LONG-TERM RESULTS OF EARLY SURGICAL RELEASE IN CLUB FEET

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One-hundred and seventy patients with 252 club feet treated by early posterior release were reviewed after a follow-up averaging 15 years 10 months. The feet were assessed both functionally and clinically and the results related to any bony deformity found radiographically; a satisfactory result was obtained in 81%. Lateral tibial torsion was examined and found to be less than in a normal population.

The relationship between primary bone deformity and eventual functional result was examined, and a classification of talon dome deformity introduced. The range of ankle movement was a major factor in determining the functional result, and this in turn was influenced by the degree of talon dome flattening. It is suggested that the primary bone deformity present at birth dictates the eventual result of treatment.

For the last 20 years a standard treatment schedule for club feet has been used, with only minor variations, at the Adelaide Children’s Hospital. The programme consisted of early splintage, posterior capsulotomy of the ankle and elongation of the tendon calcaneus, followed by long-term splintage while at rest and an exercise programme.

The aim of this present study was to examine the long-term results of this method of treatment, paying particular attention to residual structural deformity and relating these to final functional results. To aid comparison with other series and to emphasise functional performance after treatment, an assessment schedule previously described by Laaveg and Ponseti (1980) was used and the correlation between subjective and objective results examined.

Treatment usually began within 24 hours of birth, and initial correction was achieved by long-leg plaster casts applied with minimal manipulation and no anaesthesia. Plasters were changed every three or four days and no attempt was made to dorsiflex the foot until the forefoot adduction and heel varus had been corrected. In most cases the heel equinus was corrected by strapping to a Denis Browne hobble splint (Coleman 1983). If at six to eight weeks the calcaneum remained high, operation was recommended. In the earlier part of the series the decision to operate was made later than this, although all other aspects of the treatment programme remained identical.

Surgical technique. Surgical release is performed with the child prone under general anaesthesia; a tourniquet is used. If necessary, both feet are operated on at the same sitting. A longitudinal incision is made just medial to the tendon calcaneus extending proximally about 4 cm from the transverse heel crease. The tendon calcaneus is exposed and its spiral fibres split longitudinally with small artery forceps: the tendon is then elongated in a Z-manner, detaching the medial portion distally from the calcaneum; leaving a small portion of cartilage attached to the tendon facilitates later repair. After identification and protection of the neurovascular bundle, the tendon sheaths of the flexor hallucis longus and those tendons lying behind the medial malleolus are released distally as far as possible; it is usually not necessary to elongate these tendons.

The ankle joint capsule is then exposed and opened, the release extending medially and laterally around the malleoli to include the talofibular ligament, the calcaneofibular ligament and the deep portion of the deltoid ligament; it often helps to complete this step by blunt dissection with scissors or artery forceps. At this stage the joint opens appreciably, often revealing an incongruence at the mortise as the foot is dorsiflexed. To allow unhindered dorsiflexion of the talus, the distal tibiofibular joint is released by dividing both anterior and posterior tibiofibular ligaments. The subtalar joint is exposed and released to allow a little more correction of the heel equinus. With the foot held just above the neutral, the tendon calcaneus is repaired and the skin closed with a subcuticular suture. The leg is immobilised in this position for four weeks in a long-leg cast with the knee flexed at 90°.
After removal of the postoperative cast, short-leg resting splints are applied; these are retained at night until the foot reaches maturity. The parents are encouraged to stretch the feet into dorsiflexion, plantarflexion and valgus daily. If medial tibial torsion persists, the child wears derotation splints at night.

**PATIENTS AND ASSESSMENT**

Case records of all children operated on for congenital talipes equinovarus between 1960–1975 were studied. The patients were contacted by mail and were invited to attend a special review clinic; those who lived too far away completed a questionnaire, but for the purpose of analysis they were included with those patients who could not be traced. Patients who had previous extensive conservative treatment or surgery in other hospitals were excluded from the study. All the patients who were reviewed completed a questionnaire designed to assess pain, function and patient satisfaction.

Two hundred and forty-four patients with 343 club feet meeting our criteria were operated on at the Adelaide Children's Hospital between 1960 and 1975; 170 patients with 252 club feet were examined at review by two of the authors (PMH and EAC). This represents a follow-up rate of 70%; eight patients had died and 66 patients (28% of the survivors) were either untraced or were living too far away to be examined personally.

The mean age at follow-up was 16 years 4 months, with a range from 8 to 31 years. The mean follow-up period was 15 years 10 months, with a range from 7 to 25 years.

