THE ANATOMY OF UNCORRECTED CLUB FEET
A Study of Rotation Deformity

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There is some uncertainty about rotational deformity of the lower leg in club feet. Many standard textbooks and some monographs describe medial tibial torsion as occurring constantly or often (McMurray 1943, Turek 1959, Campbell 1963, Kite 1964, Le Noir 1966). Mercer and Duthie (1964) mentioned medial torsion but considered it rare. Ober (1920) and Ferguson (1957) noted that the fibular malleolus is often displaced backwards in spite of the alleged medial torsion, and Wynne-Davies (1964) asserted that the hindfoot is laterally rotated on the tibia.

In this paper we will challenge the more generally supported belief that the tibia is medially rotated and propose that in uncorrected club feet the hindfoot and ankle mortise are laterally rotated on a tibia which has no rotational deformity. We will discuss the development and the clinical implications of this.

ANATOMY OF THE ESTABLISHED DEFORMITY

The lateral radiograph (Fig. 1) of a mature uncorrected foot and ankle with the knee pointing forwards shows the calcaneus in lateral profile, but the ankle is seen as in an antero-posterior projection. The talus is apparently "flat topped" and the calcaneus is shorter than normal, either because of real shortening or because rotation presents a foreshortened image in the coronal plane. In contrast the remainder of the foot lying anterior to the talus and calcaneus is apparently correctly aligned. The antero-posterior radiograph would, however, show this to be false because the forefoot is displaced into varus and this is confirmed by clinical observation (Fig. 2).

When the radiograph of the foot is repeated with the leg medially rotated 30 to 60 degrees (Fig. 3)—depending upon extent of the abnormality of the conventional lateral radiograph—the relationship between the hindfoot and forefoot is reversed, for now it is the hindfoot and ankle mortise which appear normal and the forefoot abnormal. Notably the calcaneus seems longer, the talus has a dome and normal malleolar relationship is restored. These findings are explained by lateral rotation of the hindfoot and ankle mortise upon the tibia. The forefoot remains medially rotated in relation to the hindfoot. We therefore differ from Curtis and Butterfield (1967), who interpreted these radiographic findings as being due to medial rotation of the talus in the ankle mortise. We believe that lateral rotation of the hindfoot is the responsible secondary deformity.

Conclusions drawn from radiographs alone are notoriously fallacious unless confirmed by clinical signs. We have four such observations to support the proposition.

First, without lateral rotation of the hindfoot, the foot might lie at almost a right angle to the leg when the talo-navicular joint is fully dislocated. This, in fact, does not happen.

Secondly, the head of the talus is palpable laterally below and in front of the outer side of the ankle in uncorrected club feet. Only lateral rotation could thus modify its normal alignment, for if it rotated inwards it would lie on the medial side of its normal position.

Thirdly, the lateral malleolus is palpable posterior and the medial malleolus anterior to their normal position when the tibial tubercle is pointing directly forwards. This is the
paramount sign by which the clinical diagnosis can be made before the deformity is fully developed (Fig. 4).

Lastly, medial rotation osteotomy of the tibia not only accentuates the varus of the forefoot but improves the alignment of the hindfoot clinically and radiologically (Figs. 5 and 6).

**FIG. 1**
Figure 1—Lateral radiograph of an uncorrected club foot. The ankle mortise appears in antero-posterior projection, the talus is apparently flat-topped and horizontal, the calcaneus is short. The forefoot looks relatively normal.

**FIG. 2**
Figure 2—Photograph of patient shown in Figure 1. The forefoot and heel are in varus. The tip of the medial malleolus (marked) lies anteriorly.

**FIG. 3**
Figure 3—Radiograph of the patient in Figure 1 repeated with the leg medially rotated. The ankle mortise is now correctly aligned; the talus is dome-shaped and the calcaneal length and contour are improved. The forefoot is now definitely abnormal.

**FIG. 4**
Figure 4—Clinical photograph of the patient in Figures 1, 2 and 3 to show the abnormal positions of the lateral and medial malleoli.

