

Long-Term Outcomes of the Calcaneo-Stop Procedure in the Treatment of Flexible Flatfoot in Children: A Retrospective Study



Resultados a Longo-Prazo da Cirurgia Calcaneo-Stop no Tratamento do Pé Plano Flexível em Crianças: Um Estudo Retrospectivo

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Acta Med Port 2017 Jul-Aug;30(7-8):541-545 • <https://doi.org/10.20344/amp.8137>

ABSTRACT

Introduction: Flexible flatfoot is common amongst children, although treatment is rarely indicated. The calcaneo-stop procedure has been reported to be effective in short-term studies. We aim to evaluate the long-term outcomes of the calcaneo-stop procedure in the treatment of flexible flatfoot in children.

Material and Methods: Twenty-six calcaneo-stop procedures performed between 1995 and 2006 on 13 patients were evaluated clinically and using photopodscopy, and the FAOS questionnaire was applied for both feet.

Results: Of the 26 feet evaluated, 22 presented with heel valgus, 13 had forefoot supination and 11 had abnormal footprints. Median FAOS questionnaire score was 97.22 for 'Pain', 92.86 for 'Other symptoms', 98.53 for 'Function in daily living', 100 for 'Function in sports and recreation' and 93.75 for 'Foot and ankle-related quality of life'.

Discussion: The calcaneo-stop procedure is the least invasive and most simple surgical treatment for symptomatic flexible flatfoot in children. Short-term studies report excellent clinical and radiographic results. The authors report alterations in clinical parameters in a large proportion of patients. These findings can be due to biomechanical alterations in the years following removal of the screw. Patient foot and ankle-related satisfaction data is promising, although hard to evaluate given the absence of preoperative data.

Conclusion: Larger, prospective, controlled studies are required to better evaluate the long-term success of this procedure.

Keywords: Bone Screws; Calcaneus/surgery; Child; Flatfoot/surgery; Minimally Invasive Surgical Procedures; Orthopedic Procedures

RESUMO

Introdução: O pé plano flexível é comum entre as crianças, embora o tratamento seja raramente indicado. O procedimento *calcaneo-stop* tem sido reportado como eficaz em estudos a curto prazo. O objetivo deste trabalho é avaliar os resultados a longo prazo do procedimento *calcaneo-stop* no tratamento do pé plano flexível em crianças.

Material e Métodos: Vinte e seis procedimentos *calcaneo-stop*, realizados entre 1995 e 2006, de 13 doentes, foram avaliados clinicamente e usando fotopodoscopia, e o questionário FAOS foi aplicado para ambos os pés.

Resultados: Dos 26 pés avaliados, 22 apresentaram calcanhar valgo, 13 tinham supinação do antepé e 11 tinham pegadas consideradas anormais. As medianas das pontuações do questionário FAOS foram 97,22 para o parâmetro 'Dor', 92,86 para 'Sintomas', 98,53 para 'Funcionalidade, vida diária', 100 para 'Funcionalidade, desporto e atividades de lazer' e 93,75 para 'Qualidade de vida'.

Discussão: O procedimento de *calcaneo-stop* é o tratamento cirúrgico menos invasivo e mais simples para o pé plano flexível sintomático em crianças. Estudos com avaliação a curto prazo relatam excelentes resultados clínicos e radiográficos. Os autores deste estudo reportam alterações nos parâmetros clínicos de uma grande proporção de pacientes. Esses achados podem ser devidos a alterações biomecânicas nos anos seguintes à remoção do parafuso. Os dados relativos à satisfação do paciente em relação ao pé e tornozelo são razoáveis, embora difíceis de avaliar, dada a ausência de dados pré-operatórios.

Conclusão: São necessários estudos com mais casos, prospectivos, randomizados e com ocultação, para melhor avaliar o sucesso a longo prazo deste procedimento.

