THE PATHOLOGICAL ANATOMY OF CONVEX PES VALGUS

JAMES C. DRENNAN* and W. J. W. SHARRARD, SHEFFIELD, ENGLAND

From the Congenital Anomalies Research Unit, University of Sheffield

Convex pes valgus (vertical talus) is a rare form of congenital foot deformity, the etiology of which remains unexplained. The 10 per cent incidence in a large series of patients with foot deformities in myelomeningocele (Sharrard and Grosfield 1968) suggests that a specific neuromuscular imbalance may be responsible, at least in myelodysplastic patients, for the development of the "Persian slipper foot".

The single report in the literature discussing the anatomy of this deformity (Patterson, Fitz and Smith 1968) does not describe the significant changes in the course of major tendons and their consequent altered function, nor does it discuss the intrinsic foot musculature. This paper presents a detailed description of the pathological anatomy in a case of myelomeningocele with congenital pes valgus. The concept that a neuromuscular imbalance between the invertors and evertors of the foot causes this deformity will be discussed.

CASE HISTORY

A white girl born at full term by normal delivery and weighing 3.6 kilograms was noted at birth to have marked hydrocephalus, a large thoraco-lumbar myelomeningocele with lumbar kyphosis, and right convex pes valgus and left equinovarus deformities of the feet. Pre-operative neurological examination established that only the perineum had spontaneous function. All muscles in the right lower extremity with the exception of the tibialis posterior responded to faradic stimulation. Closure of the myelomeningocele and spinal osteotomy were performed eleven hours after birth. After operation the patient developed severe respiratory distress and died from cardiac arrest.

METHOD

Simultaneous dissection of the convex pes valgus leg and foot and that of a normal newborn infant were carried out on formalin specimens. Serial photographs were taken of each stage. All muscles were weighed, the muscle-tendon ratios determined and histological examinations performed. Particular emphasis was placed on examining the course of the tendons distal to the ankle joint and changes in the intrinsic muscles. The individual tarsal bones were disarticulated for photographic comparison.

RESULTS

Subcutaneous fat—The weight-bearing fatty tissue of the sole was normal in amount and appearance but had shifted laterally to cover the lateral side of the foot and heel, leaving the medial longitudinal arch bare.

Tendons and muscles—The feet were examined in several planes after removal of the fat. In normal feet the extensor retinaculum of the ankle continues over the dorsum of the talus (Fig. 1). This dorsal extension was absent in the convex pes valgus dissection (Fig. 2). When

* Special Fellow, National Institutes of Health, Washington, D.C.
viewed laterally the vertical thickened lower edge of the shortened retinaculum presented at the apex of the deformity between the plantar-flexed hindfoot and the calcaneo-valgus forefoot. The most pronounced part of the forefoot deformity was in the lateral rays. The long toe extensors passed acutely under the thickened inferior edge of the retinaculum. The navicular had shifted proximally, enabling the tibialis anterior to follow a straight course to its navicular insertion. The calcaneus was everted, plantar-flexed and laterally displaced relative to the tibia.

The triceps surae had a broad insertion on the postero-superior aspect of the everted calcaneus. The long toe flexors entered the plantar compartment beneath the posterior talo-calcaneal joint and were displaced laterally. The tibialis posterior tendon grooved the medial malleolus posterior to its medial tip and then splayed out and became attenuated as it passed on the medial and plantar surface of the displaced talar head. It then divided into a larger medial half inserting into the plantar aspect of the navicular and a lateral segment crossing beneath the tendon of the peroneus longus at a reduced angle to insert into the second, third and fourth metatarsal bases (Fig. 4).

All tendons to the dorsum of the foot were tethered medial to the midline of the ankle joint (Fig. 6). Tibialis anterior passed directly to its insertion on the dorsal surface of the navicular. The extensor hallucis longus passed acutely beneath the retinaculum and took its normal longitudinal course to the hallux. The extensor digitorum longus also passed acutely beneath the retinaculum and then angled sharply laterally to its attachment to the lateral rays of the everted forefoot. The peronei were subluxated anteriorly to the lower end of the fibula and ran as a bowstring across the ankle joint to the cuboid (Fig. 2). The normal oblique
plantar crossing of the peroneus longus tendon had been converted to a right angle course (Fig. 4). The most striking change in the intrinsic muscles of the sole was the marked atrophy of quadratus plantae. The origin of the abductor digiti quinti had been displaced posteriorly. The site of insertion of all intrinsic and extrinsic muscles was normal.

Comparison of the muscle-tendon ratios and the weights of the individual muscles from the convex pes valgus dissection and normal dissections revealed hypertrophy of the extensor digitorum longus and moderate atrophy of tibialis posterior. Histological examination confirmed this and showed the atrophy of the tibialis posterior to be of a simple variety.

**Ligaments**—The ligaments on the plantar surface were intact but those of the medial longitudinal arch and the long plantar ligament were attenuated (Fig. 4).

**Bones**—Significant changes were limited to the bones of the hindfoot. The head and neck of the talus were hypoplastic and were directed downwards and medially. The sustentaculum tali was blunted and offered no support to the head of the talus. No anterior talo-calcaneal joint could be identified. The calcaneus was laterally displaced and everted relative to the talus and the sinus tarsi was markedly reduced. The posterior talo-calcaneal joint had an increased lateral tilt.

**DISCUSSION**

The position of the ankle favours either a valgus or a varus posture of the foot. Plantarflexion enhances inversion of the foot and dorsiflexion increases eversion. Attenborough (1966) showed that the subtalar joint is always inverted when the talus is plantar-flexed. The longer
FIG. 3
Extrinsic tendons of the plantar aspect of the normal foot.

