



■ CHILDREN'S ORTHOPAEDICS

A comparison of ankle foot orthoses with foot abduction orthoses to prevent recurrence following correction of idiopathic clubfoot by the Ponseti method

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doi:10.1302/0301-620X.93B5.24883 \$2.00

J Bone Joint Surg [Br]
2011;93-B:700-4.

Received 4 April 2010; Accepted after revision 24 January 2011

The Ponseti method of clubfoot management requires a period of bracing in order to maintain correction. This study compared the effectiveness of ankle foot orthoses and Denis Browne boots and bar in the prevention of recurrence following successful initial management. Between 2001 and 2003, 45 children (69 feet) with idiopathic clubfeet achieved full correction following Ponseti casting with or without a tenotomy, of whom 17 (30 clubfeet) were braced with an ankle foot orthosis while 28 (39 clubfeet) were prescribed with Denis Browne boots and bar. The groups were similar in age, gender, number of casts and tenotomy rates. The mean follow-up was 60 months (50 to 72) in the ankle foot orthosis group and 47 months (36 to 60) in the group with boots and bars. Recurrence requiring additional treatment occurred in 25 of 30 (83%) of the ankle foot orthosis group and 12 of 39 (31%) of the group with boots and bars ($p < 0.001$). Additional procedures included repeat tenotomy (four in the ankle foot orthosis group and five in the group treated with boot and bars), limited posterior release with or without tendon transfers (seven in the ankle foot orthosis group and two in the group treated with boots and bars), posteromedial releases (nine in the orthosis group) and midfoot osteotomies (five in the orthosis group, $p < 0.001$).

Following initial correction by the Ponseti method, children managed with boots and bars had far fewer recurrences than those managed with ankle foot orthoses. Foot abduction appears to be important to maintain correction of clubfeet treated by the Ponseti method, and this cannot be achieved with an ankle foot orthosis.

The Ponseti method of management of idiopathic clubfeet has been adopted widely with high rates of success.¹⁻⁵ The method includes the initial correction phase of serial casting followed by percutaneous Achilles tenotomy to address residual equinus. After the initial correction, there is an extended maintenance period, during which Ponseti and others have recommended the use of a foot abduction orthosis for up to five years of age, to minimise the risk of recurrent deformity.⁵⁻⁷ The importance of bracing during this period is supported by the higher recurrence rates reported in those intolerant of, or non-compliant with, bracing.^{3,5,8-10} The foot abduction orthosis of Denis Browne boots and bar (DBB) comprises a pair of boots set at 60° to 70° external rotation (on the affected side/s), connected by a bar (Fig. 1). Despite these recommendations, some centres prescribe ankle foot orthoses (AFO) as the preferred method of bracing (Fig. 2).

We adopted the Ponseti method in the latter half of 2001. While the technique of casting

was applied rigorously during the correction phase, the initial cohort of children were braced with AFO to maintain correction because they had been used traditionally following conventional surgical treatment.¹¹ The AFO was believed to be as effective as DBB and more convenient for the child and family. In 2002, the surgeons switched to DBB. The purpose of this study was to compare the effectiveness of AFO with that of DBB in the maintenance phase following initial successful correction of idiopathic clubfeet treated by the Ponseti technique.

Patients and Methods

This was a retrospective cohort study, which received routine ethical approval.

All children with clubfeet presenting between 2001 and 2003 were identified through a database and health records. Children were included only if their clubfoot was idiopathic and had undergone successful correction by the Ponseti casting with or without a



Fig. 1a



Fig. 1b

Photographs showing a) the foot abduction orthoses with Denis Browne boots and bar and b) the extent of external rotation.



Fig. 2

Photograph showing the ankle foot orthosis.

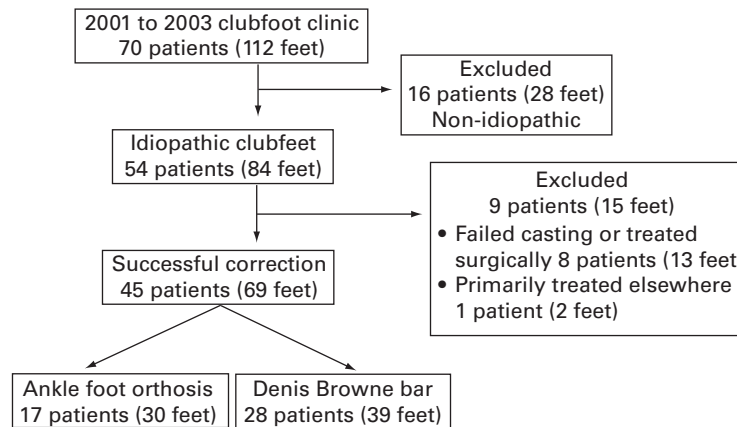


Fig. 3

Flow chart of patients in the study.

