COMPRESSION STRESS FRACTURES IN MAN AND THE GREYHOUND

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Compression stress fractures are not to be newly described in this paper; rather they are to be considered as an entity in themselves to allow the recognition of another variety of stress fractures in clinical practice. Nomenclature has tended to be descriptive of the occasion on, or activity in which the stress fracture occurred, and this has masked the fact that many stress fractures have a common pattern, despite the difference of age, occupation or sex of the patient. Thus the runner’s fracture (Devas and Sweetnam 1956) and that of middle-aged women (Burrows 1940) are one and the same; the “shin soreness” stress fracture of the tibia (Devas 1958) also resembles the latter, but, because of the different structure of the bone in which it occurs, it is rarely complete; the “recruit’s fracture” of the upper tibia may also belong to this category. However, the transverse fracture of the same bone, described in

Case 1—This girl, aged nine, developed pain in the upper left shin. After ten days a radiograph showed a slight haze of internal callus at the junction of the middle and uppermost thirds of the tibia (Fig. 1) which, after a further two weeks, had increased considerably. This is typical of a compression stress fracture (Fig. 2). There is little external callus in comparison with the amount of internal callus, and no fracture line can be seen in the cortices.

Fig. 1

Fig. 2
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ballet dancers by Burrows (1956), is quite different, as is the longitudinal stress fracture (Devas 1960), both having different radiological patterns and doubtless a different causative mechanism.

Fractures arising from injury fall into many categories, one of which is compression, and the same is true of stress fractures. That the greyhound should also suffer from this variety—amongst others—is of particular interest, as will be shown below.

The bones most frequently affected by compression stress fractures are the tibia in its uppermost part in children and its lowermost part in the older person, and the calcaneum. The neck of the femur and the pelvis also suffer compression stress fractures, as well as other

![Fig. 3](image1.png)

Case 2—A boy aged twelve complained of pain in the upper part of his left tibia, which was slightly swollen and tender. A radiograph a week after the onset of symptoms showed a thin haze of periosteal new bone (Fig. 3). Two weeks later the fracture was obvious in the radiographs but the internal callus has been screened by the external so that it does not show very clearly. One cortex can be seen to have fractured (Fig. 4). Two months after first being seen the child was free of symptoms, having had no treatment other than caution in the use of the limb. This fracture is not uncommon in children and is typical in its behaviour.

![Fig. 4](image2.png)

bones, but there is insufficient material as yet either in the literature or in the stress fracture bureau to allow these to be considered in detail.

A compression stress fracture can occur without apparent solution of continuity, and its presence may be confirmed only by the development and recession of internal callus; there may be no external callus whatsoever—particularly in the calcaneum. This, of course, is by no means always the case; indeed, gross deformity can occur, particularly in the elderly. In general the symptoms and signs are similar to those of other varieties of stress fracture. Here, however, it is again of value to emphasise that radiological confirmation can be delayed for several months, to an even greater extent than in other types of this fracture.
Case 3—A woman believed she was a stork and stood on one leg for long periods in a lunatic asylum. One day she was found to be unable to walk and the radiograph showed a typical compression stress fracture of the lowest third of the tibia on which she was wont to stand (Fig. 5). There was little displacement, but there was a haze of internal callus across the tibia at the level of the fracture. Later considerable callus developed outside the cortex (Fig. 6). This is a favourite site for stress fractures in elderly patients with slight osteoporosis. Sometimes there may be considerable displacement.
Case 4—This woman of sixty-nine fell and broke her hip, necessitating Smith-Petersen pin fixation. Three months after returning to full weight bearing, and four months after the fracture, she developed pain above the left ankle, which the author confidently diagnosed as a stress fracture of the fibula. However, radiographs remained normal for four months, when a compression stress fracture began to show in the tibia (Fig. 7). Her symptoms continued, and after a further month the fracture was typical of the compression variety (Fig. 8). Symptoms finally settled at the end of seven months. This patient showed only a little external callus postero-medially.
The compression stress fracture that occurs in the normal healthy living bone of an adult does not always show a fracture line in radiographs, although there must be some solution of continuity if external callus is formed. All that is seen initially is a hazy cloud of increased bone density at the site of the fracture (Figs. 1 and 2). The shadow does not represent bone compressed into itself because it can occur without any deformity; it represents internal callus being laid down within the cancellous bone and is not due to callus outside the cortex. External callus forms in many compression fractures but does not, except in children (Figs. 3 and 4), appear so quickly that the original internal callus cannot be seen. If the compression stress continues, the bone may concertina on itself and show not only a fracture of the cortex (Fig. 5) but slight deformity (Fig. 15).

