RELAPSING CLUB FEET

LATE RESULTS OF DELAYED OPERATION

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The operation of soft-tissue release and calcaneocuboid fusion, published by Dillwyn Evans in 1961, is described in detail and a long-term review of 118 club feet is presented. The average age of the patients at review was nearly seventeen years. All were resistant cases and in all the Dillwyn Evans "collateral operation", deliberately delayed by a policy of prolonged conservative treatment, had been the main surgical procedure.

Despite the wide variety of treatments for club feet, it is generally agreed that about half the cases can be fully corrected by some form of manipulation and splintage alone; argument centres around the nature, and particularly the timing, of any operation required in the remainder. In recent years, there has been a discernable trend towards very early soft-tissue release procedures (Attenborough 1966; Turco 1971; Main *et al.* 1977; Pous and Dimeglio 1978), on the grounds that this congenital abnormality is best treated early in order to prevent uncorrected deformity affecting normal growth. Such a policy is logical only if it can be established that club foot is not progressive; the question is, were past surgical failures the inevitable result of a truly relapsing condition, or were they simply due to inadequate operation?

One upholder of the relapsing theory was the late Dillwyn Evans who, consequently, recommended a very prolonged course of conservative management, using immobilisation in a plaster cast in the early stages. When necessary, closed tenotomy of the calcaneal tendon was performed; but apart from this, operation was deliberately withheld in all cases until the age of about six years, when it was felt that all danger of relapse had passed. The sole reason for delay was to enable total and permanent correction to be achieved by a single operation, for Evans maintained that the final results were always jeopardised by more than one major surgical procedure. In all his cases, the single procedure concerned was the one which he described and which internationally bears his name, but which he preferred to call the "collateral operation".

Fig. 1

Fig. 2

Fig. 3

Fig. 4

Figures 1 and 2—Before and after Dillwyn Evans operation. Figures 3 and 4—Radiographs before and after operation.

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The long-term results of his programme of treatment in a series of patients, now averaging seventeen years of age, are presented here. Since attention to detail has proved to be very important, the opportunity has

been taken to describe the steps of the operation more clearly than in previous publications.

OPERATIVE TECHNIQUE

This operation is in four stages, the first three consisting of an extensive soft-tissue release which enables the whole hindfoot to be realigned. Finally a calcaneocuboid wedge is excised, so removing a deformed joint and shortening the lateral border of the foot (Figs 1 to 4).

Stage I. A closed tenotomy of the plantar fascia is performed and the plantaris (cavus) deformity can then be loosened with a Thomas's wrench (Fig. 5).

Stage II. (Fig. 6) A medial skin incision is made from just in front of the tubercle of the navicular, back to a point beneath the medial malleolus. The tibialis posterior tendon is identified and divided in Z-fashion. The soft tissue between tibialis posterior and the neurovascular bundle (underlying the flexor digitorum longus), is then excised. Now the talonavicular joint is identified, this joint being very oblique in a varus foot, and the capsule is divided using a tenotome slid into the joint to cut the superior and inferior parts. Next the anterior talocalcaneal joint is identified and its capsule also divided with a tenotome. Similarly the capsule of the posterior talocalcaneal joint is divided as completely as possible. The tibialis posterior is then sutured in an elongated position.

Stage III. (Figs. 7 and 8). The calcaneal tendon is exposed through a posteromedial incision, which is approximately 7 centimetres long and which extends well down to its insertion. The tendon is divided in Z-fashion. Next, the sural and posterior tibial nerves (and vessels) are

Fig. 5
Division of plantar fascia.

Fig. 6
Medial release.

Fig. 7

Fig. 8

Figure 7—Posterior incision and excision of deep fascia. Figure 8—Posterior capsulotomy and division of ligaments.

identified laterally and medially respectively; all deep fascia between them is excised. The posterior capsule of the ankle joint and the posterior tibiotalar ligament are divided with a tenotome. Then capsulotomy of the posterior talocalcaneal joint is completed, the tibiocalcaneal fibres of the deltoid ligament being included in the division. Both the ankle and subtalar joints are often visible only as thin fissures posteriorly if severe equinus is present. Lastly, the posterior talofibular and the calcaneofibular ligaments are divided.