tenotomy. They were also excluded if they had been treated elsewhere. During this period, 70 children with 112 clubfeet were treated. Of the 25 children who did not meet the inclusion criteria, 16 (28 feet) had associated neuro-

muscular or syndromic conditions, eight (13 feet) had failed casting and/or were treated surgically and one (bilateral case) was treated primarily elsewhere. A total of 45 children with 69 clubfeet were corrected successfully using the

Table I. Baseline characteristics of the children

	Ankle foot orthoses (n = 17) (30 clubfeet)	Denis Browne boots and bar (n = 28) (39 clubfeet)	p-value
Mean age at presentation in weeks (range)	6.9 (8.0) (1 to 30)	9.7 (1 to 30)	0.28
Male:female	14:3	22:6	
Male (%)	82	78	0.76
Unilateral: bilateral	4:13	17:11	
Bilaterality (%)	76	39	0.015
Mean follow-up in months (range)	60 (50 to 72)	47 (36 to 60)	< 0.001
Mean number of casts (range)	5.5 (3 to 10)	4.8 (3 to 7)	0.07
Number requiring an Achilles tenotomy (%)	25 (83)	29 (74)	0.29

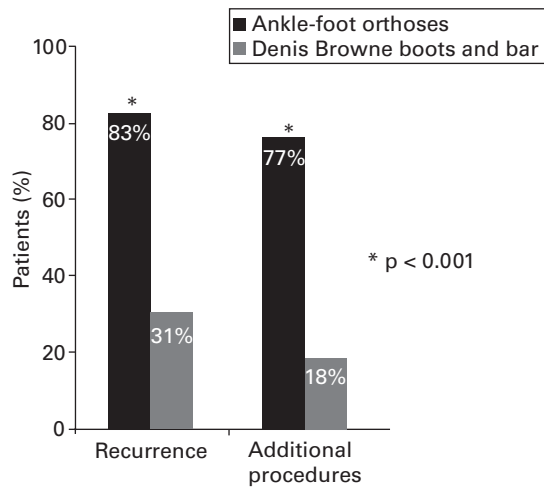


Fig. 4

Bar chart showing rates of recurrence and additional procedures (percentages) in patients treated with ankle foot orthoses and Denis Browne boots and bar.

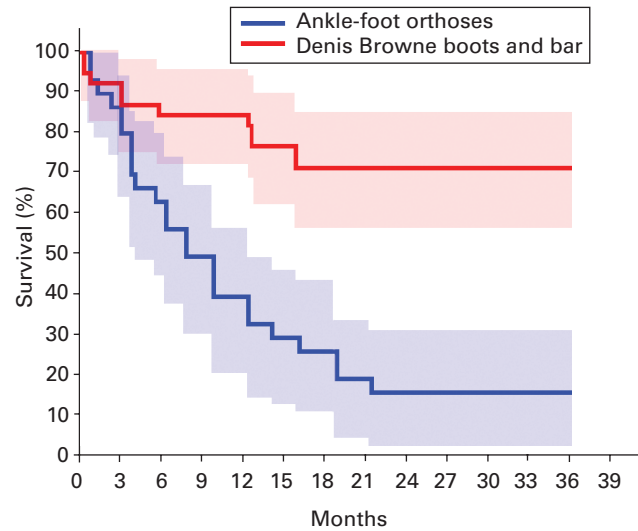


Fig. 5

Nonparametric Kaplan-Meier survival graph for clubfoot patients treated with ankle foot orthoses and Denis Browne boots and bar (95% confidence intervals represented by shaded area).

Ponseti method and braced either with AFO or with DBB. A total of 17 children (30 feet) were managed with AFO while 28 (39 feet) were prescribed DBB. No child was lost to follow-up (Fig. 3).

