FLAT FOOT
A PRELIMINARY REPORT OF AN OPERATION FOR SEVERE CASES
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The pathogenesis of flat foot and its operative correction for severe cases are reviewed. The importance of the medial plantar fascia in maintaining the structural integrity of the foot is emphasised. Reinforcement of an incompetent plantar fascia by separating the inner half of the calcaneal tendon and attaching it to the neck of the first metatarsal has given results in three patients that were satisfactory at two, six and seven years later.

It is now generally accepted that the integrity of the longitudinal arch and the stability of the weight-bearing foot are derived mainly from the intrinsic structural strength, both bony and ligamentous, and are not materially dependent on muscle action. Rose (1962) maintained that under defined conditions a particular foot under load always assumes the same posture, and Jones (1941) demonstrated that the loaded foot can, at any rate for a short time, support thrice the body weight without structural failure. It is therefore doubted whether overloading in adult life as a result, for instance, of obesity or pregnancy is a significant cause of flat foot, although such crises of excessive stress may precipitate symptoms of foot strain in the already flat foot or, indeed, even in the structurally normal foot.

On the other hand pronated feet are of common occurrence in early childhood, at which time joint flexibility, as in the metacarpophalangeal joints or elbows, is usually greater than at later ages. The feet may well share in this laxity, and to such structural immaturity the pronated feet of this age-group may reasonably be attributed. The condition is often associated with postural knock-knee, and yet a supinated foot with an inverted heel is the normal concomitant of genu valgum, as, for example, that of rachitic origin. It may therefore be surmised that the pronated foot, by realigning the counter-thrust from the ground at the calcaneo-contact surface, is the cause of the development of the postural knock-knee.

Under favourable circumstances such feet can, and usually do, achieve structural maturity and a more or less normal posture. Standing on the ball of the foot or passive extension of the big toe will, by virtue of the windlass action of the strong plantar fascia (Hicks 1954), cause the heel to invert and restore the visible arch. The degree to which this phenomenon can be elicited is an index of the integrity of the plantar fascia, and its complete absence indicates irreversible stretching of this and other medial plantar structures. The foot is no longer merely immature and pronated but structurally and irreparably flat. Prolonged, pronated weight-bearing in childhood will eventually produce this undesirable state, and this is believed to be the common cause of structural flat foot.

PREVENTION OF FLAT FOOT
The young child will inevitably outgrow the postural determinants of its pronated feet, and to prevent the latter from graduating to a state of structural collapse it is merely necessary, during the interim period, to protect the integrity of the medial plantar structures by preventing weight-bearing in pronation. The Helfet heelseat purports to achieve this by converting the vertical body weight into a horizontal force directed laterally against sustentaculum and talus, while the Schwartz meniscus acts as a wedge to prevent the calcaneus from rolling into valgus at the calcaneo-contact joint (Rose 1958); both supports too often lack the strength and rigidity to resist breakage or distortion. Rose (1962) demonstrated that, while a raise under the medial part of the heel is in itself ineffective, in association with a raise under the first metatarsal head it does correct the pronated foot. Thus the simplest expedient is to prescribe a medial sole and heel raise until such time as a structurally mature foot and a normal, neutral, weight-bearing habit is acquired. In the absence of such a precautionary measure adopted from the earliest age, many patients will go through life with a varying degree of structural flat foot. In most patients symptoms are absent, trivial or experienced only during times of exceptional stress, such as military service, and are then relieved by the appropriate shoe alteration. Thus, operative measures for the correction of structural flat foot are reserved for cases so severe that the pronation cannot be controlled by a medial shoe raise, and when more or less disabling symptoms are present or to be anticipated.

CURRENT OPERATIVE PROCEDURES
Bringing the heel and the counter-force at the calcaneocontact joint medially in relation to the subtalar axis by

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open wedge elevation of the posterior calcaneal articular process (Baker and Hill 1964), by oblique, lateral and open wedge osteotomy of the calcaneus (Lord 1923; Dwyer 1961; Silver, Simon, Spindell, Lichtman and Scala 1967) or by medial displacement osteotomy (Koutsougiannis 1971) have given gratifying results in mild or moderate cases. With the valgus heel corrected, weight-bearing in pronation is discouraged by diversion of the load from the medial plantar structures, with consequent relief of the symptoms of foot strain. However, these procedures do not achieve any material structural improvement in the longitudinal arch, and are inadequate for the more severe cases of mobile flat foot.

Attempts at structural improvement and stabilisation of the arch have not been entirely satisfactory. Hoke (1931) fused the naviculo-cuneiform joint in the correct position. He credited the muscles with an important part in maintaining the arch and believed this fusion to give a longer and more stable lever on which they might act. Jack (1953) found that this procedure reconstituted the arch only if radiographic collapse was restricted to the naviculo-cuneiform joint, but Seymour (1967), in a nineteen-year follow-up of Jack’s cases, reported 50 per cent of unsatisfactory results with development of tarsal degenerative change in many.