Powerful manual dorsiflexion of the foot now achieves full correction of the equinus and mobility of the entire hindfoot. This manoeuvre is often accompanied by a loud crack as the final strands of contracted tissue part. The calcaneal tendon is now sutured in the elongated position.

Stage IV. (Fig. 9). A short incision is made over the calcaneocuboid joint, parallel with the peroneal tendons. The sural nerve is identified and retracted, and extensor digitorum brevis is partially divided and stripped up as necessary to expose the calcaneocuboid joint. This joint is then excised with a knife (if very cartilaginous) or with an osteotome. The amount excised is usually less than anticipated, and is wedge-shaped in order to correct the varus deformity. If the foot is cavus, as it often is, then the wedge needs to be wider dorsally as well as laterally. If a rocker-bottom foot has been produced before operation, then the wedge can be made wider inferiorly.

Fig. 9

Arthrodesis of calcaneocuboid joint.

At this point, supination of the forefoot is corrected by rotating the forefoot on the capsulotomised talonavicular joint; the calcaneal and cuboid surfaces are apposed and held with two staples which maintain the correction. The amount of correction needed has in the past been judged by the external appearance of the foot; this is not altogether satisfactory and is commented on later.

After operation. The foot is immobilised in a below-knee plaster cast for four months; weight-bearing is not permitted for the first six weeks. When the plaster is removed, normal shoes are worn and no further treatment is necessary. The staples remain *in situ* until union is sound or until growth is finished.

MATERIAL AND METHOD

Only patients over the age of ten years were asked to attend. Arthrogyptotics and children with other congenital malformations were excluded. In all, eighty-four patients attended for review with a total of 118 club feet. This represents 53 per cent of the total number of collateral operations performed at Cardiff on idiopathic club feet.

Ninety of the operations had been performed by Dillwyn Evans himself; the remaining twenty-eight by surgeons trained by him and usually under his supervision.

Of eighty-four patients reviewed, sixty-two were boys and twenty-two girls. Forty-two had had a

unilateral club foot and forty-two bilateral, of which only thirty-four needed bilateral operations, since conservative management had been successful on one side in eight.

All the patients had been treated from birth by manipulation and intermittent plaster immobilisation; the average duration of this treatment was 2.8 years. Forty-two feet (35 per cent) had required a closed tenotomy of the calcaneal tendon during this initial period, and five of these (4 per cent) needed a second tenotomy. The average age of the children at operation was 6.2 years, the youngest being 2.8 and the oldest 14.6 years. The average follow-up period was 10.7 years, the shortest being six months and the longest 23.2 years. Only four cases had less than a five year follow-up. Staples were used to hold the position of the calcaneocuboid fusion in ninety-eight (83 per cent) of the feet.

Assessment was based on symptoms (functional) and on signs (clinical). Deformity is so important a feature that it was separately assessed and, where appropriate, also measured on radiographs.

Functional assessment. All patients were asked the following eight questions and given points out of eight if their answers were favourable. Have you any pain? Does your foot tire easily? Does your foot feel stiff? Can you walk normally? Can you walk normally on uneven ground? Can you run normally? Are you able to take part in sport? Do you wear normal shoes?

It was felt that anything less than a full score represented a less than satisfactory foot; hence 8 points is good, 6 to 7 fair and 5 or less is poor.

Clinical assessment. All patients were examined clinically and then scored in accordance with the system suggested by Wynne-Davies (1964). This scoring system is from 0 to 10; scores of 8 to 10 are good, of 5 to 7 are fair ("serviceable feet") and of 0 to 4 are poor.

All feet were also assessed using the system advocated by Main *et al.* (1977) whereby any foot whose activity is limited in any way, or with residual fixed deformity, inability to dorsiflex or evert to neutral, or which needs further operation, represents an unsatisfactory result.

Assessment of deformity. The deformity in club foot can be divided into five components, which may occur in any combination. Equinus was measured as a distance; supination was assessed clinically, the other three were measured on radiographs. Lateral films were taken in the standing position; anteroposterior films were taken with the foot plantarflexed 30 degrees as described by Beatson and Pearson (1966). These films were also used to measure the talocalcaneal index, which provides a general assessment of deformity of the hindfoot.

