TREATMENT OF CONGENITAL CLUB FOOT
WITH A MODIFIED DENIS BROWNE SPLINT

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We treated 91 congenital club feet in 59 children using a modified Denis Browne splint, and followed them for an average of 6 years and 3 months. The modified splint has an aluminium crossbar holding a pair of plastic shoe inserts moulded into corrected positions, and its use was started in children whose ages ranged from four weeks to nine months. Operation was later required in only 31 feet in 20 children.

We have reviewed the other 60 feet in 39 children treated by splintage alone. All 60 feet had excellent or good function and from radiographic assessment, equinus, adduction, varus and cavus deformities had all been well corrected. Our results show that the modified splint can give good results.

Denis Browne described his splint for the treatment of congenital club foot in 1931; since then several modifications have been reported, but the results were not very good. Bertelsen (1957) reported only 34% complete cures and Jansen (1957) had satisfactory or good results in only 43%. Fripp and Shaw (1967) had only 19% success with the splint. The splint is now sometimes used to maintain the correction which is gained by other methods of treatment.

We have again modified the Denis Browne splint, using it at first after surgery. Since 1974 we have used this modified splint to correct deformities by non-operative treatment. We review our experience and evaluate the results.

PATIENTS AND METHODS

From 1974 to 1985 we treated 93 congenital club feet in 61 children with the modified Denis Browne splint after serial plasters. One child also had bilateral hypoplasia of the thumbs and great toes, and another also had a unilateral congenital hip dislocation. Two children were excluded: one died of pneumonia and one was lost to follow-up. The 91 remaining club feet were in 45 boys and 14 girls, being bilateral in 32 and unilateral in 27.

Follow-up ranged from three to 13 years, averaging 6 years 3 months. Our splint was first used at an average age of 3.5 months (range 4 weeks to 9 months), depending on the time of the first visit to our clinic. Once the child began to walk, the splint was used at night, and shoe inserts by day, up to the age of three years.

Operation was performed after the age of one year if the maximum dorsiflexion of the ankle was less than 10°, and the tibiocalcaneal angle in maximum dorsiflexion (as shown by a radiograph) was more than 80° (Yamamoto and Furuya 1988). The age at operation ranged from 10 months to 4 years (average 2.6 years).

The modified Denis Browne splint. The usual Denis Browne splint has a crossbar between a pair of foot plates or shoes; it is difficult to hold the hindfoot and to correct the equinus deformity. We replaced the foot plates or shoes by plastic shoe inserts fixed to an aluminium crossbar (Fig. 1). The plastic shoe inserts are made by moulding a heated plastic sheet over a positive cast in which adduction, varus and equinus deformities have been corrected (Fig. 2). If the foot slides off this insert in forced dorsiflexion, its contour can easily be changed by reheating so that it holds the hindfoot. The shoe insert was fixed to the crossbar at an angle of from 25° to 35°, and the length of the crossbar was the width of the patient's shoulders. The splint is light (down to 40 g), and does not hinder kicking movements.

Functional assessment. The functional results were assessed using the McKay rating system (McKay 1983), which includes 10 categories giving a maximum of 180 points. These are: ankle motion (30 points), angle of the bimalleolar plane to the longitudinal plane of the foot (20), strength of triceps surae (20) and of flexor hallucis longus (10), the position of the heel (10) and forefoot (10),
ankle pain (30), subtalar pain (20), shoe wear (15), and sports ability (15).

Radiological assessment. Radiological assessment was by anteroposterior and lateral radiographs of the feet taken while standing, and a lateral view in maximum dorsiflexion. The anteroposterior radiograph was taken with the beam angled at 30° to the vertical, and from this the talocalcaneal and the talo-first metatarsal angles were measured. The talocalcaneal angle is that between the long axes of talus and calcaneus; on this view it is an index of varus deformity. The talo-first metatarsal angle is that between the long axis of the talus and that of the first metatarsal; it is an index of adduction deformity.

On the lateral radiograph in maximum dorsiflexion, the tibiocalcaneal angle was measured as an index of equinus deformity. From the standing lateral radiograph the vertical talo-first metatarsal angle was measured as an index of cavus deformity.

RESULTS
Of the 91 feet reviewed, 60 were treated without operation; surgery was required for 31 feet (34%) in 20 children with residual deformities. Operation was needed in 13 boys (29%) and seven girls (50%) (Table I); 14 of them had bilateral involvement (43.8% of all bilateral cases) and six had unilateral involvement (22.2%). Before operation in these cases the average tibiocalcaneal angle in maximum passive dorsiflexion was 93.7°. The average lateral talocalcaneal angle in maximum dorsiflexion was 21.1°, and the average anteroposterior talocalcaneal angle was 26.3°. The average anteroposterior talo-first metatarsal angle was -2.3° and the average lateral talo-first metatarsal angle was 175°.

We evaluated 60 feet (66%) in 39 children (66.1%) which were treated without surgery. On the McKay rating system, 42 feet scored 180 points, two feet scored 175, 14 feet scored 170, and two feet scored 165 points. On this scale 73% were graded as excellent (175 to 180 points) and 27% were good (160 to 174). There were no fair or poor results. The average angle of dorsiflexion was 20.8° (s.d. 5.1°). The angle of the bimalleolar plane to the longitudinal plane of the foot was 83° to 90° in 44 feet (73%), and 76° to 82° in 16 feet (27%), and, during standing the heel was in 0° to 5° valgus in all feet. The forefoot was in a neutral position in 57 feet (95%), and in 5° adduction in three feet (5%). No child complained of ankle or subtalar pain or needed special shoes. The strength of triceps surae and flexor hallucis longus was normal in all feet. The radiographic angles are shown in Table II in comparison with our figures for normal feet. All the splinted feet showed angles a little greater than normal, but all were within the normal range of angles reported in the literature (Simons 1980). These radiographic assessments show that equinus, adduction, varus and cavus deformities were all well corrected.

