FATIGUE FRACTURES OF THE FIBULA


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In describing certain fractures of the fibula, sustained without violence, the writer (Burrows 1940) expressed the hope that further cases would be published so that something could be learnt of these uncommon fractures. Additional cases have now been described. The writer has encountered five other personal cases, and scrutiny of the literature has revealed at least one previous case (Detlefsen 1937). It seems fitting, therefore, to review the subject in detail. Fatigue fracture* of this bone ranks in frequency after the metatarsus, the tibia, and perhaps the femur (Asal 1937, Richmond 1945). As a site for fatigue fracture the fibula has a special, though not unique, place in being a non-weight-bearing bone—a fact which emphasizes the importance of the stresses of muscular action rather than those of weight-bearing.

FATIGUE FRACTURE OF THE LOWEST THIRD OF THE FIBULA

Detlefsen (1937) described an overloading fracture 6 cm. above the lower end of the fibula which developed without injury in a compulsory state worker. He compared it with the fatigue fractures of inanimate materials in industry.

In 1940 Weaver and Francisco described the case of a student, aged twenty-two years, who had been carrying out running practice for several months when for no apparent reason he sustained what was almost certainly a fracture of the right fibula, 3 cm. above its lower end. Five months later a similar condition developed in the neck of the left fibula. The authors regarded the lesions as "pseudo-fractures" and ascribed them to non-suppurative osteomyelitis.

Simultaneously and independently the present writer (Burrows 1940) described two cases of spontaneous fracture of the apparently normal fibula in its lowest third, developing with no history of injury but in association with much activity (cross-country running in one case). While recognising that two cases alone warranted speculation rather than conclusion he suggested an analogy with march fracture of a metatarsal bone. He compared the condition with other military fractures occurring without obvious violence, and indicated the desirability of recording further cases.

Detlefsen (1941) described fatigue fracture of the lowest third of the left fibula in a woman thirty-seven years of age whose work at a machine called for depression of a vibrating pedal with the left foot for eight hours daily. Ingersoll (1943) described fatigue fractures in the lowest two or three inches of the fibula of three patients—all boys, all aged nine years, and all beginners at ice-skating. In one case the fracture was bilateral.

In 1944 Hamilton and Finklestein described bilateral fatigue fracture of the lowest third of the fibula in a recently recruited infantryman who was undergoing training and subsequently suffered march fracture of the second metatarsal bone. The fibular fractures were described as march fractures. In another bilateral case recorded by Ronald (1945) the symptoms began during a cross-country run and changes developed in the right fibula about two weeks after those in the left.

Richmond (1945) described two unilateral cases in soldiers undergoing training. In one, the pain developed after a cross-country run. McPhee and Franklin (1946) recorded cases in a track runner and a basketball player.

*Spontaneous fractures are fractures without material violence (i.e., without acute trauma), and may occur in pathological bone or in seemingly normal bone. Fatigue fractures are spontaneous fractures of seemingly normal bone. They appear to result from a summation of stresses, which singly are insufficient to produce fracture.
### FATIGUE FRACTURES OF THE FIBULA

#### TABLE I—Analysis of Published and Personal Cases of Fatigue Fracture of the Fibula

(\textit{Doubtful cases in italics})