Equinus. This was the measured distance between the heel and the floor when the patient stood with the tibia vertical.

Plantaris (known alternatively as forefoot equinus or

cavus). This we have defined as an angle of less than 131 degrees between the longitudinal axis of the os calcis and that of the shaft of the first metatarsal as seen on a lateral radiograph (Fig. 10). The normal lower limit in a personal series of seventy normal feet was found to be 131 degrees.

Fig. 10
Plantar angle.

Supination. This was assessed as the amount of varus deformity of the heel with the patient standing. Only moderate and severe degrees of varus were considered abnormal. Any elevation of the head of the first metatarsal in the standing position was also noted.

Varus of the navicular. This refers to medial displacement of the navicular on the head of the talus. We have defined it as a talonavicular angle of less than 85 degrees, this being the distal lateral angle between the long axis of the talus and the transverse axis of the navicular as seen on an anteroposterior radiograph (Fig. 11); the normal range is 85 to 100 degrees (Rasul Mir 1977; and personal series of forty normal feet).

Varus distal to the navicular. This is often called

Fig. 11 Fig. 12

Figure 11—The talonavicular angle. Figure 12—The metatarso-navicular angle.

metatarsus varus, though some of the deformity may also be in the naviculocuneiform joint; it is measured by the metatarso-navicular angle (Fig. 12) as described by Lowe and Hannon (1973). Any angle over 100 degrees was considered to be abnormal.

RESULTS

Functional assessment. Forty-seven per cent of the cases were rated as good, scoring 8 points; 31 per cent were rated as fair, scoring 6 or 7 points and 22 per cent were rated as poor, scoring 5 points or less. We noted that the function of the foot was not closely related to the clinical score, nor to the radiological appearance. In particular, a valgus displacement of the navicular on the head of the talus resulted in a foot which was radiologically poor but functionally better than the average in this series. Function was, however, related to the sex of the patient: boys' feet averaged 7 points which was very acceptable, whereas girls' feet averaged only 5 points which was poor.

Table I. Clinical assessment using Wynne-Davies' scoring system

Clinical score (Wynne-Davies' system)	Boys	Girls	Total
Good (8-10)	33 (36%)	3 (11%)	36 (31%)
Fair (5-7)	48 (53%)	16 (59%)	64 (54%)
Poor (0-4)	10 (11%)	8 (30%)	18 (15%)
Totals	91 (100%)	27 (100%)	118 (100%)

Table II. Clinical assessment using Main's system

Clinical result (Main's system)	Boys	Girls	Total
Satisfactory	56 (62%)	10 (37%)	66 (56%)
Unsatisfactory	35 (38%)	17 (63%)	52 (44%)
Totals	91 (100%)	27 (100%)	118 (100%)

Clinical assessment. It can be seen from Table I that, using Wynne-Davies' scoring system 85 per cent of the feet were clinically acceptable. The score was unrelated to the age of the patient at operation; but as, with the functional score, it was related to the sex of the patient, 89 per cent of the boys but only 70 per cent of the girls having acceptable results. These results compare favourably with Wynne-Davies' own (1962, 1964) which for good, "serviceable" and poor were 31, 34 and 35 per cent respectively.

From Table II it can be seen that, using the system advocated by Main *et al.*, 56 per cent of the feet were satisfactory. Again, the incidence of satisfactory results was unrelated to age at operation, and again, it was

related to the patients' sex: 62 per cent of the boys' feet were satisfactory but only 37 per cent of the girls'. Main's criteria are very strict. An unsatisfactory result does not necessarily imply that the foot is clinically unacceptable; it is simply the poor result of an attempt to produce a normal foot. Nevertheless, our series compares unfavourably with Main's (70 per cent of his were satisfactory); it may be relevant that all his patients were operated upon fairly soon after birth.

Table III. Incidence of deformity before operation and at review

Deformity	Percentage incidence before operation	Percentage incidence at review
Equinus	*	10
Plantaris	58	12
Supination (varus heel)	*	18
Varus of the navicular	83	31
Varus distal to the navicular	51	35

* No accurate figures are available though the likely figure approaches 100 per cent.

