Boehm S, Limpaphayom N, Alaei F, Sinclair MF, Dobbs MB. Early results of the Ponseti method for the treatment of clubfoot in distal arthrogryposis. *J Bone Joint Surg Am.* 2008;90(7):1501-7.
 26. Laaveg SJ, Ponseti IV. Long-term results of treatment of congenital club foot. *J Bone Joint Surg Am.* 1980;62(1):23-31.
 27. Cooper DM, Dietz FR. Treatment of idiopathic clubfoot. A thirty-year follow-up note. *J Bone Joint Surg Am.* 1995;77(10):1477-89.
 28. Segev E, Keret D, Lokiec F, Yavor A, Wientroub S, Ezra E, et al. Early experience with the Ponseti method for the treatment of congenital idiopathic clubfoot. *Isr Med Assoc J.* 2005;7(5):307-10.
 29. Herzenberg JE, Radler C, Bor N. Ponseti versus traditional methods of casting for idiopathic clubfoot. *J Pediatr Orthop.* 2002;22(4):517-21.
 30. Cummings RJ, Davidson RS, Armstrong PF, Lehman WB. Congenital clubfoot. *J Bone Joint Surg Am.* 2002;84(2):290-308.