Palavras-chave: Calcâneo/cirurgia; Criança; Pé Chato/cirurgia; Parafusos Ósseos; Procedimentos Cirúrgicos Minimamente Invasivos; Procedimentos Ortopédicos

INTRODUCTION

Flatfoot is characterized by an absent or diminished longitudinal medial arch. Flatfoot can be flexible, if an arch can be created by manipulation of the foot, or rigid.¹ Flexible flatfoot is extremely common amongst infants,² having been described in almost 100% of children under 18 months by Morley.³ True incidence is hard to ascertain as there are no consensus on the radiographic and clinic criteria that define a flatfoot.⁴ Children typically develop a longitudinal arch in

their first decade of life,⁵ but those who don't are unlikely to do so spontaneously.⁶

Clinically, flatfeet are defined by a straight or convex plantar-medial border of the foot, straight or concave lateral border, the hindfoot is in valgus alignment and, when reverted to the neutral position, supination of the forefoot is revealed.⁴ Weightbearing anteroposterior and lateral views of the foot are most commonly used to evaluate flexible

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Recebido: 22 de agosto de 2016 - Aceite: 10 de abril de 2017 | Copyright © Ordem dos Médicos 2017



flatfoot, although they are not necessary for diagnosis.

The majority of children with flexible flatfoot are asymptomatic.⁴ However, this condition may rarely cause pain, or difficulties in physical activities, such as walking or running. It is not necessary to treat most children with asymptomatic flexible flatfoot.⁶

Nonoperative treatments include exercise programs and foot orthoses. A recent systematic review has demonstrated that most nonoperative treatments have limited evidence of efficacy.⁷

Three operative treatment options have been described: arthroereisis, arthrodesis and osteotomies. Arthroereisis (calcaneo-stop procedure) consists of placing an implant within the sinus tarsi, limiting the mobility of the tarsus and preventing eversion of the subtalar joint. Although there are many short-term follow up studies reporting the efficacy of arthroereisis procedures,⁸⁻¹² long-term follow-up and comparative studies are lacking.⁶

We aim to evaluate the long-term outcomes of the calcaneo-stop procedure in the treatment of flexible flatfoot in children, in one surgical centre.

MATERIAL AND METHODS

Patient selection

Files from all patients submitted to the calcaneo-stop procedure between January 1, 1995 and December 31, 2006 in at least one foot, who were younger than 15 years old by the time of the procedure were reviewed (n = 40). Patients with major congenital malformations, severe neurological disorders, or those submitted to other foot

procedures simultaneously were excluded (n = 36). Patients were contacted by telephone to schedule an appointment.

Operative technique

Indication for surgery was symptomatic flexible flatfoot, defined by clinical and radiographic evaluation, resistant to nonoperative treatment.

Patients were submitted to the standard calcaneo-stop procedure in our institution, consisting of a variation of the technique described by J. Jerosch *et al*.¹¹ Surgery was performed under general anesthesia. A *tourniquet* was applied above the knee. Patients were placed in a supine position with the foot internally rotated. A 1.5 cm incision was made anterior to the peroneal tendons. A 3.2 mm drill was placed under fluoroscopic control, through the sinus tarsi directed towards the calcaneal tuberosity, with the calcaneus in neutral position. A 4.5 mm cortical screw was placed, its size adjusted to the calcaneus' dimensions, so that screw head impinged against the lateral aspect of the talus preventing eversion at the subtalar joint (Fig. 1). Patients were allowed full weight-bearing as tolerated. Following screw removal, all patients were observed within a 6-months period and none reported symptoms at that time.

Evaluation

All demographic parameters were obtained in patients' files, as well as dates of implantation and removal of screws. Clinical assessment was performed by two observers and consisted of evaluation of heel valgus, forefoot supination



Figure 1 – Intraoperative fluoroscopic image showing screw placement directed toward the calcaneal tuberosity

and uneven shoe wear. Patients' weight and height was measured. A photograph of the podoscopic examination was taken. Photographs were then cropped to include only one foot and those of left feet were inverted. Footprints were then classified as 'flat', 'normal', or 'high' arched independently by five orthopedic surgeons, experienced in the area. The mode of classifications was considered. Patients symptoms, pain, function in daily life, sports/recreation, and foot and ankle-related quality of life was assessed using the Portuguese version of the Foot and Ankle Outcome Score.^{13,14} The questionnaire was applied to all subjects, one questionnaire for each foot.