As in other series, there were twice as many boys as girls with congenital club feet. Bilateral involvement was present in half the patients. In those with unilateral involvement there was a slight bias towards the right foot being affected.

**Initial treatment.** Treatment had begun in the first week of life in 74% of feet and in the first two weeks in 84%; almost all feet had been treated within 100 days of birth. Ninety-nine percent of patients had been treated by a programme of plaster correction followed by Denis Browne splintage; the rest had serial fixed plaster treatment alone before operation.

All patients were operated on after the age of six weeks. Thirty-seven percent were operated on by 12 weeks, 64% by 24 weeks and 89% by one year. These figures could be misleading since, over the study period, earlier surgery became standard: in 1965 the mean age of surgery was 26 weeks but by 1975 this had dropped to 10 weeks. Night plasters were worn for a varying number of years but in 39% of patients they were worn for more than 10 years.

Operative complications were insignificant and occurred after the first operation in nine feet (3.6%), with wound breakdown or infection occurring in seven and plaster sores in two. All healed without further complications. The resulting surgical scar was inconspicuous in 70% of feet, obvious and widened in 30% and painful in one case.

Sixty-five patients (26.6%) had required an additional 84 surgical procedures (Table 1), the most common being a second posterior release; a lateral rotation osteotomy of the tibia was performed in 21% of those requiring further surgery. An extensive medial release was required in only four feet. The final results in patients needing additional procedures were less satisfactory than in those for whom this was not necessary ($P < 0.0001$).

**Clinical assessment.** At follow-up a clinical examination was performed to evaluate the gait pattern, leg length discrepancy, calf size, residual foot deformity, heel position and shape, ankle and hindfoot movement and the degree of tibial torsion. Two features of this examination deserve special mention. First, tibial torsion was measured on a torsiometer similar to that described by Wynne-Davis (1964); its essential features were a proximal reference point centred on the tibial tubercle, and mobile distal markers that could be centred on the tips of the malleoli; from these points the degree of tibial torsion could be measured (Fig. 1). Secondly, footprints were recorded using the Berkmann Orthoprint Foot Impression System (Orthopaedic Resources Corporation). This gave a graphic record of static pressure distribution through the sole and revealed subtle persisting deformities (Fig. 2).

A functional rating score derived from Laaveg and Ponseti (1980) was used; points were allocated for pain, limitation of activity, patient satisfaction, foot movement, heel position and gait; a score of over 70 was considered a satisfactory result.

**Radiographic assessment.** Three standard views were taken of all feet: a standing lateral; an anteroposterior view with the beam angled at 25° to the vertical (Laaveg and Ponseti 1980); and a true lateral radiograph of the ankle with the malleoli superimposed (Dunn and Samuelson 1974).

From these radiographs we were able to calculate:

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**Table 1. Additional procedures in 65 patients with club feet**

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Repeat posterior release</td>
<td>23</td>
</tr>
<tr>
<td>Medial release</td>
<td>4</td>
</tr>
<tr>
<td>Plantar fasciotomy</td>
<td>4</td>
</tr>
<tr>
<td>Tibial osteotomy</td>
<td>14</td>
</tr>
<tr>
<td>Os calcis osteotomy</td>
<td>13</td>
</tr>
<tr>
<td>Evans fusion</td>
<td>2</td>
</tr>
<tr>
<td>Metatarsal osteotomy</td>
<td>5</td>
</tr>
<tr>
<td>Hindfoot arthrodesis</td>
<td>6</td>
</tr>
<tr>
<td>Other</td>
<td>13</td>
</tr>
<tr>
<td>Total</td>
<td>84</td>
</tr>
</tbody>
</table>

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The degree of tibial torsion was measured by a torsiometer.

a) the talocalcaneal index (Beatson and Pearson 1966); b) the R/L ratio, that is, the ratio of the curvature of the talar dome to the length of the bone (Hjelmstedt and Sahlstedt 1980) (Fig. 3); c) the degree of talar flattening: as the study progressed, it became apparent that the degree of talar flattening in club feet was significant and feet were graded accordingly (Fig. 4); d) the degree of distortion at the talonavicular joint: this was assessed by the stage of navicular subluxation (Fig. 5) and the presence or absence of talar beaking (Fig. 11).

A full photographic record was made of all feet. The statistical analysis tests most commonly used were the Yates corrected chi-square (Yates 1934) and the Welch one-way analysis of variance (Welch 1947).

