THE TERMINAL PHALANX OF THE GREAT TOE

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Studies on hallux valgus commonly contain reference to an outward deflexion of the terminal phalanx at the interphalangeal joint (Emslie, 1939; Hardy & Clapham, 1952). Personal investigations have shown that the apparent deformity in this region lies mainly in the terminal phalanx itself, and that it is a *normal* feature of the human foot.

MATERIAL AND METHODS

The feet of thirty medical students (thirteen male, seventeen female; aged 18–21 years) and the terminal phalanges from the great toes of thirty-five aged cadavers have been examined radiologically. Measurements of the degree of diaphysial angulation are necessarily approximate, but by taking a series of mid-points distal to the epiphysis a line may be constructed which represents with moderate accuracy the plane of the shaft. Seventeen great toes from adults and ten from infants have been dissected. A great toe from each of three male and three female foetuses (aged 4, 4½, 5½ (2) and 9 (2) months) has been studied by means of 100μ horizontal unstained sections, cut by a freezing microtome. Certain lower primates have also been examined.

RESULTS OF INVESTIGATION

The shaft of the terminal phalanx is not set at right angles to its proximal articular surface, but deviates towards the fibular side of the foot (Fig. 1). In the male students the range of deflexion was 8–23° (mean 14·7°, S.D. 4·1); in the female students 10–22° (mean 14·7°, S.D. 4·3); and in the cadavers 3–25° (mean 14·4°, S.D. 4·5). Though the distal articular surface of the *proximal* phalanx is rarely placed exactly at right angles to the shaft of this bone, the deflexion is relatively small.

Histological sections of foetal great toes also reveal lateral deviation of the terminal diaphysis comparable in degree to that noted in the adult (Fig. 2).

This diaphysial angulation appears to have modified the insertion of the flexor hallucis longus, a suggestion prompted by comparison between the bony roughenings for the distal attachment of this tendon and the corresponding tendon in the thumb; the latter has been described in detail elsewhere (Wilkinson, 1953). The shaft of the terminal phalanx of the thumb is usually set at right angles to the interphalangeal joint, though sometimes it exhibits a slight deflexion towards the ulnar side. The flexor pollicis longus is inserted into a curved bony ridge (Fig. 3*a*). Whilst there is a similar arch-shaped roughening for the insertion of the flexor hallucis longus, its apex is displaced towards the fibular side (Fig. 3*b*, *c*). Moreover, the arch is very strongly marked on the tibial side of the ventral surface and here constitutes an oblique ridge as portrayed by Grant (1947). As this ridge extends distally, with a lateral inclination, it sometimes reaches the terminal tuberosity of membrane bone (tuberositas unguicularis), forming a sort of bony 'flying buttress' (Fig. 3*c*).

Dissections of the flexor hallucis longus tendon in the adult show that the fibres

proceed more distally on the fibular side than on the tibial side of the plantar surface of the phalanx. Fig. 4 illustrates a frequent arrangement: a sheaf of fibres extends more distally on the fibular side to become attached to the ventral surface of the tuberositas unguicularis. This asymmetry of insertion is not so obvious in the infant.

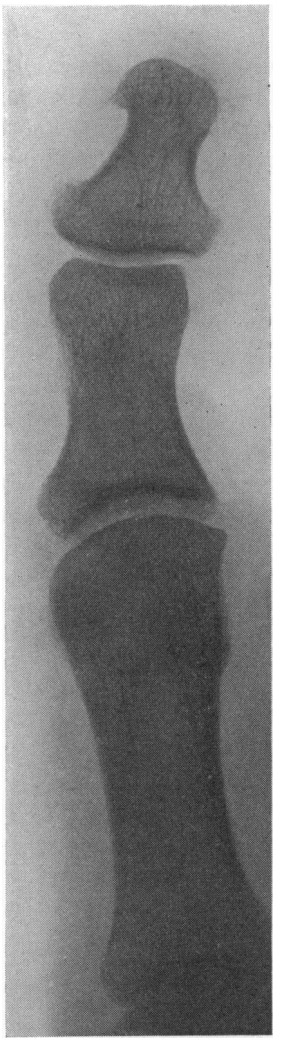


Fig. 1. Radiograph of a right great toe. The shaft of the terminal phalanx is not set at right angles to its articular surface.