DISCUSSION
Various success rates have been reported for the nonoperative treatment of congenital club foot. Kite (1964) reported that 92% of 922 patients were corrected by casts and wedging continued for some years. Meehan (1982) reported that Price and Lovell had reviewed 32 of 121 feet treated by Kite between 1950 and 1956 and reported that 21 feet (65.6%) had good results at an average follow-up of 23.6 years. Blockey and Smith (1966) treated 186 feet by manipulation and splintage; acceptable results
were obtained in 34.9% at a 3-year assessment and in 27.6% at five years. Fripp and Shaw (1967) reviewed 221 patients with a follow-up of two to 12 years and reported that only 19% of 105 patients treated in Denis Browne splints had successful results, while 71% of 96 patients were effectively treated by stretching and strapping and none of 20 patients had successful results with serial casts. Turco (1981) reviewed at seven years, patients treated from birth; only 35% were successfully treated non-operatively. Harrold and Walker (1983) treated 103 feet with serial plasters; 53.4% responded satisfactorily, success depended on the severity of the deformities at birth.

These varying results may reflect methods of treatment, but are much influenced by the severity of the abnormalities, the method of assessment and the length of follow-up. Our patients all had equinus, adductus, varus and cavus deformities which had resisted correction to neutral position by manipulation, and our follow-up averaged 6 years and 3 months. Of 91 feet, 66% responded to treatment with the modified Denis Browne splint, showed good radiological alignments and were excellent or good on the McKay rating system. Although comparison is very difficult, our success rate is similar to that reported for Kite (Meehan 1982).

Our success rate for girls (50%) was lower than that for boys (71%); as was that for bilateral involvement (56%) as compared with unilateral (78%). The two children with other anomalies did not respond. These results probably reflect the influence of the severity of deformity on the success of treatment. Coleman (1983) pointed out that congenital club foot has a polygenic inheritance pattern with a threshold effect. There is a continuum of multiple gene loci: deformity occurs when the number of abnormal genes exceeds a certain threshold. A clinical deformity would be more severe if more abnormal genes were present. This threshold appears to be sex-related, with a lower boundary level in males than in females. Thus males are more commonly affected, and females require a higher number of abnormal genes to manifest the deformity, thus tending to have a more severe deformity. The mode of inheritance of congenital club foot in Japan is also polygenic (Yamamoto 1979) and the sex ratio is 1 female to 2 males. Our results are compatible with Coleman's explanation.

The mechanism of action of the Denis Browne splint has been discussed. Browne, in 1931, used his splint to maintain either partial or total correction after manipulation had given the foot a normal range of movement and position of rest. Thomson (1942) modified this approach, believing that the principle should be to allow the infant to correct the deformities by its own kicking. The Denis Browne splint is now commonly used after initial correction, but we believe that the splint can act in the manner suggested by Thomson. Babies do kick incessantly from the age of three weeks under the influence of the primitive reflexes, which include the asymmetric neck reflex, the tonic neck reflex and the crossed extension reflex (Fig. 3). The splint is thus very

<table>
<thead>
<tr>
<th>View</th>
<th>Angle</th>
<th>Deformity</th>
<th>Normal feet</th>
<th>After treatment by splint alone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lateral forced dorsiflexion</td>
<td>Tibiocalcaneal</td>
<td>Equinus</td>
<td>40.5 ± 4.8</td>
<td>62.8 ± 6.8</td>
</tr>
<tr>
<td>Lateral</td>
<td>Talocalcaneal</td>
<td></td>
<td>37.5 ± 6.3</td>
<td>33.4 ± 6.1</td>
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<tr>
<td>Anteroposterior</td>
<td>Talocalcaneal</td>
<td>Varus</td>
<td>28.6 ± 5.0</td>
<td>26.6 ± 6.8</td>
</tr>
<tr>
<td>Anteroposterior</td>
<td>Talo-first metatarsal</td>
<td>Adduction</td>
<td>−12.5 ± 2.3</td>
<td>−10.0 ± 9.6</td>
</tr>
<tr>
<td>Lateral standing</td>
<td>Talo-first metatarsal</td>
<td>Cavus</td>
<td>180.2 ± 0.5</td>
<td>180.3 ± 4.8</td>
</tr>
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useful up to the age of six months after which these reflexes decrease.

In congenital club foot there is subluxation or dislocation of the talonavicular joint and changes in the position of the calcaneus and the navicular with respect to the talus. The calcaneus inverts under the talus, showing adduction, varus and equinus deformities (Irani and Sherman 1963; Settle 1963). The navicular also displaces medially from the head of the talus and the forefoot is adducted. When one leg extends and the other flexes in the Denis Browne splint, the foot on the flexed side is forced into dorsiflexion, abduction and eversion.

Our carefully moulded shoe inserts are able to hold the hindfoot firmly to produce this effect. Foot plates or shoes which do not grip the calcaneus allow it to slide off; the forefoot is forced to dorsiflex and the foot develops a rocker bottom deformity as a result of kicking. The angle at which the shoe insert is attached to the crossbar is important. As this is increased, the calcaneus is abducted, and inserts which are made in full correction can act during kicking both to correct adduction of the forefoot and the displacement of the navicular. Our study has shown that congenital club feet can be corrected by the use of a modified Denis Browne splint.

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.

REFERENCES