**Case 5**—A woman of sixty-seven with mild diabetes, but otherwise well, developed pain in the right heel on walking. Two weeks later a more severe pain developed in the left heel, but the symptoms improved on the right (probably due to limitation of activity because of the pain on the left side). After a further three weeks she attended for treatment, and the radiographs (Figs. 9 and 10) showed bilateral compression stress fractures of the calcanea. Clinically she was tender all round both the affected bones, with pain in each on forced plantar flexion against resistance as when standing on tiptoe. A few weeks later a radiograph showed a second line of internal callus—that is, a second stress fracture—on the left (Fig. 11). This appearance is not uncommon, and both fractures developed at the same time. She continued to have symptoms for several months but was able to get about her daily duties with simple measures, such as firm binding of the feet and calves and sponge rubber heel pads.

**CLINICAL VARIETIES**

**The tibia in children**—The child with a stress fracture of the tibia develops pain and a limp; swelling may or may not be obvious. Tenderness varies both in degree and in the length of the shaft affected.
The earliest radiological sign may be either a haze of increased density across the upper part of the tibial shaft (Figs. 1 and 2) or a thin line of callus which delineates the haematoma around the fracture (Fig. 3), or both. The appearance is often suggestive of a neoplasm. However, in this particular stress fracture the radiological change occurs rapidly, and in a few days further calcification within the haematoma, which remains the same size—provided the limb is at rest—confirms the diagnosis (Fig. 4). Nevertheless, if there is doubt a biopsy must be done.

The tibia in the older person—Middle-aged and old people frequently develop stress fractures of the lowest third of the tibia, but, unlike those in young adults, the fracture is transverse (Figs. 5 to 8). Sometimes the onset of pain is sudden and the patient falls to the ground and is thus thought to have caused the fracture by falling. In others it is more gradual. The fracture at this site is not always obvious if the initial haze of bone is not recognised for what it is (Figs. 7 and 8).

The calcaneum—This fracture has been well documented in young adults (Hullinger 1944, Leabhart 1959, Winfield and Dennis 1959) but it also occurs in the older person. It is perhaps the best example of simple compression. Pain in the heel, with or without radiological evidence of a calcaneal spur, may be caused by a stress fracture. Some of the painful heels that are seen so commonly in clinical practice and eventually clear up without a satisfactory diagnosis are no doubt due to this condition. Clinical examination will reveal considerable tenderness on both sides of the calcaneum, as well as below on the ball of the heel, and up the calcaneal tendon, and sometimes there is swelling posteriorly in this region. Standing on tiptoe may cause the pain, as does walking or other similar activities. This fracture may take a long

Case 6—A man aged forty-nine was kick-starting a motor mower when it backfired. The pedal under the ball of his foot forced the ankle into dorsiflexion against the resistance of his calf muscles. A fracture, with some displacement, but following the line of a compression stress fracture, was caused by this violence transmitted through the long plantar ligament in one direction and resisted by the calcaneal tendon and its muscles in the other. This caused compression of the tuberosity of the calcaneum. It is probable that it is this mechanism that causes the compression stress fractures in this bone that occur in marching or walking.