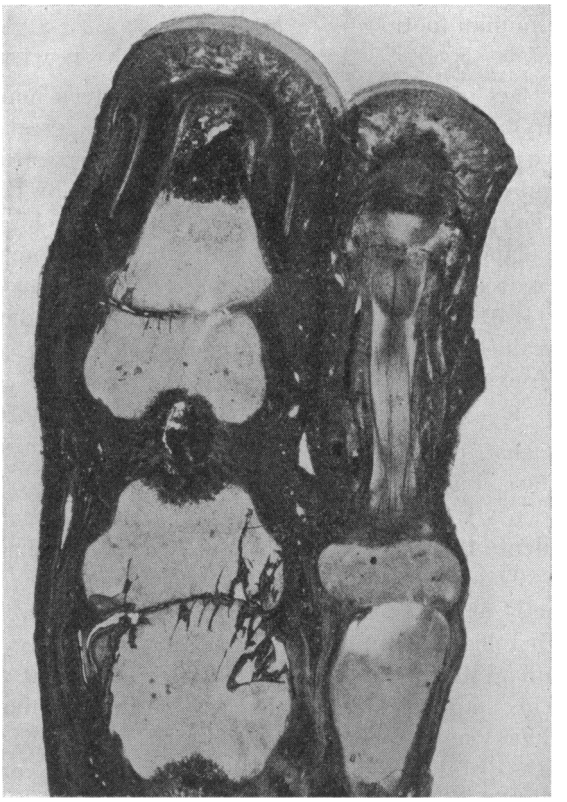
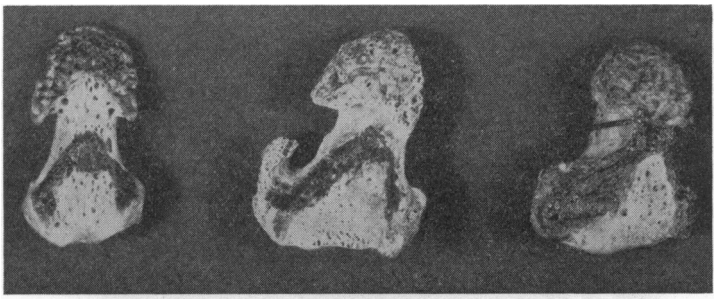


Fig. 2. Horizontal section through the right great toe of a 5½-month foetus (×7·5).

On each side a ligament extends between the base of the bone and the tuberositas unguicularis comparable to that present in manual digits. It provides a partial, and sometimes extensive, insertion for the tendon. The attachment of this ligament to

the base of the terminal phalanx is not uncommonly indicated by a bony projection (Fig. 3*b*).



(*a*) (*b*) (*c*)

Fig. 3. Terminal phalanx of a thumb (*a*), and of each of two left great toes (*b*, *c*). The arch-shaped roughening for flexor tendon insertion has been marked with indian ink. In (*c*) this ridge reaches the tuberositas unguicularis, spanning a small foramen in which a bristle has been placed.

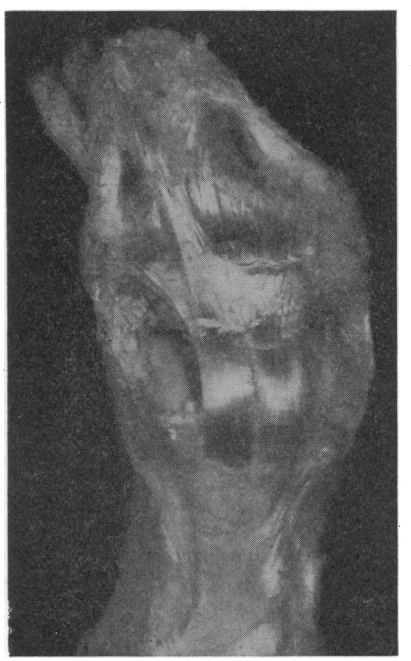


Fig. 4. Dissection of the insertion of flexor hallucis longus in a right great toe. The insertion extends more distally on the fibular side (× 1·5).