RESULTS

Functional grading. Using the Laaveg and Ponseti grading system (1980), feet were graded excellent (90 to 100 points) in 17.4%, good (80 to 89 points) in 39.9%, fair (70 to 79 points) in 23.7% and poor (under 70 points) in 19%; a satisfactory result was obtained in 81% of feet.

Fig. 1
The degree of tibial torsion was measured by a torsiometer.

Fig. 2
Foot printing in club feet. From left to right: a normal foot; a supinated forefoot; a high heel with an early mid-foot break; and a broken foot with weight-bearing under the midpoint of the longitudinal arch.

Fig. 3
Talar distortion. The R/L ratio, an index of trochlear flattening, was determined by measuring the radius of trochlear curvature of the talar dome (R) with Mose rings, and the length of the talus (L) from its posterior extremity to the centre of the head.

Fig. 4
Grades of talar flattening in club feet. Grade 0, a normal concentric curve with small recesses anteriorly and posteriorly; Grade 1, a concentric flattened joint with increased radius of curvature, lacking marginal recesses; Grade 2, a flattened joint with irregularities and no longer congruous; Grade 3, gross flattening and irregularity of the talar dome.
There was no statistically significant relationship between the functional result and the age at which treatment was begun or surgery performed; nor of the age to which the night splint was worn (Fig. 6), the degree of ankle movement or the R/L ratio. There was, however, a significant relationship between the functional grade and the talocalcaneal index ($P = 0.0003$).

There was no deterioration of function with increased length of follow-up.

**Subjective assessment.** Most patients (81.4%) claimed to be satisfied with their feet at the end of treatment. Residual deformity revealed by the footprint was not significantly related to patient satisfaction, which correlated closely with foot movement ($P = 0.0014$) and a normal gait ($P = 0.0001$).

Females, however, were significantly less satisfied with their feet than males (36.2% as opposed to 11.2%; $P < 0.0001$), and concern about the shape of the foot and leg was expressed by 60% of females but by only 25% of males ($P = 0.0001$).

Ninety per cent of patients were never or only occasionally limited even in strenuous activities: 146 patients were able to play the sport of their choice, but 24 were unable to do so; in this respect there was no significant difference between the sexes. Sports that required jumping tended to be avoided and several boys preferred soccer to Australian Rules football because they lacked the necessary plantarflexion to kick an oval ball. Abnormalities of gait were closely related to the limitation of activities ($P < 0.0001$).

Eighty per cent of patients rarely, if ever, had pain even on strenuous activity and the incidence of pain did not increase with length of follow-up. When present, pain was usually located about the lateral aspect of the hindfoot and was felt to be arising from the subtalar joint. No patient had required a triple arthrodesis for pain.

**Objective assessment.** A normal gait was associated with 23% of the feet. Abnormalities of toe-off were common and, in many patients a short-leg gait was detectable. The most common abnormality was noted during heel-walking, often achieved only by supination of the forefoot.

A limb-length discrepancy, measured from the anterior superior iliac spine to the base of the heel pad with the foot in the plantigrade position, was present in 110 patients. The mean shortening in these patients was 13 mm (range 5 mm to 35 mm). There was a significant
discrepancy of calf size in 20% of patients with unilateral club foot.

Most affected feet were shorter and wider than normal, with a more squat heel, and residual forefoot adduction was present in 35 feet (14%). Subtle deformities were detected on foot printing in 35% of cases, while persistent supination was present in 28%, a high heel in 5% and varying degrees of midfoot break and adduction in 16% and 14% respectively (Fig. 2). Persistent heel varus was present in 17% of feet, and varus of more than 10° was present in only two.

In-toeing was present in 30 cases and was related both to persistent metatarsus adductus and to decreased lateral tibial torsion. In 24 cases adduction of the forefoot was present and this was the sole cause of in-toeing in five. In six patients there was no evidence of persistent metatarsus adductus. Lateral tibial torsion in the in-toeing group was considerably less than normal and significantly less than in the club foot series as a whole. The mean tibial torsion in the normal leg was 17.5°; in club feet, 15°; and in those with in-toeing, 9° (P=0.0001) (Fig. 7).

Ankle movement was equal to the normal side in only two patients, and the foot would not dorsiflex above the neutral in 44% of cases. Movement was not influenced by the age at which treatment had begun or at which surgery was performed, nor did it deteriorate with time. The deterioration in mean ankle movement in each functional group was significant (P<0.0001). The degree of ankle movement in each group is shown in Figure 8.

Radiographic assessment. The talocalcaneal index was measured in all cases and showed a significant relationship to the functional grading (P=0.0003) (Fig. 9).