Assessment of deformity. Triple arthrodesis was performed on three feet; these have been excluded from this assessment. Only 37 per cent of the remainder had full anatomical correction of the deformity, although in a further 39 per cent only one component of the deformity remained. The persistence of deformity was unrelated to the sex of the patient or to the age at operation.

Table III lists the incidence of the five components of the club foot deformity, before operation and at review. It must be emphasised that this table takes no account of the degree of deformity, merely recording its presence which, particularly in the case of varus, may only be detectable radiographically.

Varus forefoot. We have described varus deformity as occurring proximal to the navicular or distal to it; clearly both may co-exist. Table IV compares our results with other published figures.

The persistence of talonavicular varus in 31 per cent of our cases led us to compare the radiographs before operation, after operation and at review (Fig. 13). It can be seen, that the talonavicular angles were considerably improved by operation and, more important, the review curve is almost identical with that soon after operation, indicating that once operation has been performed, the navicular is permanently fixed in relation to the head of the talus. We conclude therefore that any persistence of varus of the talonavicular joint at review, is due to undercorrection at operation and not due to any subsequent relapse.

Formal correction of metatarso-navicular varus (metatarsus varus) has not been part of the collateral operation up to now; hence the improvement in this

deformity from 51 to 35 per cent is likely to be fortuitous. Indeed, reference to Figure 14 shows that, in general, the metatarsus varus was not greatly altered by operation; nor has it corrected spontaneously over the years which have elapsed until review. This result is at variance with Wynne-Davies' (1964) conclusion that metatarsus varus "walks itself straight" as the club foot grows.

Valgus forefoot. Before operation, twelve cases of metatarsus valgus (a metatarso-navicular angle of less than 85 degrees) were found. All were associated with a varus navicular, and presumably represented the results of over-zealous manipulation at the wrong site. These feet did not look grossly deformed; hence, only a small calcaneocuboid wedge had been excised at operation. The result was that in seven the navicular varus was not completely corrected.

Before operation, there were no cases of valgus displacement of the navicular (a talonavicular angle of more than 100 degrees). However, seven cases of overcorrection of the varus navicular were found at review, four of these were severe resulting in extreme flat foot. Five of the seven had had metatarsus varus before operation: excision of the calcaneocuboid wedge had produced a cosmetically straight foot, but one with a radiological deformity. As mentioned earlier, the valgus navicular appeared to have no detrimental effect on function.

Table IV. Incidence of persistent varus forefoot: a comparison with other series

Varus	Lowe and Hannon (73 feet) per cent	Rasul Mir (52 feet) per cent	Present series per cent
Proximal to the navicular	38	14	26
Distal to the navicular	27	43	30
Deformity at both levels	15	2	5
Total radiological varus	80	59	61

From the above observations, it would seem that good correction of the navicular, judged by the external appearance of the foot, is not possible and accurate knowledge of the bony alignment of the whole forefoot is essential before operation.

Supination. Twenty-one cases (18 per cent) were found at review still to have moderate or severe varus deformity of the heel. All these cases were associated with recurrence, or undercorrection, of other aspects of the club foot deformity.

Forty-five cases (39 per cent) had elevation of the first metatarsal head. Twelve of these were associated with varus heels; four of the remaining thirty-three had abnormal plantar callosities and could be classified as metatarsus primus elevatus. Of the other twenty-nine, although the head of the first metatarsal was elevated

clinically, the skin underneath it was in contact with the floor, showed normal thickening and, when walking, weight-bearing appeared to be normal. In other words, twenty-nine forefeet were slightly supinated when standing still, and this appeared to be irrelevant.

Equinus. In all feet, equinus was fully corrected at operation. Dillwyn Evans was indeed obsessive about obtaining this correction. Nevertheless in twelve cases (10 per cent), the equinus had recurred, implying that in these feet at least, the pathological process had still not stabilised, though their average age at operation was 6.8 years.

Talocalcaneal index. The sum of the talocalcaneal angles

subtalar movement (Mahaffey 1945; Craig and Goldberg 1977), led us to believe that the cause of the stiffness in this joint did not necessarily lie in the operation.