As in the thumb, the extensor tendon of the terminal phalanx of the great toe has a more proximal insertion than the corresponding flexor (Fig. 5); this is probably related to the extent of the nail bed. The tendon of the extensor hallucis longus is inserted proximal to the site of diaphysial angulation.

DISCUSSION

The importance of the human great toe is reflected in the commonest pedal digital formula. The size of the long flexor tendon, greater in cross-section than that of any other human digital flexor, necessitates extensive distal attachments. These are provided by the base and shaft of the terminal phalanx, and often by the tuberositas unguicularis, the ligaments which lie on each side between this and the base of the bone, and by the fascial trabeculae of the fatty pulp. The position of insertion of the

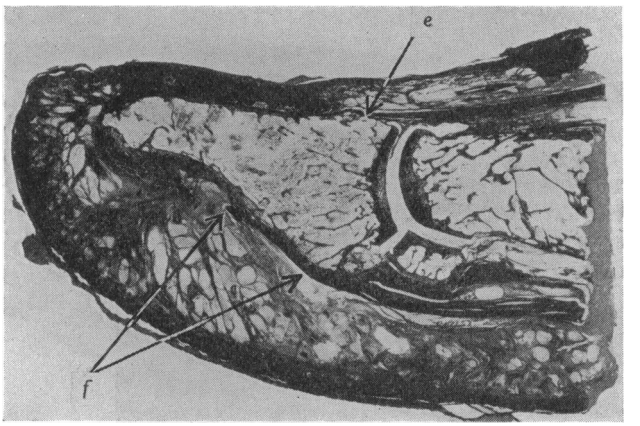


Fig. 5. Sagittal section of the great toe of an adult. (*e*) insertion of extensor hallucis longus, (*f*) insertion of flexor hallucis longus (Verhoeff) (×2).

flexor hallucis longus is commonly portrayed incorrectly in anatomical illustrations. Thus Testut (1928) and Jamieson (1947) confine it to the base of the terminal phalanx.

A comparison with the insertion of the flexor pollicis longus suggests that the insertion of the flexor hallucis longus tendon has been modified by two factors: (1) the necessity for an extensive distal attachment, and (2) the maintenance of an alinement between the tendon and the toe despite a terminal diaphysial deformity.

The deviation of the shaft towards the fibular side of the foot—commonly featured in anatomical atlases—is not primarily caused by the adoption of unsuitable footwear, for it was well established in the foetuses examined; it is not more marked in one sex; it cannot be related to the oblique pull of the long extensor tendon nor is it a feature peculiar to hallux valgus. The reasons for its presence are rather obscure. In the material studied, a fibular-sided deflexion was found only in feet whose structure has been adapted for orthograde locomotion. Thus it was absent in a chimpanzee examined, and there was a deviation towards the tibial side in a baboon and a rhesus monkey. In the 'take-off' position the human foot is usually pointed outwards and pressure is brought to bear on the medial border of its distal extremity. As an inherited structural adaption to function, such a factor may explain this curiously constant bending of the terminal phalanx of the great toe.

SUMMARY

The diaphysis of the terminal phalanx of the great toe deviates towards the fibular side of the foot in all the adult and foetal human material examined, and this deflexion represents the normal condition in man. The feet of other primates studied have not shown this feature. The insertion of the flexor hallucis longus appears to have been modified by this bony conformation. The corresponding extensor tendon is inserted proximal to the site of angulation.

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REFERENCES

EMSLIE, M. (1939). Prevention of foot deformities in children. *Lancet*, **2**, pp. 1260–1263.

GRANT, J. C. B. (1947). *An Atlas of Anatomy*, fig. 277, p. 231. London: Baillière, Tindall and Cox.

HARDY, R. H. & CLAPHAM, J. C. R. (1952). Hallux valgus, predisposing anatomical causes. *Lancet*, **1**, pp. 1180–1183.

JAMIESON, E. B. (1947). *Illustrations of Regional Anatomy*, 7th ed., pl. 303. Edinburgh: Livingstone.

TESTUT, L. (1928). *Traité d'Anatomie Humaine*, **1**, fig. 490, p. 456. Paris: Doin.

WILKINSON, J. L. (1953). The insertions of the flexores pollicis longus et digitorum profundus. *J. Anat., Lond.*, **87**, 75–88.