We present the results of the management of 17 relapsed club feet in 12 children using the Ilizarov method with gradual distraction and realignment of the joint. Review at a mean of three years after surgery showed maintenance of correction with excellent or good results in 13 feet. Five mobile feet which had been treated by a split transfer of the tibialis anterior tendon two weeks after removal of the frame had an excellent result.

**Patients and Methods**

Between 1994 and 1996 we treated 12 children, seven boys and five girls, with idiopathic club feet who had undergone corrective surgery, but whose deformity had recurred, using the Ilizarov technique. Table I gives the details of the patients including their previous surgery, and the degree of recurrent deformity. Their mean age was 7.8 years (6 to 11). There were seven unilateral and five bilateral deformities. All the operations were carried out by the senior author (CFB).

**Operative technique.** The fixator was applied to the lower limb and foot under general anaesthesia. In cases of bilateral deformity both feet were treated at the same operation. The frame was assembled on the leg at the time of surgery, and not beforehand. All the frames included two tibial rings attached with four crossed 1.5 mm wires which were tensioned to between 90 and 100 kg. The tibial rings were applied first and then the foot frame was constructed. The forefoot half-ring was applied first and secured by two crossed wires passing through the metatarsals but transfixing only those of the little and great toes. This half-ring was then fixed to the distal tibial ring as shown in Figure 1. The assembly allows correction of the recurrent supination deformity by shortening the lateral rod while lengthening the medial rod. The forefoot deformity was corrected acutely until soft-tissue resistance was encountered. The hindfoot half-ring was then applied using two crossed wires through the os calcis and secured to the distal tibial ring by rods and hinges as shown in Figure 1. The hinges were placed to allow gradual correction of the hindfoot varus and equinus. They allowed descent of the heel but did not dictate that correction should occur at the level of either the ankle or subtalar joint. Correction was achieved by distraction and realignment of both these joints. This could therefore be classified as an ‘unconstrained’ frame.

Gradual correction of the deformity was begun on the day after surgery. Hindfoot correction was performed by lengthening of the two posterior rods, in the medial rod at...
a greater rate than in the lateral, to correct both equinus and varus simultaneously. The precise rates of lengthening depended on the degree of deformity. Usually, that for the medial rod was 2 mm daily in four increments of 0.5 mm, while for the lateral rod it was 1 mm daily in four increments of 0.25 mm. Deformity of the forefoot was corrected simultaneously by adjusting the two connecting rods at 1 mm daily, shortening the lateral while lengthening the medial.

When the hindfoot deformity and the forefoot supination

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Table I. Details of the 12 patients and the results of treatment

<table>
<thead>
<tr>
<th>Case</th>
<th>Gender</th>
<th>Age (yr)</th>
<th>Side</th>
<th>Previous treatment in addition to first release*</th>
<th>Initial deformity (Eq, Var, Ad, Sup)(degrees)†</th>
<th>Final deformity (degrees)</th>
<th>Time in frame (wks)</th>
<th>SPLATT‡</th>
<th>Length of follow-up (yr)</th>
<th>Result</th>
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<td>6</td>
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<td>Mt ost</td>
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<td>No</td>
<td>2</td>
<td>Fair</td>
</tr>
<tr>
<td>2</td>
<td>F</td>
<td>10</td>
<td>Right</td>
<td>Mt ost</td>
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<td>3</td>
<td>M</td>
<td>6</td>
<td>Left</td>
<td>Mt ost</td>
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<td>2</td>
<td>Excellent</td>
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<tr>
<td>4</td>
<td>F</td>
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<td>No</td>
<td>3</td>
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<td></td>
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<tr>
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<td>7</td>
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<td>7</td>
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<td>Right</td>
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<tr>
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<td>Calc ost, Tib ost</td>
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<td>7</td>
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<td>TATT, Tib ost</td>
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<td>Poor</td>
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</tbody>
</table>

* Mt ost, metatarsal osteotomy; Calc, calcaneal; Tib, tibial; Med, medial; Smal, supramalleolar; TATT, tibialis anterior tendon transfer; Rpt PMR, repeat posteromedial release; DEs, Dillwyn Evans
† Eq, equinus; Var, varus; Ad, adduction; Sup, supination
‡ split tibialis anterior tendon transfer

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Fig. 1a Fig. 1b Fig. 1c

Anteroposterior (a) medial (b) and lateral (c) views of the frame.
had been corrected, additional rods were added to connect the hindfoot and forefoot half-rings as shown in Figure 1. By adjusting these rods any forefoot adduction may be corrected. This was achieved by lengthening the medial rod at the rate of 1 mm daily and the lateral rod at 0.5 mm daily.

**Aftercare.** The children were usually discharged home within a week of operation. Their carers were instructed as to how to look after the frame and taught which rods to adjust. All the children were reviewed at weekly intervals while correction was proceeding and the frame adjustments made as required. Radiographs were taken at weekly intervals while correction was being performed and the position of the talus in the ankle mortice monitored. Physiotherapy was given two or three times per week on an outpatient basis to prevent the development of knee or toe contractures. Any toe deformity was treated by toe slings attached by rubber bands to the forefoot or distal tibial ring.