Data analysis

Data analysis was performed using IBM SPSS Statistics 22®. Questionnaire outcomes were evaluated according to the scoring sheet.

Ethical issues

All procedures performed involving human participants were in accordance with the ethical standards of the institutional research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. A written consent form was signed by all participants or a parent if they were 17 years old.

RESULTS

Thirteen patients were evaluated, seven male and six female, mean age at evaluation was 21 (range, 17 - 25) years. All underwent bilateral surgery simultaneously (26 feet). Mean age at surgery was nine (range, 6 - 11) years. Mean time between implantation and removal of the screws was 3.25 (range, 0.86 - 7.09) years. Mean follow-up time was 12 (range, 8 - 17) years. Population demographics are summarized in Table 1.

Heel valgus was found in 22 feet and forefoot supination in 13 feet. Footprints were classified as flat arched in 8 feet, normal in 15 feet and high arched in 3 feet. Uneven shoe wear was present in 20 feet. Data regarding clinical evaluation is summarized in Fig. 2.

The FAOS Questionnaire evaluates 5 different subscales. Median score for subscale 'Pain' was 97.2, for 'Other Symptoms' 92.9, for 'Function in daily living (ADL)

Table 1 - Population description

Sex		
	Male (n = 7)	53.8%
	Female (n = 6)	46.2%
Age (years)		
	Mean ± SD	21.0 ± 2.66
	Minimum	17
	Maximum	25
IMC		
	Mean ± SD	23.84 ± 4.41
Age at surgery (years)		
	Mean ± SD	8.8 ± 1.72
	Minimum	6
	Maximum	11
Time between surgeries (years)		
	Mean ± SD	3.25 ± 1.76
	Minimum	0.86
	Maximum	7.1
Follow-up (years)		
	Mean ± SD	12.21 ± 2.79

98.5, 'Function in sport and recreation (Sport/Rec)' 100 and 'Foot and ankle-related quality of life (QOL)' 93.8. The distribution of scores in the questionnaires according to its subscales is displayed in Fig. 3.

No correlations between clinical outcomes, period of time between implantation and removal of screws, age at the time of surgery, and foot and ankle-related satisfaction level were looked due to the small size of the sample (Fig. 4).

No record of complications was found on patients' files.

DISCUSSION

The calcaneo-stop technique was developed by Recaredo in 1970.¹⁵ He inserted a cancellous screw into the calcaneus bone to limit the subtalar joint mobility. It has been proposed that the screw's effect is not limited to mechanics, but proprioceptive alteration occurs, possibly accounting for contralateral improvement following surgery.^{9,16,17} Many implants and operative techniques are currently used, and

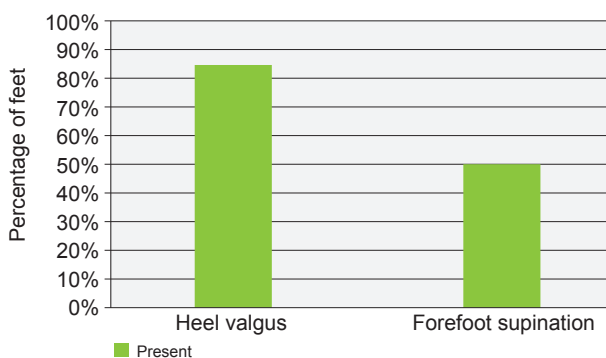


Figure 2 – Clinical evaluation outcomes: prevalence of heel valgus and forefoot supination

