

EXPERIMENTAL EPIPHYSIAL INJURY AND FREIBERG'S DISEASE

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In Freiberg's original paper in 1914 on the condition that bears his name he reported six cases and described a definite history of injury in three; hence his term "infracion." In 1926 he described another case, in which, although the second metatarsal shaft was thickened, the gross radiological appearances of the metatarsal head were normal. Because of this case, which was hardly typical of the condition he first described, he was ready to acknowledge that "simple trauma is not a satisfying explanation of the clinical and roentgenographic phenomena." In sympathy with this, Köhler considered it altogether unlikely that trauma was an important etiological factor.

Smillie (1957) favoured the traumatic view, postulating stress rather than a single injury.

I have attempted to assess the linear strength of the second metatarsal and proximal phalanx at varying ages, and to ascertain the "weakest link in the chain."

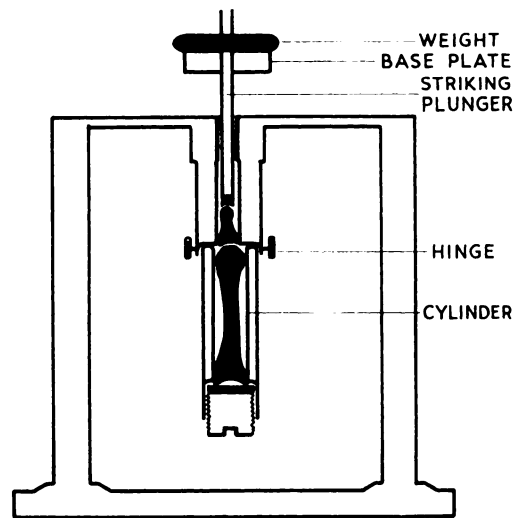
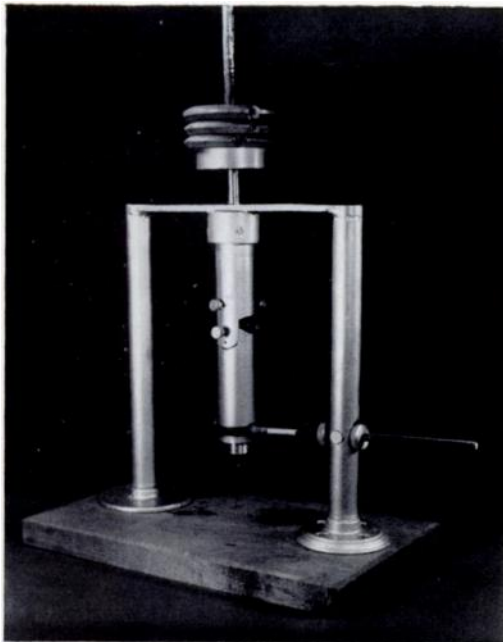


FIG. 1
The apparatus.

APPARATUS

The articulated metatarsal and phalanx were placed in a cylinder (Fig. 1) containing a striking plunger which rested on the head of the phalanx. Weights were dropped from varying heights on to a base plate affixed to the plunger, the force thus being transmitted through the plunger, phalanx, metatarso-phalangeal joint and metatarsal. A hinge adjustment was provided at the level of the metatarso-phalangeal joint so that the phalanx and metatarsal could be accurately aligned.

MATERIAL

Fresh necropsy specimens of the second metatarsal and proximal phalanx were dissected out with care to avoid damage to the metatarso-phalangeal joint. They were removed from both feet. The subjects had normal skeletons, being dead of acute illness or accident. Age and sex are shown in Table I.

PROCEDURE

After insertion of each specimen in the machine a 1 lb. weight was dropped from a height of three inches, and then from progressively greater heights up to twenty-one inches. The same procedure was repeated with 2 lb., 3 lb. and 4 lb., or until a fracture occurred. After each impact the metatarsal and phalanx were carefully inspected and the articular surfaces gently probed. A small hole in the plantar part of the capsule allowed an adequate view without causing instability.

TABLE I
DETAILS OF THE EXPERIMENTS

Specimen number	Age (years)	Sex	Effect on phalanx		Effect on metatarsal head		Weight (lb.)	Height (inches)
			Right	Left	Right	Left		
1	4½	F	Fracture	Fracture	—	—	3	12
2	5½	M	Fracture	Fracture	—	—	3	18
3	6½	M	Fracture	Fracture	—	—	3	21
4	6¾	M	Fracture	Fracture	—	—	3	18
5	8	F	Fracture	Fracture	—	—	4	18
6	10	M	Fracture	Fracture	—	—	4	12
7	11	M	Fracture	Fracture	—	—	4	18
8	12½	F	—	—	Fracture	Fracture	4	18
9	11	F	—	—	Fracture	Fracture	4	21
10	4 adults		Fracture	Fracture	—	—	4	18

It was necessary to transmit force through the proximal phalanx to the metatarsal head because, in this way, a striking surface (the base of the phalanx) was provided, which was congruous with and proportional in size to the metatarsal head.