In both groups, the weekly manipulation and casting by the Ponseti technique was performed by a trained consultant orthopaedic surgeon (JGW, UGN) or a fellow under the direct supervision of the responsible surgeon. When the forefoot correction was complete (70° of abduction) and the hindfoot was in valgus, a percutaneous Achilles tenotomy was performed in order to address the residual equinus (< 10° of ankle dorsiflexion). Parental preference determined whether the tenotomy was performed under local anaesthesia in the clinic or under general anaesthesia in the operating theatre. Most were done in the outpatient clinic and the foot was immediately cast in the fully-corrected position for three weeks.

An AFO was initially used to maintain the correction (Fig. 2). They were prescribed for full-time use until the age of five. The children were followed at three and six months after the initiation of bracing and thereafter at six-monthly intervals.

In 2002, the post-correction bracing was changed to the DBB foot abduction orthosis, set at 70° of external rotation on the affected side/s and 45° external rotation on the unaffected side (Fig. 1). The brace was prescribed full-time for the first three months, followed by night- and sleep-time use thereafter until four years of age. The children were followed at six weeks and three months after the initiation of bracing, three months after switching to night- and sleep-time use and then at six-monthly intervals.

Baseline information included age at presentation, gender, number of casts required for correction, need for Achilles tenotomy, follow-up time and post-correction management (Table I). The assessment of outcome included whether there was recurrence of deformity, when this occurred (months after correction) and what additional treatment was necessary. A successful outcome at two years was defined as a plantigrade foot with a straight lateral border and normal hindfoot valgus during weight bearing, a heel-toe gait, ability to wear ordinary shoes comfortably and at least 10° of ankle dorsiflexion with the knee extended. Recurrence was defined as any deformity that required additional casting and/or

surgical procedures to restore satisfactory position in a child who had completed casting, with or without an Achilles tenotomy and had been prescribed either an AFO or DBB.

Statistical analysis. The groups were compared for differences in the baseline prognostic characteristics and outcomes. Means were compared using Student's *t*-test. Rates of recurrence were compared using the chi-squared or Fisher's exact tests and adjusted odd ratios were generated. In order to account for the difference in length of follow-up in both groups, Kaplan-Meier survival analysis was used to compare the probability of survival (free from recurrence) and the timing of recurrences between the two groups, and the log-rank (Mantel-Cox) test was performed for equality of survival distribution. Statistical significance was considered at a two-tailed level of < 0.05 . Analyses were carried out using SPSS 12.1 (SPSS Inc., Chicago, Illinois).

Results

The baseline characteristics of the children in both groups were similar with respect to age at presentation, gender distribution, number of casts required to achieve correction, and percentage requiring Achilles tenotomy (Table I). There was a higher percentage of bilateral involvement in the AFO group (76% vs 39%, $p = 0.015$). As expected, the mean follow-up of 60 months in the AFO group was longer than the 47 months in the DBB group because most of the AFO group were treated in the early period of the study.

Recurrent deformity requiring additional treatment occurred in 25 feet (83%) in the AFO group and in 12 feet (31%) in the DBB group ($p < 0.001$) (Fig. 4). Recurrence was identified at a mean of 33.3 weeks (4 to 76) in the AFO group and 42.9 weeks (2 to 171) in the DBB group. At three years of follow-up, the probability of survival without recurrence for the AFO group was 0.17 (95% confidence interval (CI) 0.03 to 0.30) compared with 0.72 (95% CI 0.58 to 0.86) for the DBB group. The log-rank (Mantel-Cox) test of equality of survival distribution between the groups had a *p*-value of < 0.001 (Fig. 5). The odds ratio, adjusted for bilaterality, was 10.6 for the AFO group; i.e., the use of an AFO was associated with a 10.6 times higher risk of recurrence when compared with the use of DBB, even after adjusting for baseline differences in bilaterality.

Of the 25 feet in the AFO group who developed recurrent deformity, two required a repeat Achilles tenotomy, seven had a posterior release, with or without tendon transfers, nine had a complete posteromedial release, and five needed an osteotomy. Two feet with recurrent equinus did not initially undergo Achilles tenotomy and have required this subsequently.

In the 12 feet in the DBB group with recurrent deformity, five were treated with repeat percutaneous Achilles tenotomy and two with a posterior release. The remaining five feet were treated with casting only. Overall, the rate of additional procedures (discounting re-casting or alone) in children treated with AFO was 77% (23 of 30) compared with 18% (7 of 39) with DBB ($p < 0.001$, Fig. 4). The rate

of more significant surgery was 21 of 30 (70%; posterior or posteromedial release, osteotomy) in the AFO group, two of 39 (5.1%; posterior release only) in the DBB group.