Mobility was restricted while in the frame, particularly before the achievement of a plantigrade foot. When the foot was plantigrade the children were allowed to bear weight fully in the frame and were provided with a cushioned sole attachment or slipper, secured to the frame by either laces or velcro straps (Fig. 2).

The aim was for slight overcorrection of the foot and when this had been achieved the frame was retained for a further six weeks until removal under general anaesthesia. A below-knee plaster was then applied to maintain correction and worn for six weeks with a change at two weeks, when a cast was taken for an ankle foot orthosis (AFO). The AFO was then worn day and night for six months.

If the deformity was rigid before surgery it was anticipated that the outcome would be a rigid but plantigrade foot and thus no additional tendon transfer was undertaken after removal of the frame. In children with a mobile but deformed foot it was hoped that mobility would be maintained after correction.

In this case a split transfer of the tibialis anterior tendon was performed two weeks after removal of the frame to try to maintain the correction. The delay of two weeks was to allow any swelling to settle after removal of the frame. The foot was then protected in plaster for a further six weeks.

**Results**

The mean time to achieve correction of the deformity was 4.5 weeks (3 to 6). All the children then spent an additional six weeks in the frame. They were reviewed independently by the junior author (SN) and the results were analysed using a scoring system based on the degree of correction achieved. The preoperative deformity had been measured in all children using a goniometer and expressed in terms of the degree of equinus, hindfoot varus, forefoot adduction and supination. The sum of the measured final angles was expressed as a percentage of the initial deformity. An excellent result was a plantigrade foot or one with only a trace (5° or less) of residual deformity. A good result was a foot with correction of more than 75%, a fair result of between 50% and 75% and a poor result of less than 50%.

Using this system eight feet were graded as excellent, five as good, two fair and two poor. In the five feet in which a tendon transfer had been performed after removal of the frame all the results were excellent.

The feet were also assessed in terms of function and parental satisfaction. Those children with a poor outcome did not have improved function. In all those with an excellent and good result, walking ability and shoe wear were improved and their parents were pleased with the outcome, noticing a considerable improvement in the shape of their child’s foot.

Figure 3 shows the appearance of the foot in one child (case 11) during and after completion of treatment. This patient had a split transfer of the tibialis anterior tendon after removal of the frame and has maintained an excellent result at the follow-up at three years.

**Complications.** Most patients had at least one episode of
infection at a site of insertion of the wire. All responded to antibiotics and no wires had to be replaced because of persistent infection or breakage.

One child developed a flexion deformity of his great toe which did not respond to dynamic splintage. Under general anaesthesia the toe was manipulated into the straight position and stabilised by a Kirschner wire secured to the frame (Fig. 3b). In one child separation of the distal tibial physis was observed after correction of the equinus deformity. Subsequently, full correction was achieved and the result was classed as excellent. His tibia continues to grow satisfactorily and there is no evidence so far of arrest of growth.

The frame was well tolerated by all the children and none of the parents or children requested its premature removal.

Discussion

The aim of treatment for club foot is to obtain a fully corrected and mobile foot at maturity. Recurrent deformity is observed in approximately 20% of cases. In the long term a foot with some residual deformity, but retaining mobility, may be superior to that with an absolute anatomical correction but which is stiff. However, recurrent deformity, in which the child walks on the side of the foot or there is interference with shoe-fitting, requires attention. The conventional treatment is to perform either repeated or more radical soft-tissue releases, tendon transfers or ostotomies. Each of these may result in stiffness of the foot or reduction in the size of an already small foot.

The Ilizarov technique achieves correction by distraction of the joint allowing realignment. The soft-tissue tension may also stimulate bone growth but this is difficult to determine radiologically. It has also been suggested that there is less stiffness with the Ilizarov technique, but in our series most of the feet were stiff before treatment and we were therefore unable to assess this. It is our impression, however, that no additional stiffness was created, which agrees with the conclusion of Wallander et al.

Ganel et al reported the development of bone cysts after this treatment, most commonly in the base of the fifth metatarsal. We also observed these but their significance is as yet unknown and their occurrence did not correlate with the outcome or interfere with the function of the foot in any way.

The best results in our series were obtained in those
children who had retained some mobility of the foot but had developed an equinus, varus, adduction and supination deformity which necessitated walking on the side of the foot. The Ilizarov technique allowed correction of the deformity without the need for an open operation. After this procedure a split transfer of the tibialis anterior tendon has maintained the correction in five feet which retained mobility. In children with rigid feet on which a tendon transfer was not performed, the results have been less predictable, probably because correction was achieved by generating incongruity of the joint. In those feet with an unsatisfactory outcome the deformity recurred as the deformed joints returned to their original positions. These cases would probably have benefited from osteotomies to aid their correction. Paley\(^9\) has recommended that osteotomies of the foot be used in conjunction with Ilizarov treatment in children over eight years of age. In younger children who retain some mobility of the foot, however, the technique of joint distraction alone has proved to be reliable. In these children the Ilizarov technique should be considered as an alternative to repeated soft-tissue releases or correction by osteotomies. In recurrent equinus deformity it avoids the need for further lengthening of tendo Achillis, thus reducing the risk of weakening 'push-off' and generating a calcaneus deformity.\(^{13}\)

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