Gleich (1893), the originator of calcaneal osteotomy, removed a medial and plantar based wedge, not only bringing the heel medially but advancing it with increase in the angle between the calcaneal axis and the floor and so some structural improvement in the longitudinal arch.

Rose (1962) pointed out that with a particular foot in its characteristic weight-bearing position the tarsometatarsal joints are always fully extended and that the limitation of their extension is a determinant of the posture adopted. Thus a raise under the head of the first metatarsal discourages pronation, whereas a medial raise of the sole alone fails. To correct the pronated foot permanently some alteration in the skeletal structure must be achieved. On this principle it was found that, towards the end of growth, fusion of the first cuneiform metatarsal joint in plantar flexion was successful in correcting moderate, mobile flat foot, though inadequate for the more severe cases for which the operation described below is suitable.

THE OPERATION

The principle—Hicks (1954) pointed out the great strength of the medial plantar fascia and stressed its importance in preserving the integrity of the longitudinal arch, which he described as a truss system, the tie of which is represented by the plantar fascia. The windlass action of the latter, which he described and the clinical demonstration of which has already been mentioned, renders the tie of this truss system adjustable in length. Permanent stretching or disruption of the plantar fascia is a major factor
in the establishment of a structurally flat foot, and the object of the operation about to be described is to replace this fascia by the medial half of the calcaneal tendon. Because the tendon is fixed, not to the proximal phalanx of the big toe, but to the neck of the first metatarsal bone, the tie so provided is fixed and is not adjustable because it lacks the windlass action of the normal plantar fascia.

The procedure—Through a stocking-seam incision deviating distally to the medial side of the calcaneal tendon, the tendon is split sagittally into two halves. The upper end of the medial half, including its fascial prolongation over the muscle belly, is divided from the muscle but is left attached to the calcaneus at its lower end. Skin and fat are undercut and separated from the infero-medial aspect of the calcaneus. A second small incision is made over the medial aspect of the neck of the first metatarsal bone and a hole is drilled through it. A Kocher's forceps is insinuated subcutaneously from this incision to emerge at the lower end of the first incision. The separated upper end of the medial strip of calcaneal tendon is grasped in the Kocher's forceps and drawn out at the second incision. Here the rolled-up fascial prolongation is passed through the drill hole in the neck of the first metatarsal bone and sutured to itself with the arch held in the corrected position. The wounds are closed and a

Case 2. Figures 6 and 7—Radiograph and clinical photograph of the right foot before treatment. Figure 8—Clinical photograph to show weight-bearing two years after operation.

Case 3. Figure 9—Radiograph of the right foot before operation. Figure 10—Radiograph of the right foot five years after operation. Figure 11—The clinical appearance of the right foot before operation. Figures 12 and 13—Clinical photographs of the right foot bearing weight three years after operation.
padded, below-knee plaster cast is applied. Six weeks after operation a walking plaster is applied, and at three months unprotected weight-bearing is allowed.

CASE REPORTS

So far the operation has been done on only three feet in three patients, in all of whom some exceptional pathological factor contributed to an unusually severe degree of deformity. The maintenance in all three of a gratifying result over several years suggests that this procedure will indeed give lasting correction of severe, mobile flat foot.

Case 1—A coloured girl was first seen in 1965 at the age of ten, with slight congenital hypertrophy of the left lower limb and bilateral rocker-bottom feet, very severe on the left side. Irons and T-straps were worn for two years without improvement, and in 1967 a calcaneal tendon replacement of the plantar fascia was done on the left side. Seven years later in 1974 the left foot was symptomless, with a well-formed arch and a neutral heel (Figs. 1 to 5).

Case 2—A coloured boy aged five years was admitted in 1967 with the nail-patella syndrome and a severe rocker-bottom right foot with a break at the midtarsal joint. A calcaneal tendon replacement of the plantar fascia was done and, when last seen two years later, the foot, though still flat, had a neutral heel, no midtarsal hypermobility and no rocker-bottom deformity (Figs. 6 to 8).

Case 3—A coloured boy was first seen in 1964 at the age of five and a half years with severe pes planovalgus associated with excessive laxity of wrists and fingers, 5 degrees of genu recurvatum and calcaneus hypermobility. For nearly three years he was treated, first with medial sole and heel raises, later with irons and T-straps, but without improvement. In 1967 the defective plantar fascia was replaced by a calcaneal tendon transplant on the right side and, when last seen six years later, the foot was symptomless, the heel neutral and the arch restored both clinically and radiographically (Figs. 9 to 13).

REFERENCES