**CAUSE OF THE DEFORMITY IN THE VERY YOUNG**

Attenborough (1966), studying the movements of feet in normal babies, noted that full passive dorsiflexion was accompanied by valgus at the heel and full plantar-flexion by varus. We agree with this important observation but deny that the cause is wholly due to the shape of the talus. We believe that dorsiflexion is accomplished in two stages. First, at the ankle joint, which requires relaxation of the calcaneal tendon, and, secondly, at the subtalar joint,
around which the remainder of the foot rotates as the tibialis posterior muscle relaxes (Figs. 7 to 10). Shortening of either or both of these tendons will prevent full normal dorsiflexion. If both are tethered the heel remains in equinus. If one is involved dorsiflexion will be incomplete or spurious as in the valgus abequino of the older writers who noted excessive valgus deformity at the heel when the calcaneal tendon was short. Wiley (1959) also emphasised that secondary shortening of these tendons, so that they cannot relax on manipulation of the foot, is of prime importance in preventing correction.

However, if a baby's foot is placed in full equinus and varus the lateral malleolus can be felt to move posteriorly as the ankle mortise rotates laterally, so that to some extent the total varus is obscured (Figs. 11 and 12). This is a clinical observation confirmed by Rose (1962) which we are unable to adequately explain. Possibly tension develops in the lateral ligament during inversion when the talo-calcaneal relationship is altered.

In club foot both the medial and the posterior tendons are shortened. If both yield to preliminary stretching the outcome is likely to be favourable, but if either or both remain unyielding full dorsiflexion will not be obtained and primary correction will fail. If the primary deformity is severe it is impossible to manipulate the hindfoot by pressure on the small heel in the recommended fashion, and we can only influence the hindfoot by pressure on the long anterior lever of the forefoot, which is usually first pressed into eversion and abduction. Sometimes the midtarsal deformity yields but more commonly the correcting force is transmitted to the hindfoot which, being tethered medially by tibialis posterior, rotates laterally at the ankle joint, thus displacing the fibular malleolus backwards (Figs. 7 and 8). Relaxation of the tibialis posterior permits normal dorsiflexion (Figs. 9 and 10). In the most severe cases the fibular malleolus is displaced posteriorly at birth and attempted correction merely establishes this deformity.

There are, therefore, two ways in which a club foot may be falsely or spuriously corrected. The familiar "rocker-bottom" deformity is the result of a transverse breach in the midtarsal...
Figure 7—Dorsiflexion without relaxation of tibialis posterior. The lateral malleolus is still posteriorly displaced. Figure 8—Radiograph of Figure 7. Note incomplete dorsiflexion, forefoot inversion and position of lateral malleolus.

Figure 9—After relaxation of tibialis posterior. The lateral malleolus has now moved forward. Figure 10—Radiograph of Figure 9. Dorsiflexion is complete, the malleolar relationship is normal and the forefoot no longer inverted.

Figure 11—Neonatal foot in position of equinovarus seen from lateral side. There is a pin in the lateral malleolus which lies posterior. Figure 12—Radiograph of Figure 11.
area occurring when dorsiflexion is applied prematurely. A longitudinal breach may also occur when the midtarsal deformity remains uncorrected in the horizontal plane. In these circumstances the varus deformity at the forefoot persists and abstraction is transmitted to the hindfoot which is rotated spuriously into lateral rotation. We call the resulting deformity the "bean-shaped foot."

**CLINICAL SIGNIFICANCE IN INFANCY**

During the first phase of non-operative correction, be it by splint, manipulation or plaster, surgeons are alert to the dangers of causing a transverse breach by premature forced dorsiflexion. It is important to realise, however, that a longitudinal breach may also be produced by premature eversion of the hindfoot before correction of the midtarsal varus (Wynne-Davies 1964). This reflects the traditional teaching that the foot should be corrected in sequence from before backwards, not proceeding to the next stage until the deformity distal to it has been overcome.

We have followed the recent trend towards early posterior release operations when the calcaneus remains clinically and radiologically in equinus after a reasonable trial of non-operative methods (Attenborough 1966). Although the object of this has been to prevent a transverse breach and a rocker-bottom foot it sometimes also corrects a longitudinal breach (Figs. 13 to 15).

Early posterior release has in general been a rewarding procedure, but in some patients the results are disappointing. In the failures the longitudinal breach has remained uncorrected.

Our present practice, based upon the findings we have described, is to review each club foot carefully at between two and three months. We regard equinus deformity of the calcaneus and posterior displacement of the lateral malleolus occurring alone or together as indications for operation. Clinical examination alone will establish the presence or absence of these deformities, but confirmation may be obtained by a lateral radiograph—carefully centred on the hindfoot and ankle with the foot as near as possible to a right angle in relation to the leg (Fig. 13).