Only 221 radiographs (88%) were adequate for assessing the shape of the talar dome, and of these 74% showed an abnormal degree of talar flattening (Table II).

There was a gradual deterioration in ankle movement as the talus became flatter, and this was accompanied by a lower functional score. The type of treatment and the age at which it had begun had no influence on the degree of
talar flattening, nor did the talus become any flatter with increasing age.

Significant navicular subluxation (Stages 2 and 3) existed in 27% of cases, although in only 4% did the navicular abut against the medial malleolus (Stage 3). No significant relationship existed between the degree of displacement and the age at which the first operation was performed, and there was insufficient data to link the age of beginning treatment with displacement. In the more severe cases, restoration of a nearly normal placement of the navicular was achieved by distorting its shape so that it became wedge-shaped; this, however, was associated with distortion of the talar head (Figs 10 and 11). Talar beaking became significantly more common with longer follow-up; the presence of a spur correlated closely with limitation of activity ($P = 0.0033$) but did not show any significant relationship to pain.

The R/L ratio was related to the talocalcaneal index (correlation coefficient = 0.2025) and correlated with the degree of talar flattening (Table III). The shape of the talus, as measured by the R/L ratio, was not significantly influenced by either the age when treatment began or the age at operation. The normal value did not differ significantly from the normal values quoted by Hjelmstedt and Sahlstedt (1980).

**Untraced patients.** These differed from the main study group in that they were older and there were more females. These differences could be explained by difficulties in tracing women who changed their names with marriage. In other aspects the groups were similar and therefore did not detract from the conclusions in the study.

**DISCUSSION**

The comparison of success rates for the treatment of any medical condition is complicated by two factors: variation between study groups, and the absence of common assessment protocols. Recently quoted success rates for the treatment of club feet vary between 50% (Main et al. 1977) and 84% (Ghali et al. 1983), but the criteria for success also vary. One dissimilarity in the assessment of treatment is that some surgeons depend predominantly on manipulative treatment and consider operative intervention a criterion of failure (Wyne-Davies 1964; Fripp

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**Table II.** Talar flattening in 221 club feet assessed radiographically, and correlated with functional score and ankle movement

<table>
<thead>
<tr>
<th>Talar grade</th>
<th>Number of feet</th>
<th>%</th>
<th>Mean age at first treatment (days)</th>
<th>Mean age at first operation (weeks)</th>
<th>Mean functional score ± SD</th>
<th>Mean ankle movement ± SD (degrees)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>57</td>
<td>26</td>
<td>8.8</td>
<td>43</td>
<td>82.3 ± 10.39</td>
<td>31.6 ± 7.5</td>
</tr>
<tr>
<td>1</td>
<td>118</td>
<td>53</td>
<td>6.1</td>
<td>22</td>
<td>81.7 ± 9.9</td>
<td>26.4 ± 8.8</td>
</tr>
<tr>
<td>2</td>
<td>43</td>
<td>19.5</td>
<td>7.2</td>
<td>20.6</td>
<td>77.6 ± 10.3</td>
<td>18.3 ± 6.9</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>1.5</td>
<td>4</td>
<td>21.5</td>
<td>70.3</td>
<td>5</td>
</tr>
</tbody>
</table>

* Laaveg and Ponseti 1980

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**Table III.** Grade of talar distortion correlated with the R/L ratio in normal and club feet

<table>
<thead>
<tr>
<th>Talar flattening</th>
<th>R/L ratio ± SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>0.365 ± 0.045</td>
</tr>
<tr>
<td>Club feet 0</td>
<td>0.411 ± 0.058</td>
</tr>
<tr>
<td>1</td>
<td>0.450 ± 0.059</td>
</tr>
<tr>
<td>2</td>
<td>0.492 ± 0.078</td>
</tr>
<tr>
<td>3</td>
<td>NA</td>
</tr>
</tbody>
</table>
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and Shaw 1967; Laaveg and Ponseti 1980), while for others an operative approach is standard (Turco 1971; Main et al. 1977; Ghali et al. 1983; Porat, Milgrom and Bentley 1984). There are series that emphasise radiographic features as a measure of success (Turco 1971; Thompson, Richardson and Westin 1982), the most common criterion being the lateral talocalcaneal angle (Turco 1971; Laaveg and Ponseti 1980; Thompson et al. 1982), although Beatson and Pearson (1966) thought that better delineation of results could be obtained by the talocalcaneal index. Clinical features have been taken into account in most series, although very few have paid attention to the patient’s own assessment of the foot at the end of treatment (Laaveg and Ponseti 1980).