Discussion

The Ponseti method for treatment of idiopathic clubfeet has been shown to be consistently successful in achieving correction of deformity without the need for extensive surgery.^{1,2,6,8,12,13} Ponseti stressed the importance of bracing after initial correction and suggested that only a foot abduction brace is effective in maintaining correction.

We recently published our experience with the Ponseti technique, in which only 5 (3%) of 171 idiopathic clubfeet required any surgical treatment beyond the percutaneous tenotomy.¹³ Excluded from that study was an early cohort of patients who were prescribed AFO after initial correction. We subsequently changed to the DBB which have remained part of our protocol.

We have shown clearly the superiority of the DBB over AFO in terms of rate and risk of recurrence and additional procedures. However, this retrospective study has some limitations. It was important to ensure that the two treatment groups were prognostically similar at the outset. We did not use the Pirani¹⁴ or Dimeglio¹⁵ scores to classify the feet. While these systems quantify the severity of the clubfeet, they have not been shown as reliably prognostic of the outcome. Nevertheless, it is conceivable that the severity was different in the two groups. This is less likely due to the similarity of other baseline characteristics, such as age at presentation, gender, number of casts needed for correction or the percentage requiring tenotomies. There was higher percentage of bilateral involvement in the ankle foot orthosis group, but we adjusted for this difference in our multivariate analyses.

Secondly, children in the AFO group were treated earlier in the surgeon's experience with the Ponseti method than those treated with the DBB. The impact of the learning curve would most likely have had an effect on the success rates of the correction phase, but not of the maintenance phase. We only included those patients who had successfully achieved full correction following serial casting and tenotomy. Since they were similar in both groups in terms of number of casts needed and necessity for a tenotomy, it is unlikely that the casting learning curve would have had any influence on the rates of recurrence. It is possible that the higher rate of surgical procedures needed to deal with recurrences in the AFO group could have been due, in part, to the effect of the learning curve. Recurrences may have been more likely to be managed with surgery than repeated casting early in the surgeons' experience. However, this would not explain the higher rates of recurrence.

Thirdly, the mean follow-up of 60 months in the AFO group was significantly longer than the 47 months in the DBB group, because most in the AFO group were treated before the change to DBB. The higher rates of recurrence in the AFO group could potentially be explained by the longer

follow-up period. However, most recurrences occurred within the first year and only one occurred after two years. Given the minimum follow-up of three years and mean follow-up of almost four years, it is unlikely that further follow-up of the DBB group would reveal sufficient additional recurrences to alter the conclusions.

Finally, we were unable to verify actual brace wear in the two groups as this information was not consistently acquired or recorded in the database. It is well recognised that tolerance of DBB remains a challenge for some children. It might be assumed that an AFO is more likely to be tolerated than DBB and therefore any difference in compliance rates would only strengthen the conclusions of this study. However, we have no data to substantiate this assumption.

Notwithstanding these limitations, our results provide compelling evidence of the superiority of DBB over AFO in preventing recurrences following correction of clubfeet using the Ponseti method. Previous studies have shown the importance of bracing, with higher rates of recurrence associated with poorer compliance.^{3,5,8-10} However, this study provides the first published data to verify Ponseti's recommendation of the specific use of the foot abduction orthosis as critical to the maintenance of correction. Abduction of the foot is required to stretch the medial soft tissues, and an AFO is unable to control this. The 83% rate of recurrence in the AFO group would suggest that the orthoses are not much better than no bracing at all.

The DBB design of the foot abduction orthosis is not universally tolerated and newer braces such as the Mitchell Brace (MD Orthopaedics, Wayland, Iowa) and the Dobbs articulated abduction orthosis (Orthotics & Prosthetic Labs, St Louis, Missouri) have been introduced to improve tolerance and retention of the foot in the braces.¹⁶ Their effectiveness remains to be proven. However, they retain the principles of stretching the medial structures of the foot and ankle.

In conclusion, we found that AFO are ineffective in preventing recurrences following correction of idiopathic clubfeet by the Ponseti method. We recommend the DBB foot abduction orthoses during the maintenance phase. Recurrences do occur with the use of a foot abduction

orthosis but far less frequently. Any recurrences can be managed with repeat casting, with or without a second tenotomy, or limited posterior release. The age at which bracing can be stopped remains unclear but, based on when most recurrences present, splintage for at least three years seems prudent.

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

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