Stiffness of the ankle. Dorsiflexion and plantarflexion were judged to be severely limited in 20 per cent, limited to some extent in 70 per cent and normal in only 10 per cent. The degree of mobility was unrelated to abnormality of the lower tibial epiphysis (38 per cent) or to a flat-topped talus (5 per cent) both of which were spread proportionally through the three classifications of this movement. There was in fact no evidence that this stiffness of the ankle was related to the operation.

Fig 13

Fig.14

Figure 13—Comparison of talonavicular angles before operation, after operation and at review. Figure 14—Comparison of metatarsonavicular angles before operation, after operation and at review.

as measured on anteroposterior and lateral radiographs is known as the talocalcaneal index. In normal feet this averages between 56 degrees (Main *et al.* 1977) and 62 degrees (Beatson and Pearson 1966). In our series, the average talocalcaneal index was 31 degrees at review.

COMPLICATIONS

The “collateral” operation was found, at review, to have had the following complications.

Shortening of the foot. The average discrepancy in the lengths of the two feet in the unilateral cases was 1.9 centimetres (range 0–3 centimetres). This compares favourably with other series (Wynne-Davies 1964; Reimann 1967) in which no calcaneocuboid fusions were performed, and we infer, therefore, that the collateral operation has no harmful effect on the growth of the foot.

Circulatory disturbance. Only five feet (4 per cent) were noted to be troublesome in cold weather, but all had normal peripheral pulses.

Stiffness of the subtalar joint. Inversion and eversion of the hindfoot were found to be severely limited in 50 per cent of the feet and slightly limited in 43 per cent. Only 7 per cent were judged to be normally mobile. However, these 7 per cent together with reports of patients with congenital calcaneocuboid fusion who had normal

Pseudarthrosis. The use of staples was unrelated to eventual bony union of the calcaneocuboid joint which persisted as a pseudarthrosis in fifteen feet (13 per cent). The occurrence of a pseudarthrosis was also unrelated to the age of these patients at operation (average 6.8 years), to the number of operations (only one had had the operation repeated), or to the eventual clinical and functional result. The average minimum time for radiological calcaneocuboid fusion to occur was 1.7 years with a range from six months to four years. Only thirty-eight cases had sufficient radiographs for these last figures to be estimated.

Repeat operations. Nineteen feet (16 per cent) required a repeat of the collateral operation and five feet (4 per cent) required a second repeat. The initial operation had been performed on these feet rather earlier than average (mean 5.0 years) and we felt that it was undercorrection at this operation which necessitated the revisions. The final functional and clinical results were worse than average, the clinical result being particularly poor following a second repeat operation. This would appear to justify Evans’s policy of avoiding staged procedures.

Total failures. Three feet were completely unacceptable and in them triple arthrodesis had been performed. Five more feet are awaiting arthrodesis, making a total absolute failure rate of 7 per cent.

DISCUSSION

The results of this long-term survey suggest that the method adopted by Evans was, on the whole, successful. Thus 78 per cent had an acceptable functional result while, depending on the method of analysis, 56 to 85 per cent had a clinically acceptable result. As others have noted before, analysis of radiographs brings to light a surprising amount of hidden deformity and only 37 per cent of our patients had full anatomical correction.

The results of our series compare well with many published previously, particularly when it is borne in mind that our series was loaded with severe cases referred from elsewhere because conservative treatment had failed. This is reflected by the fact that operation was required for about 60 per cent of the total number treated.

Nevertheless, the results are not as good as those of Main *et al.*, where early operation was employed; the average age of their patients at follow-up was only about seven and a half years compared with almost seventeen years in our series and it remains to be seen whether their advantage persists. Late deterioration might be anticipated from the findings in the present series for, in spite of the most meticulous correction at operation, equinus recurred in 10 per cent of our cases.

Four other findings are worthy of special mention. First, there was a high incidence of limitation of movement at the ankle and subtalar joints, a tendency noted also by Reimann (1967), who found that, irrespective of the regime of treatment, such limitation was present in every club foot examined. This implies that some loss of mobility in these joints is unavoidable, or at least becomes unavoidable at a very early age.