In the past much emphasis has been placed on anatomical and radiographic perfection but, in a condition where bony deformity at birth is well documented (Scaopa 1818; Adams 1866; Irani and Sherman 1963; Settle 1963; Kaplan 1972; Waisbrod 1973), it is unreasonable to expect that treatment either by plaster or by surgery will restore normal anatomy in the more deformed feet. In our review we have therefore chosen to use the predominantly subjective assessment previously published by Laaveg and Ponseti (1980).

However, patient satisfaction was difficult to interpret. It was apparent from the study that women were three times more dissatisfied with the final result of treatment than men, and this was mostly due to the appearance of the calf. However, because calf wasting is part of the generalised limb dysplasia there seems little chance of influencing this outcome at present. Fifty per cent more women than men considered themselves disabled, and although concern was expressed about the appearance of the foot and leg, other features such as limited ankle movement and gait abnormalities also were important considerations.

The incidence of scar problems after posterior release was high (30%), with broadening of the scar and varying degrees of keloid formation accounting for the majority of problems; this occurred despite careful closure with a non-retained synthetic subcuticular skin suture. Problems with wound healing after posterior release are known to be common (Gillies and Chalmers 1970; Inglis et al. 1976; Nistor 1981), and perhaps a shoe-top incision would be more appropriate.

Over the last few decades there has been a move to operate on feet earlier on the assumption that better correction is achieved (Main et al. 1977; Ghali et al. 1983; Porat et al. 1984), and this trend has been reflected in the current series. There are, however, authors who support treatment at a later age, when the foot is larger and the bones more calcified (Turco 1971; Hjelmstedt and Sahlstedt 1980; Thompson et al. 1982). In our series it has not been possible to link the success rate or any clinical and radiographic features with the age at which operation was performed. We believe, however, that early operation corrects the foot to a plantigrade pos-

The current series is similar in many ways to that published by Laaveg and Ponseti (1980): both have had comparable follow-up periods and both have been assessed in a similar manner. The overall satisfactory result in both groups was over 80%, although our series had fewer excellent results. In both series, rates for limited activity or restricted sports due to pain, heel position and hindfoot movement were similar. A difference did exist in measured ankle movement: in our current series, 44% of patients were unable to dorsiflex above the neutral position, whereas Laaveg and Ponseti had at least 70% who could achieve that movement. This may have contributed to their greater number of excellent results. The prolonged use of night splints has been an essential part of our treatment programme, with many children wearing them into their teens. From this study we have not been able to detect any differences in the eventual functional results in children who discarded splints early and those who used them for longer periods. In view of this finding, and considering the imposition on children having to wear night splints, we would recommend that they be removed at an earlier stage of treatment.

Several authors have debated whether tibial torsion is increased, decreased or normal in patients with club feet (Hutter and Scott 1949; Kite 1964; Wynne-Davies 1964; Swann, Lloyd-Roberts and Catterall 1969; Ker-

mosh. Lior and Weissman 1971; Dunn and Samuelson 1974; Sage 1980). Our figures confirm that lateral tibial torsion is not increased in club feet (Fig. 7) but is significantly less than normal, especially where there is persistent in-toeing. This finding also emphasises that persistent in-toeing after treatment for club foot may not be the result of under-correction of the forefoot and suggests that there may be a place for lateral rotation osteotomy of the tibia in these patients. It may be that the findings of increased lateral tibial torsion in some series parallels poor correction of the forefoot and is compensatory.

Analysis of tibial torsion in patients treated with or without derotation bars has failed to reveal any significant difference between the two groups, and they were thus not separated in our analysis; similar reports about the effect of such splints on femoral rotation have been presented elsewhere (Fabry, MacEwen and Shands 1973). It is therefore possible that no place exists for these splints in the treatment of tibial torsion, and we would recommend a prospective study of their use.

The abnormal bony feature found most consistently in club feet at birth is the medial and plantar deviation of the talar head and neck (Adams 1866; Irani and Sherman 1963; Settle 1963). Although emphasis has been placed on the flattening of the talar dome secondary to pressure or ischaemia (Swann et al. 1969; Dunn and Samuelson 1974), less comment has been made about the degree of abnormal flattening that may exist before any manipula-
tive treatment begins (Kaplan 1972; Hjelmstedt and Sahlstedt 1978). The distortion of bony anatomy interferes with normal foot movement, as navicular displacement prevents both dorsiflexion (Main and Crider 1978) and subtalar movement (Turco 1971), while flattening of the talar dome interferes with normal ankle mobility (Hjelmstedt and Sahlstedt 1980). It is these bony abnormalities that treatment, whether manipulative or operative, aims to correct and its success will depend on the severity of the abnormality; correct re-orientation of the navicular, for example, has been directly related to a successful outcome (Main and Crider 1978; Thompson et al. 1982).