Operation is performed through an incision medial to the calcaneal tendon, extending behind the medial malleolus to the middle of the calcaneus. After posterior release the foot is dorsiflexed to just beyond the right angle. Tension developing in the tibialis posterior muscle demands that it be lengthened; this is combined with plantar fasciectomy and excision of any prolongation of the calcaneal tendon to the plantar fascia. After operation we apply Robert Jones strapping and continue with this method as though operation had not been performed. Our experience with this, although short, is promising. Denham (1967) has reported good results with a similar technique in more patients.
CLINICAL SIGNIFICANCE IN OLDER CHILDREN

The development of hindfoot lateral rotation in a foot in which primary correction has failed is not necessarily undesirable. Without it many feet would be more disabling because the forefoot would lie much more adducted in relation to the leg on walking. This can be demonstrated by rotating the leg medially on the flexed knee until the malleoli are correctly related in the horizontal plane.

Sometimes, indeed, when lateral rotation does not compensate adequately for forefoot varus so that this remains inconveniently adducted the child will reinforce lateral rotation of the hindfoot by walking with the whole leg outwardly rotated from the hip (Fig. 16). In such circumstances lateral rotation osteotomy of the tibia may be helpful (Figs. 17 and 18).

We have found Dillwyn Evans’s operation (1961) to have significant advantages over medial release alone. We suggest that its virtue lies in lateral rotation of the forefoot, which

Figure 16-To show lateral rotation of the leg used to reinforce lateral rotation at the ankle joint when the foot remains in varus. The positions of the patella, tibial tubercle and medial malleolus are indicated. Figures 17 and 18—The result of lateral rotation tibial osteotomy in a patient with signs similar to those shown in Figure 16.

is thus aligned more closely to the similarly rotated hindfoot. He, as it were, lengthens the concavity and shortens the convexity of the "bean-shaped foot."

Residual fixed equinus—In established club foot attempts to correct this deformity by release of the posterior soft tissues are often unsuccessful. It is sometimes suggested that widening of the anterior part of the talus is responsible but we cannot accept this. The talus, rotated more than the ankle mortise, loses congruity because the medial side of its dome escapes and lies outside the mortise in contact with the edge of the tibia. Dorsiflexion is prevented by contact at this point. Furthermore, the talus lies more horizontal than normal, parallel to rather than inclined downwards towards the calcaneus (Figs 1 and 3). The talus, therefore, is already fully dorsiflexed in spite of calcaneal equinus and thus attempted correction by further dorsiflexion at the ankle is likely to fail.

If persisting equinus demands attention and some useful tarsal movement is still present triple arthrodesis is unnecessarily mutilating. Low tibial osteotomy, with removal of a wedge based anteriorly, at the level of the epiphysial scar corrects the deformity and retains movement in a cosmetically satisfying manner.

Flat-topped talus—True flattening may undoubtedly occur if forced manipulation causes osteochondral compression fracture or ischaemic necrosis. This diagnosis, which implies an adverse long-term effect on the ankle joint, is often too readily made from a cursory inspection
of the radiograph. The more the talus is laterally rotated the more it offers its frontal profile in the lateral radiograph, so appearing to have a flat summit. Repeating the radiograph with medial rotation resolves the problem (Figs. 1 and 3).

Varus heel—Observed from behind, the heel seems to have a varus curve and an axial radiograph apparently confirms this. If, however, the leg is medially rotated the heel also rotates and now lies nearer the sagittal plane. Similarly, if the axial radiograph is repeated with the malleoli in their normal horizontal relationship and not rotated the varus curve of the calcaneus is greatly reduced.

This is because the posterior part of the calcaneus lies behind the axis of rotation of the hindfoot. Thus lateral rotation at the ankle joint produces medial rotation of the posterior part of the calcaneus which lies behind it and medial rotation has the opposite effect.

This does not imply that calcaneal osteotomy (Dwyer 1963) is an irrational procedure, for as in Dillwyn Evans’s operation one part of the foot is laterally rotated to align it with the greater part of the hindfoot which is already in this position.

**SUMMARY**

1. We have considered torsional deformity in club feet and conclude that medial torsion does not occur in the tibia.
2. It is suggested that in uncorrected feet the hindfoot with the ankle mortise is laterally rotated.
3. We have discussed the cause, prevention and consequences of spurious correction by lateral rotation.
4. The "bean-shaped foot" seems an appropriate description of the final deformity as it is commonly seen.

**REFERENCES**