A stress element was obviously introduced by repeated striking forces, but this was the same for each specimen.

OBSERVATIONS

1. The metatarsal epiphysis was the weakest component in specimens 8 and 9.
2. It was not possible to produce any grades of epiphysal damage. Either the epiphysis largely disintegrated or it remained intact. This is in conformity with the physical characteristics of a sphere.
3. In spite of gross comminution of the epiphysis radiographs showed little change (Figs. 2 and 3).

It is unlikely that the slight distortion in the lateral radiograph would be noticeable in a radiograph of the foot, of which a true lateral projection cannot be obtained.

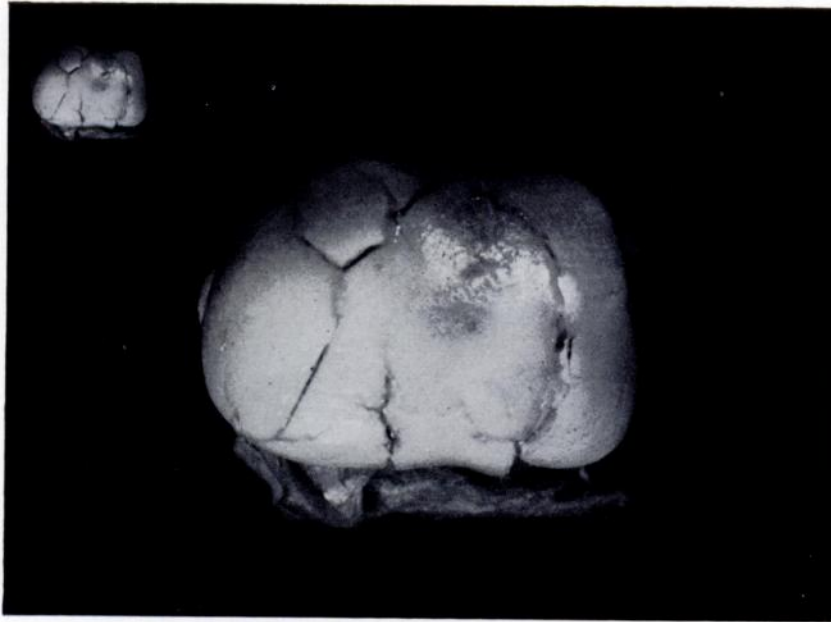


FIG. 2

Photograph of specimen 8 showing gross disruption of the articular surface but maintenance of its general shape.