Secondly, varus of the navicular was undercorrected in one third of the feet; this was probably due to the custom, at operation, of judging correction from the

external appearance of the foot, and not from the precise positions of the bones themselves. Since the position of the navicular remains permanently fixed after operation, full correction must be obtained at the time of operation. This can be reliably achieved only by checking the reduction visually before the calcaneocuboid joint is fixed, which requires a slightly modified medial incision.

Thirdly, we found much poorer results, both clinically and functionally, in girls as compared with boys. As far as we can ascertain, this has not previously been noted, nor can we offer any explanation.

Lastly, it was not possible to demonstrate a relationship between the final results and the age of the patient at operation. Hence, we are unable to confirm Evans' opinion, supported by Abrams (1969), that there is a minimum age of four to four and a half years below which his operation is not likely to succeed.

This long-term review of the collateral operation shows a good percentage of acceptable results in very resistant club feet. Most of the poor results of correction of the deformity are due to technical errors at operation. It would seem likely, however, that in some cases failure is due to a dynamic element in the pathogenesis of the lesions. If this is so, methods of treatment based on the assumption of a purely static deformity invite relapse. There were no serious complications of the operation.

Two observations seemed particularly important. Firstly, the position of the navicular is permanently stabilised by this operation; accurate reduction at operation is therefore essential. Secondly, varus distal to the navicular (metatarsus varus) is not significantly altered by this operation; it would therefore seem appropriate to identify the presence of this deformity before operation, and to attempt its correction at the same time as the other deformities are being corrected.

We would like to express our gratitude to our secretary Mrs M. Hart without whose organising abilities this project would never have been completed, to Miss B. Wales and her team of radiographers and to Mr C. Walker, Mr P. Blake and Mr S. McAllister for the illustrations. Finally we would like to thank Mr H. Weisl for allowing us free access to his patients and both he and Professor B. McKibbin for their helpful criticism and advice.

REFERENCES

- Abrams, R. C. (1969) Relapsed club foot. The early results of an evaluation of Dillwyn Evans' operation. *Journal of Bone and Joint Surgery*, **51-A**, 270-282.
- Attenborough, C. G. (1966) Severe congenital talipes equinovarus. *Journal of Bone and Joint Surgery*, **48-B**, 31-39.
- Beatson, T. R., and Pearson, J. R. (1966) A method of assessing correction in club feet. *Journal of Bone and Joint Surgery*, **48-B**, 40-50.
- Craig, C. L., and Goldberg, M. J. (1977) Calcaneocuboid coalition in Crouzon's syndrome (craniofacial dysostosis). *Journal of Bone and Joint Surgery*, **59-A**, 826-827.
- Evans, D. (1961) Relapsed club foot. *Journal of Bone and Joint Surgery*, **43-B**, 722-733.
- Lowe, L. W., and Hannon, M. A. (1973) Residual adduction of the forefoot in treated congenital club foot. *Journal of Bone and Joint Surgery*, **55-B**, 809-813.
- Mahaffey, H. W. (1945) Bilateral congenital calcaneocuboid synostosis. *Journal of Bone and Joint Surgery*, **27**, 164-165.
- Main, B. J., Crider, R. J., Polk, M., Lloyd-Roberts, G. C., Swann, M., and Kamdar, B. A. (1977) The results of early operation in talipes equino-varus. *Journal of Bone and Joint Surgery*, **59-B**, 337-341.
- Pous, J. G., and Dimeglio, A. (1978) Neonatal surgery in clubfoot. *Orthopedic Clinics of North America*, **9**, 233-240.
- Rasul Mir, G. (1977) Forefoot adduction deformity in treated congenital talipes equino-varus. Thesis submitted to University of Liverpool (UK) for M.Ch.Orth.
- Reimann, I. (1967) *Congenital Idiopathic Club Foot*. Copenhagen: Ejnar Munksgaard.
- Turco, V. J. (1971) Surgical correction of the resistant club foot. *Journal of Bone and Joint Surgery*, **53-A**, 477-497.
- Wynne-Davies, R. (1962) The cause of congenital talipes equino-varus, together with a study of the functional anatomy after completion of treatment. Robert Jones Prize Essay, British Orthopaedic Association. (Personal communication.)
- Wynne-Davies, R. (1964) Talipes equinovarus. *Journal of Bone and Joint Surgery*, **46-B**, 464-476.