Case 7—This boy fell from the roof of a shed and landed on his heels. The symptoms suggested a fracture of the calcaneum, but the first radiograph was normal (Fig. 13). Three weeks later a traumatic compression fracture can be seen quite clearly (Fig. 14), but the direction of the internal callus is quite different from that in a compression stress fracture, for here it runs horizontally and at right angles to the line of force that caused the fracture.
time to show radiologically and the changes may be very slight, especially if treatment is given promptly by reduction of activity and provision of a sponge heel pad. Figures 9 to 11 illustrate this; they show the thin haze of bone, roughly parallel to the line of the cortex of the tuberosity, but with no break in the cortex (Hullinger 1944)—although this has been seen occasionally. It is also important to realise that the fracture "haze" may on occasion be double, as in the left heel of Case 5 (Fig. 11).

The mechanism of this type of stress fracture is interesting. It is not caused by the heel thumping down on the ground when walking, but by compression across the neck of the calcaneum from the calcaneal tendon pulling hard on the upper part of the tuberosity, the pull being resisted by the long plantar ligament attached to the lower part. Figure 12 illustrates this. It is the radiograph of a man who, when pressing the kick starter of a motor mower with his forefoot, had his ankle suddenly dorsiflexed by the motor back-firing. There was no direct violence to the heel, yet he sustained a fracture at the same site as a stress fracture and one with a similar shape and direction, but with slight deformity. When a fracture of the calcaneum occurs from landing heavily on the heels in a fall from a height the direction of the fracture line is different. This is shown in Figures 13 and 14. This boy fell on to his heels from a shed; the clinical diagnosis was beyond doubt, yet there was initially no radiological confirmation. Three weeks later the fracture could be seen, with no deformity but with internal callus developing. Although this has the same hazy outline as that of a stress fracture, the site and direction are quite different.

**Other bones. The femur**—The femoral neck can sustain stress fractures. Some of these have little or no displacement, and are compression stress fractures; they show first on the under part of the neck with the usual internal callus (Figs. 15 to 19). Even if the patient continues to bear weight the fracture may not disrupt, but it is wise to use internal fixation not only for safety but also to avoid the lengthy disability that occurs with conservative treatment.

**The pelvis**—The stress fractures that occur in the inferior pubic and ischial rami seem to follow the pattern of compression, but here, with a different bone structure, the internal callus is not seen so clearly (Figs. 20 and 21).

**The first metatarsal bone**—Only one example has been seen, but the appearance was so typical of a compression fracture that there can be no doubt about the diagnosis (Figs. 22 and 23).

**COMPRESSION STRESS FRACTURES IN THE GREYHOUND**

The calcaneum and navicular bone frequently sustain stress fractures in the greyhound. This interesting condition has been observed for many years, and Mr J. K. Bateman, to whom I am indebted not only for my knowledge of this condition but also for the illustrations,
Case 9—A very obese girl of twenty-four complained of pain in the left hip and thigh, with no history of injury, and worse towards the end of the day. After one month she was radiographed at the request of her own doctor, and this was thought to be normal, but on close inspection and in the light of later knowledge, a small hazy line can be seen in the bone of the left femoral neck (Fig. 16). Two months later the pain was still continuing and a further radiograph (Fig. 17) confirmed the site of the lesion and showed new bone formation on the under part of the neck of the femur. Meanwhile, blood investigations had been of no help, as everything was normal. After a further two months the stress fracture was consolidating (Fig. 18); the patient had remained all the while up and about. A tomograph after a further two months, that is, six months after the onset of symptoms (Fig. 19), showed the fracture line clearly. Eight months later she was discharged free of symptoms.
Case 10—An elderly lady, who had noticed a little pain in the region of the left hip, spent three hours at a church service after which the pain became severe. Thereafter all movements of the leg or pelvis were painful. A radiograph taken a few days later showed a stress fracture of the inferior pubic ramus (Fig. 20) and one month later the fracture was consolidating (Fig. 21). The appearances in the radiograph suggest a compression stress fracture.