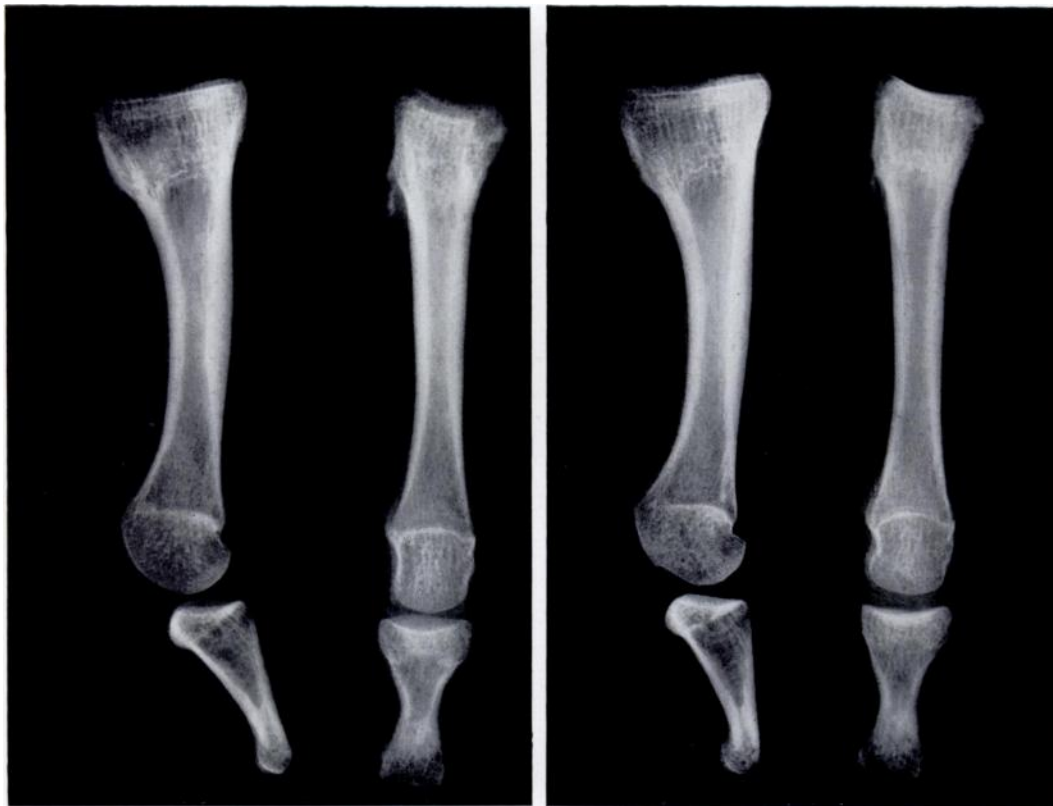


FIG. 3

On the left, second metatarsal before injury. *On the right*, same metatarsal after fracture of the articular surface by a 4 lb. weight dropped from eighteen inches.

DISCUSSION

Five cases of Freiberg's disease have been collected showing radiological appearances resembling those shown in Figures 5 to 7. Comparison of the radiographs in Figure 5 with that of the specimen in Figure 3 reveals a similar stage of epiphysial maturation. It seems an important observation that, in the experiment, the phalanx broke in all the specimens except in the two (specimens 8 and 9) in which the stage of epiphysial maturation compared closely with that seen in early Freiberg's infraction. In these two specimens the fracture of the metatarsal epiphysis suggests that it is relatively more fragile at this stage of maturation.

Freiberg's infraction occurs most commonly in the second, less commonly in the third and rarely in the fourth metatarsal. It is only occasionally bilateral.

The second is the most fixed metatarsal, the third rather less fixed and the fourth quite mobile. Because of its fixation, the second metatarsal would be likely to be affected more by



FIG. 4

Radiograph of foot in tiptoe position.

injury than those that are more mobile. The second metatarsal is also usually the longest metatarsal, although by no means always so in Freiberg's infraction.

In tiptoeing (Fig. 4) the metatarsals take weight vertically. The main direction of weight transmission is through the talus, the three cuneiform bones and the first three metatarsals, the second metatarsal forming the centre.

The increased density apparent on the radiograph is a very early change and probably due at this stage to the formation of callus in and around the fracture (Fig. 8).

The radiograph in Figure 7 shows hypertrophy of the metatarsal shaft in a year. This hypertrophy is only indirectly associated with the disease and may be ascribed to the increased stress on the second metatarsal caused by loss of dorsiflexion at the metatarso-phalangeal joint. This would explain the delay in its appearance.

Because of the degree of comminution postulated it is perhaps not surprising that small fragments are rendered avascular. Those fragments subjacent and attached to portions of