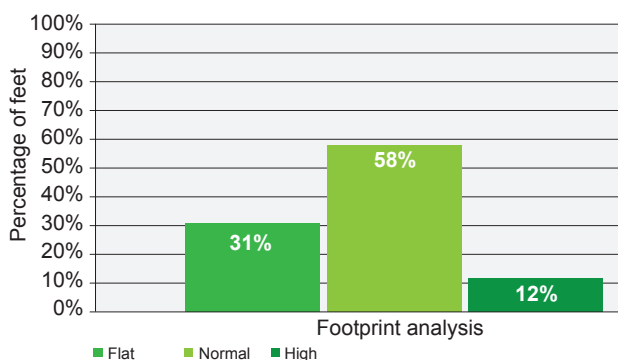


Figure 3 – Clinical evaluation outcomes: footprint classifications distribution in the study population

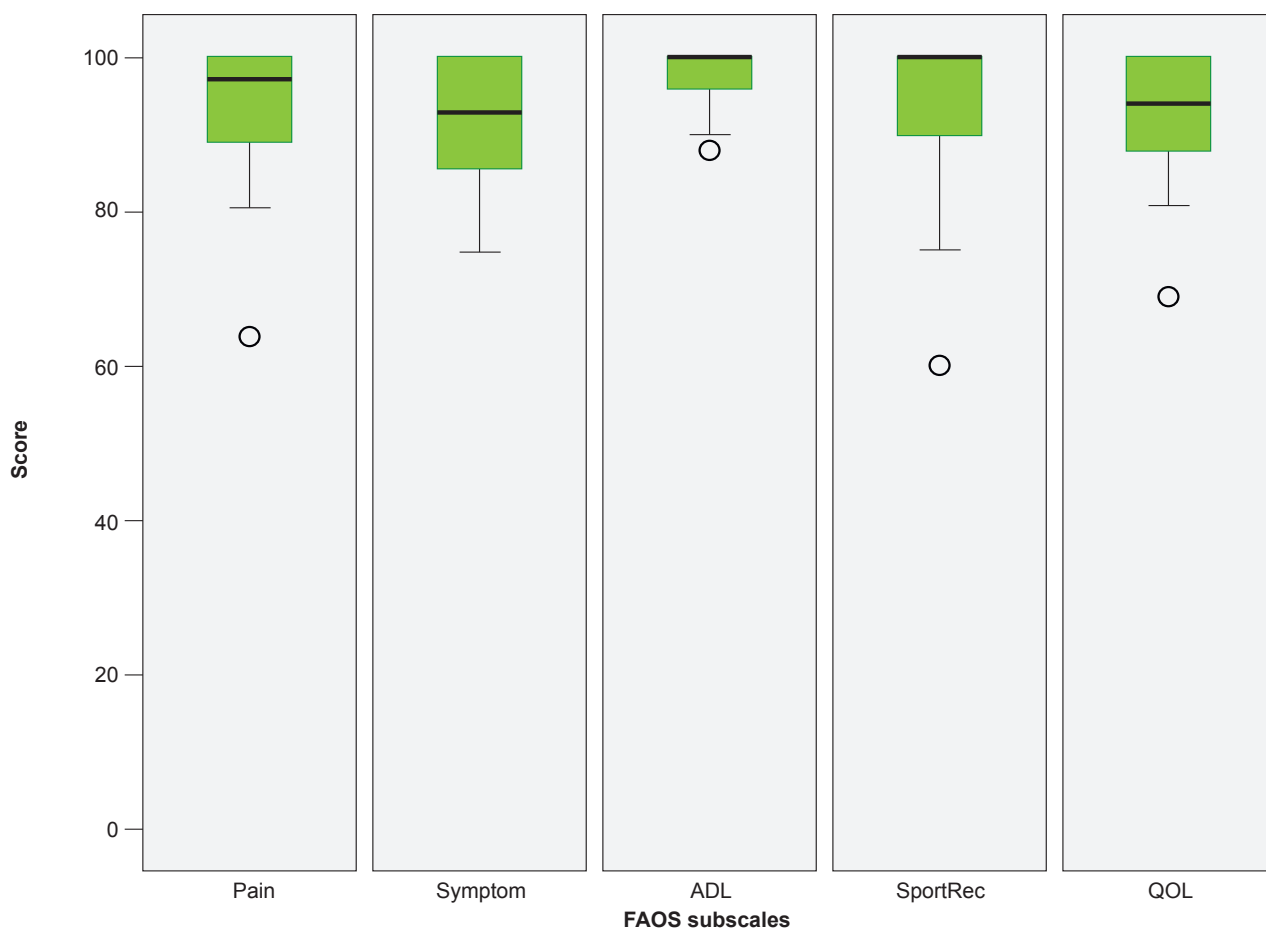


Figure 4 – Distribution of scores in each subscale of the questionnaire. Median is represented by the bold line and interquartile range (IQR) is displayed in the form of a box. Horizontal lines outside the box represent the minimum score, excluding outliers.