Case 11—A girl aged twenty pushed a delivery cart on a milk round for one month and then developed pain on the inner side of the right foot. This was worse with exercise and better with rest. Clinically there was tenderness at the base of the first metatarsal, and a radiograph confirmed the presence of a compression stress fracture (Fig. 22). Three months later the fracture was disappearing (Fig. 23). The characteristic haze of new bone produced by internal callus allowed the diagnosis to be made with certainty from the radiographs.
has operated on both these fractures successfully, so that the greyhounds not only return to racing but also win.

The interest in the navicular fracture in the greyhound lies in the fact that it always occurs on the right side. The dogs always race anti-clockwise round the track, so that the right hind leg has additional work, and therefore increased stress, in pushing the dog round the corner to the left. When it is realised that the greyhound races at speeds up to or over thirty miles an hour, the extra force required to change direction sharply is considerable.
(Figs. 24 to 26). Normally the dog, turning left, leans over to the left with the left hind leg well underneath; but if "out of step" at the crucial moment, the right hind leg takes the cornering strain. According to Bateman (1958, 1960) it is this type of incident that causes the stress fracture of either the navicular bone or calcaneum (Figs. 27 and 28). No trauma is involved.

For practical purposes the midtarsal joints of the hind foot of the greyhound are devoid of movement; they transmit the tremendous thrust from the hind leg to the forefoot in the manner of a lever. There is, therefore, a compression thrust from the talus through the navicular bone, which, when it breaks, tends to have the fragments extruded (Figs. 27 and 28). It is of interest that the lack of midtarsal movement allows the navicular bone either to be held in place by a metal plate screwed to the talus above and the cuneiform bones below, or to be equally successfully replaced by a Perspex prosthesis.

The calcaneum is broken by the pull of the calcaneal tendon; in the greyhound this is not a compression fracture because the length and angle of the posterior part of the calcaneum
are longer and straighter than in man (Fig. 28). Often both the navicular bone and the calcaneum are broken, because it is probable that the greyhound will continue to run with a fractured navicular bone, only to fracture the calcaneum a few moments later. It is presumed that the loss of length of the foot from the compression fracture of the navicular bone relaxes the long plantar ligaments, thereby allowing a greater strain on the neck of the calcaneum.

DISCUSSION

One interesting feature of the navicular bone of the greyhound is that, when taken from a normal animal, it frequently shows bruising, almost invariably worse on the right, though it can be quite marked on the left (Fig. 27). This indicates that there has been soft-tissue damage within the bone, though the bone itself has not broken. In navicular bones that have been examined after fracture this "bruising" is usually present (Bateman 1960). Although many theories on the fatigue of bone have been advanced, it must also be considered that a stress fracture may, in fact, be a pathological fracture occurring in bone in which the soft-tissue elements, either within the bone or on its surface, have been damaged, with impairment of the blood supply to a certain part of the bone. Thus, in that part, the bone is deprived of its ability to undergo continuous reconstitution and it remains no longer healthy, and perhaps, in fact, no longer living. Under these circumstances fatigue, in the metallurgical sense, would set in, a small break would appear, and this would cause further pathological changes with further oedema of the soft tissues to compress the blood supply and a vicious circle would soon be in operation. It must, however, be emphasised that it is extremely unlikely that there should be but one cause for all forms of stress fractures.

SUMMARY

1. Compression stress fractures are described.
2. These fractures have all been previously described in various bones but have not been associated as a clinical or radiological entity.
3. The greyhound suffers a compression stress fracture of the navicular bone. This is described with certain deductions therefrom.

It would be invidious to single out those of my colleagues at home or abroad whose patients are described here; so I can only record my great gratitude to all who have sent, and still are sending, stress fractures to me. I do owe, however, a very special debt to Mr J. K. Bateman for his help and instruction, as well as for the photographs and radiographs of the greyhounds. I would also like to thank Mr P. H. Newman for his continued support, and Mr M. Turney of the Photographic Department, Middlesex Hospital, for his invaluable assistance.

REFERENCES