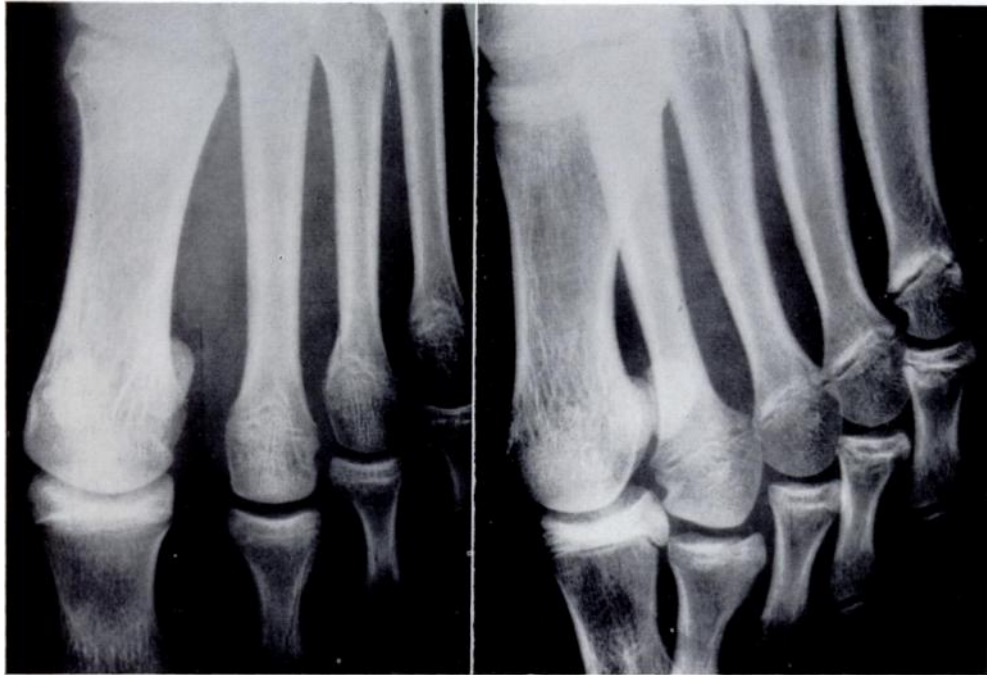


FIG. 5

Antero-posterior and lateral radiographs showing an early example of Freiberg's infraction in a girl of fourteen.



FIG. 6

Figure 6—The same forefoot two months later.



FIG. 7

the fissured articular cartilage never revascularise because they are able to obtain a new blood supply from only one surface. The necrosis and disintegration of this attached part probably accounts for the collapse shown in a section of a typical example of the late healed case (Fig. 9).

It seems strange that no fracture as such has ever been described in such a vulnerable epiphysis. It is proposed, as a result of this investigation, that Freiberg's infraction is indeed a fracture, although somewhat modified by its environmental epiphysial plate and articular cartilage.

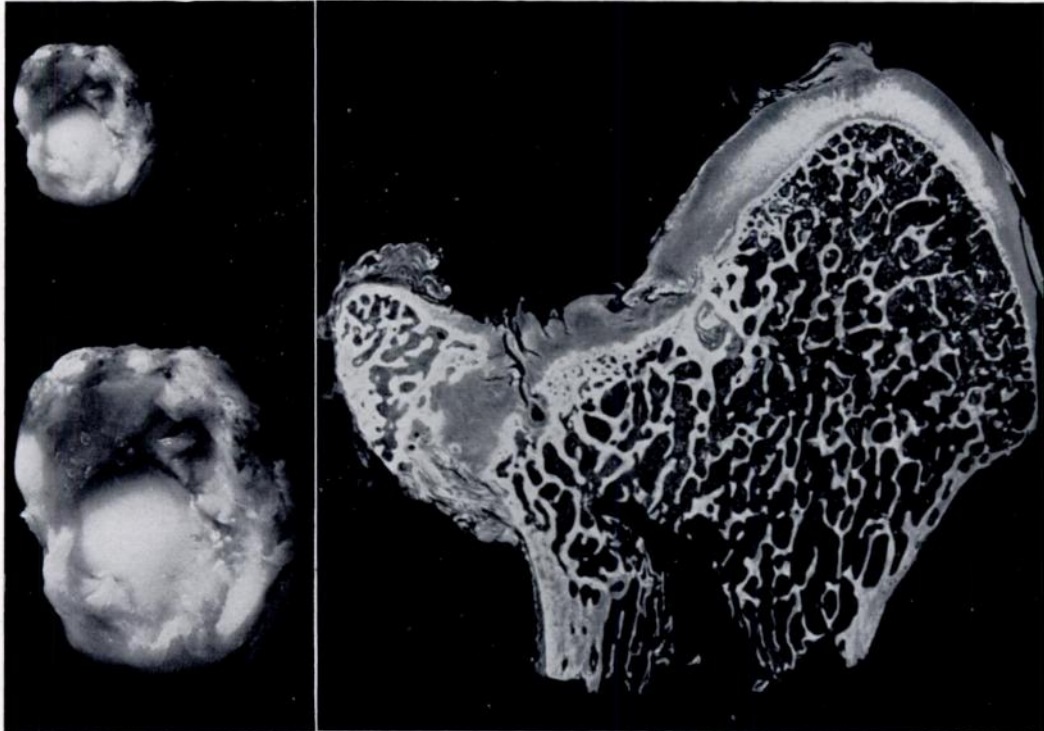


FIG. 8

FIG. 9

Figure 8—Enlarged photograph of articular surface of metatarsal head in the healed phase of Freiberg's infraction (shown actual size above). Figure 9—Section from specimen shown in Figure 8, showing collapse with the articular surface intervening between the flattened metatarsal head and the dorsal fragment.

SUMMARY

1. Experiments show relative weakness of the second metatarsal epiphysis at a certain stage of epiphysial maturation.
2. It is shown that at this stage Freiberg's infraction is likely to occur.
3. It has been demonstrated that even gross comminution with disruption of the articular cartilage of the second metatarsal head is compatible with a radiograph of almost normal appearance.

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