In many feet abnormal anatomy persists after treatment (Hjelmstedt and Sahlstedt 1980) or may be distorted even more by treatment (Ponseti et al. 1981; Thompson et al. 1982). When the head and neck of the talus are grossly deviated, the navicular, to be orientated to the line of the foot, becomes progressively wedge-shaped.

To measure talar distortion we have used the R/L ratio of Hjelmstedt and Sahlstedt (1978): the flatter the talar dome and the shorter the overall length of the talus on the true lateral, the higher the ratio; moreover, a ratio found at an early age does not change (Hjelmstedt and Sahlstedt 1980). As our normal figures are similar to those published in the earlier article, we feel that the talar shape does not vary markedly beyond the age of eight years. The ratio probably indicates the degree of deformity at the start of treatment and therefore provides a useful measurement for comparing retrospective series.

As in other series, the quality of the end result in our patients related closely to the talocalcaneal index; this in turn depended on talar distortion as measured by the R/L ratio. These findings suggest that, in the more deformed feet, the anatomy of the talus inhibits reduction and a normal angle cannot be restored unless the bony anatomy is altered.

Gross degrees of talar flattening (Keim and Ritchie 1964; Dunn and Samuelson 1974), were uncommon and accounted for only 1.5% of feet in this series. For two of our patients it was not possible to relate this damage to forced manipulation, but we nonetheless considered these cases as complications of treatment.

The eventual functional results showed a significant dependence on ankle movement, which in turn was related to the degree of talar flattening. As this latter feature remains largely unchanged after birth, it seems that ankle movement is predetermined at the start of treatment (Hjelmstedt and Sahlstedt 1980) and that ankle capsulotomy only releases the talus to its full potential range of movement. The most significant difference between the grades of talar flattening is the greater mean age at operation in the Grade 0 group; we feel that these less anatomically abnormal feet probably had responded better to initial manipulative treatment and were therefore operated on later.

Residual navicular subluxation was present in 27% of feet but in only 4% was the navicular touching the medial malleolus; in these the head and neck of the talus was deviated medially. Navicular displacement was related to our functional results and this is in agreement with other authors (Main and Crider 1978; Thompson et al. 1982) in that results were worse if the navicular remained medially displaced.

Full ankle movement has been a prerequisite for an excellent result in several series (Main et al. 1977; Thompson et al. 1982; Ghali et al. 1983; Porat et al. 1984). In our series normal ankle movement was found in only two patients. Even in the group with excellent results there was a significant decrease in range of movement and this progressively deteriorated as the functional score dropped. We equated this limitation of ankle movement to the progressive flattening of the talar dome (Table II); medial and plantar deviation of the talus head seems to cause additional restriction, and this inhibits the talus on the calcaneum (this was demonstrated by the link between the talocalcaneal index and the R/L ratio). That abnormal subtalar movement was occurring, and therefore interfering with normal ankle movement, was demonstrated by the increased incidence with age of traction spurs on the talus head. Distorted talar anatomy therefore precludes normal ankle and subtalar motion.

Our treatment programme was used by many surgeons of varying degrees of experience; it is safe, simple and gave an acceptable result in 81% of club feet, a result that did not deteriorate with age. The eventual result is a plantigrade foot that is rarely painful, that dorsiflexes to the neutral and that rarely restricts the patient's activities. The result is, however, predetermined at birth by the structural constraints of the bony anatomy; if one is to improve results further, one should consider operating on the abnormal talus itself (Hjelmstedt and Sahlstedt 1980).

We wish to thank all consultants, past and present, who have encouraged follow-up of their patients, and the staff of the Radiographic and Medical Illustration Departments at the Adelaide Children's Hospital who have given their assistance during this study. We are grateful to the staff of the Data Processing Department of the Adelaide Children's Hospital and to Philip Leppard of the Department of Statistics, University of Adelaide, for their help in the interpretation of the data. Miss Sharon Slater has been invaluable during the study, both in contacting patients and in typing the manuscript. The work has been financed by grants from the Channel 10 Children's Medical Research Foundation of South Australia and the Adelaide Bone and Joint Research Foundation Inc.
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