ADL: function in daily living; SportRec: function in sport and recreation; QOL: foot and ankle-related quality of life

reports have been thoroughly studied in a critical review,¹⁸ therefore describing all of them is beyond the scope of this discussion. Focus will be given to the works of Jerosch *et al*,¹¹ Pavone *et al*¹⁰ and De Pellegrin *et al*,¹² given the similarity of the technique, which allows a fair comparison of results.

Jerosch *et al*¹¹ evaluated a series of 21 flatfeet who had undergone the calcaneo-stop procedure from 1999 and 2007. Significant clinical improvement in heel valgus angle at rest and during tip-toe standing and in podographic evaluation was reported. No complications were found in this series and screw removal was performed 2 - 3 years after implantation.

Pavone *et al*¹⁰ reported a series of 410 feet (242 patients) undergoing the calcaneo-stop procedure for treatment of symptomatic flexible flatfoot. Outcome was satisfactory in 97% of patients, normalization of footprint occurred in 80% and there were statistically significant variations in radiographic angle measurements. No complications were reported by the time of removal of screws, three years after implantation.

De Pellegrin *et al*¹² described a series of 485 patients (785 feet), throughout 13 years, undergoing subtalar extra-articular arthroereisis. Indications for surgery were

symptomatic flexible flatfoot and clinical and radiographic parameters. They reported good clinical and radiographic outcomes in almost 100% of cases and a complication rate of 6.3%. Evaluations post-screw removal (average 2.9 years after screw implantation) were also performed in a subset of patients, revealing no statistical modification in radiographic measurements. Patient satisfaction wasn't evaluated.

The authors report alterations in clinical parameters in a large proportion of patients (85% had heel valgus, 50% presented forefoot supination and in 42% footprint was considered abnormal). Considering the results described above, it can be proposed that this findings can be due to biomechanical alterations in the years following removal of the screw, as they have been proven to be corrected while screw is in place.

Operative correction of flexible flatfoot is performed aiming at alleviating symptoms, more than correcting a foot shape that has been described as normal and indicative of strong and stable foot in adults. The median scores in each subscale of the questionnaire were very satisfactory (all above 90), reflecting a very successful symptomatic treatment of these patients. Despite that, the prevalence of reported symptoms/limitations in some patients, considering the minimum scores, was higher than

expected. In those patients, the presence of symptoms/limitations can be due to unsuccessful operative correction of flatfoot, inappropriate time between placement and removal of screws or biomechanical alterations following screw removal. However, it is unsure whether these results can't, in fact, represent an improvement compared to the symptoms reported before operative treatment, as patients' foot and ankle-related satisfaction wasn't evaluated in a comparable manner then. Serial, periodical evaluations throughout childhood, adolescence and adulthood could overcome this limitation.

The limitations of the study were the small number of patients, lack of a control group, possible bias in clinical evaluation and lack of objectively measurable parameters.

CONCLUSION

Larger, prospective, controlled studies are required to better evaluate the long-term success of this procedure.

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PROTECTION OF HUMANS AND ANIMALS

The authors declare that the procedures were followed according to the regulations established by the Clinical Research and Ethics Committee and to the Helsinki Declaration of the World Medical Association.

DATA CONFIDENTIALITY

The authors declare having followed the protocols in use at their working center regarding patients' data publication.

CONFLICTS OF INTEREST

The authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest or non-financial interest in the subject matter or materials discussed in this manuscript.

FUNDING SOURCES

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

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