FIG. 4
Plantar structures in convex pes valgus foot. The marked change in the course of the major tendons is seen.

THE JOURNAL OF BONE AND JOINT SURGERY
length of the lateral side of the superior talar articular surface also assists inversion. He demonstrated that the forefoot is also inverted when the talus is plantar-flexed.

The position of the hindfoot is determined by the balance achieved by the four major muscle groups. The triceps surae is the dominant muscle and its action modifies the mechanical advantage through which the other groups must work. The increased functional power of the invertors and the apparent weakness of the peronei in uncorrected congenital talipes equinovarus demonstrates this fact.

Tibialis posterior is the principal invertor of the foot. Its ability to invert the whole foot is made possible by its dual insertion into the navicular and the lateral metatarsal bases. Fried (1959) stated: “Its function is combined and its contraction produces in the normal foot a position not unlike that of a club foot”. Plantar-flexion increases the mechanical advantage of the tibialis posterior. The hindfoot becomes inverted, causing the triceps surae to become a secondary invertor.

The axis of movement of the ankle joint passes from anterior-medial to posterior-lateral. It is only when the talus is dorsiflexed that eversion of the subtalar joint can occur and act to increase the functional advantage of the evertors. The lateral insertion of the extensor digitorum longus and peroneus tertius everts the forefoot during dorsiflexion. This strengthens the action of the peronei as evertors of the forefoot. The combined action of these two groups causes the hindfoot to go into eversion and the triceps surae gains secondary evertor action.

The normal pattern of balance of action between the triceps and the invertor and evertor muscles can be altered either by functional overactivity or paresis of one of the major muscle groups. The long toe tendons do not significantly influence this pattern of balance in the normal foot. They may become involved as substitutes for a paretic group, and this activity may lead to the development of a secondary forefoot as well as hindfoot deformity.

Our case with convex pes valgus appears to be an example of this concept. The functioning triceps surae causes the hindfoot to plantar-flex but the normal pattern of inversion does not
develop because of diminished function of the tibialis posterior. This enables the functioning
and antagonist evertors to act with an increasingly unopposed mechanical advantage. The
active triceps surae holds the hindfoot in plantar flexion while the forefoot is pulled into
dorsiflexion and eversion. The foot is displaced laterally and this causes a relative medial
movement of the extensor digitorum longus at the ankle joint where it is tethered by the
extensor retinaculum (Fig. 6). This abnormal medial position causes the extensor digitorum
longus and the peroneus tertius to develop an acute lateral angle, significantly increasing their
ability to dorsiflex and evert the forefoot. The thickened retinaculum acts as a fulcrum to
increase this improved mechanical advantage. The distance between the lateral malleolus and
forefoot is shortened and the peronei bowstring across the ankle joint to become forefoot
dorsiflexors as well as evertors (Fig. 2). This also gives the tendon of peroneus longus a more
effective angle for increasing forefoot eversion (Fig. 4). The combined action of these two
muscle groups carries the calcaneus laterally and the triceps surae secondarily becomes an
evertor.

The two talo-calcaneal joints in the normal foot form the major plantar support for the
talus. The posterior tibial tendons support the exposed part of the talar head. The downward
and medial direction of the longitudinal axis of the talus is increased by plantar-flexion. No
tendons are inserted into the talus and its position is passively determined. In convex pes
valgus the triceps surae places the entire hindfoot into plantar-flexion. As the calcaneus is
pulled laterally the posterior subtalar joint angle enlarges, allowing the talus to slide medially
and removing the support of the sustentaculum tali. The weakened tibialis posterior is unable
alone to support the plantar-flexed talus and with the navicular held in dorsiflexion by the active
tibialis anterior, the talus is passively forced into a vertical position. The atrophy of quadratus
plantae allows the long toe flexors to move laterally, further weakening plantar support of
the head of the talus. The osseous and ligamentous changes described appear to be secondary
to the muscular imbalance. Our observations suggest that an imbalance between a weak
tibialis posterior and strong dorsiflexors and evertors is the underlying cause of the development
of this deformity.

Most authors who discuss the etiology of convex pes valgus stress the marked association
of this deformity with central nervous system abnormalities. Mau (1930) postulated that a
spinal cord lesion in early embryonic life favoured a predominance of peroneal action which
casted a secondary convex pes valgus. Lamy and Weissman (1939) noted the high incidence
of neurological abnormalities in their review of the literature and stated that the role of the
nervous system appeared to be the most important. Thirteen of twenty-two patients reported
by Lloyd-Roberts and Spence (1958) and six of eight patients reported by Hark (1950) had
associated neurological abnormalities, particularly arthrogryposis. Coleman and Jarrett (1966)
declared that “convex pes valgus is almost invariably associated with neuromuscular
abnormalities”. Sharrard and Grosfield (1968) found an incidence of 10 per cent in a large
series of patients with myelomeningocele who had foot deformities. The conclusion of this
paper that weakness of tibialis posterior is responsible for the development of this foot
deformity in myelomeningocele may be applicable to other forms of spinal dysraphism. The
striking proportion of neurological abnormalities reported by authors who have carefully
evaluated their cases suggests the need to exclude primary abnormalities of the central nervous
system before accepting convex pes valgus as an isolated primary deformity.

SUMMARY

1. The pathological anatomy in a case of convex pes valgus in a patient with myelo-
meningocele is described.
2. A neuromuscular imbalance between the tibialis posterior and the evertors of the foot is
suggested as the underlying cause of this type of foot deformity.
REFERENCES