<table>
<thead>
<tr>
<th>Part of fibula affected</th>
<th>Author</th>
<th>Year</th>
<th>No. of pts</th>
<th>Side</th>
<th>Age (Yrs.)</th>
<th>Sex</th>
<th>Occupation</th>
<th>Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Gruner</td>
<td>1910</td>
<td>1</td>
<td>R</td>
<td>--</td>
<td>M</td>
<td>Grenadier recruit</td>
<td>Doubling</td>
</tr>
<tr>
<td></td>
<td>Finny</td>
<td>1924</td>
<td>1</td>
<td>R and L</td>
<td>--</td>
<td>M</td>
<td>Infantry private</td>
<td>Cross-country running</td>
</tr>
<tr>
<td></td>
<td>Detlefsen</td>
<td>1937</td>
<td>1</td>
<td>--</td>
<td>20</td>
<td>--</td>
<td>-- Compulsory state service</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Weaver and Francisco</td>
<td>1940</td>
<td>1</td>
<td>R</td>
<td>22</td>
<td>M</td>
<td>Student</td>
<td>Running practice for &quot;Track team&quot;</td>
</tr>
<tr>
<td></td>
<td>Burrows</td>
<td>1940</td>
<td>2</td>
<td>L</td>
<td>61</td>
<td>F</td>
<td>Parish worker</td>
<td>Much walking Cross-country running</td>
</tr>
<tr>
<td></td>
<td>Detlefsen</td>
<td>1941</td>
<td>1</td>
<td>L</td>
<td>37</td>
<td>F</td>
<td>Muster needlewoman</td>
<td>Depression of vibrating pedal</td>
</tr>
<tr>
<td></td>
<td>Ingersoll</td>
<td>1943</td>
<td>3</td>
<td>R and L</td>
<td>9</td>
<td>M</td>
<td>Schoolboy</td>
<td>Beginner at ice skating</td>
</tr>
<tr>
<td></td>
<td>Hamilton and Finklestein</td>
<td>1944</td>
<td>1</td>
<td>R and L</td>
<td>--</td>
<td>M</td>
<td>Infantry recruit</td>
<td>Training</td>
</tr>
<tr>
<td></td>
<td>Richmond</td>
<td>1945</td>
<td>2</td>
<td>L</td>
<td>--</td>
<td>M</td>
<td>Infantry N.C.O., training</td>
<td>Cross-country running Assault course, etc.</td>
</tr>
<tr>
<td></td>
<td>Ronald</td>
<td>1945</td>
<td>1</td>
<td>L and R</td>
<td>--</td>
<td>M</td>
<td>(Not stated? airman)</td>
<td>Cross-country running</td>
</tr>
<tr>
<td></td>
<td>McPhee and Franklin</td>
<td>1946</td>
<td>2</td>
<td>R</td>
<td>--</td>
<td>M</td>
<td>University athlete</td>
<td>Track running Basketball</td>
</tr>
<tr>
<td></td>
<td>Burrows</td>
<td>1948</td>
<td>5</td>
<td>R</td>
<td>20</td>
<td>M</td>
<td>Medical student</td>
<td>Cross-country running</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>R</td>
<td>45</td>
<td>F</td>
<td>Nurse</td>
<td>Much on feet</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>L</td>
<td>56</td>
<td>F</td>
<td>Housewife</td>
<td>Household duties and running</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>R</td>
<td>51</td>
<td>F</td>
<td>Housewife</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>R</td>
<td>63</td>
<td>F</td>
<td>Housewife</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hopfengärtner</td>
<td>1907</td>
<td>39</td>
<td>--</td>
<td>--</td>
<td>M</td>
<td>Infantry in first year</td>
<td>Jumping (25 cases)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1909</td>
<td>1</td>
<td>--</td>
<td>--</td>
<td>M</td>
<td>Fusilier in first year</td>
<td>Attacking from kneeling</td>
</tr>
<tr>
<td></td>
<td>Gruner</td>
<td>1910</td>
<td>1</td>
<td>R</td>
<td>--</td>
<td>M</td>
<td>Grenadier recruit</td>
<td>Training</td>
</tr>
<tr>
<td></td>
<td>Scherf</td>
<td>1933</td>
<td>9</td>
<td>4R</td>
<td>--</td>
<td>M</td>
<td>Artillery recruits</td>
<td>Jumping exercises from double-knees-bend</td>
</tr>
<tr>
<td></td>
<td>Asal</td>
<td>1936</td>
<td>&quot;Many&quot;</td>
<td>2 bilateral</td>
<td>--</td>
<td>M</td>
<td>Artillerymen (mostly)</td>
<td>Jumping on and off limber for hours on end</td>
</tr>
<tr>
<td></td>
<td>Asal</td>
<td>1937</td>
<td>&quot;Many&quot;</td>
<td>12 bilateral</td>
<td>--</td>
<td>M</td>
<td>Artillerymen (mostly)</td>
<td>Gun exercises, with much jumping on and off limber</td>
</tr>
<tr>
<td></td>
<td>Wachsmuth</td>
<td>1937b</td>
<td>1</td>
<td>L and R</td>
<td>21</td>
<td>M</td>
<td>Infantry recruit</td>
<td>Training exercises</td>
</tr>
<tr>
<td></td>
<td>Wachsmuth</td>
<td>1937a</td>
<td>&quot;Several&quot;</td>
<td>--</td>
<td>--</td>
<td>M</td>
<td>Infantry in training and artillerymen</td>
<td>Jumping, knee-bending, squatting</td>
</tr>
<tr>
<td></td>
<td>Detlefsen</td>
<td>1937</td>
<td>1</td>
<td>R</td>
<td>21</td>
<td>--</td>
<td>-- Compulsory state service</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Weaver and Francisco</td>
<td>1940</td>
<td>1</td>
<td>L</td>
<td>22</td>
<td>M</td>
<td>Student</td>
<td>Running practice for &quot;Track team&quot;</td>
</tr>
<tr>
<td></td>
<td>McPhee and Franklin</td>
<td>1946</td>
<td>1</td>
<td>L</td>
<td>--</td>
<td>M</td>
<td>University athlete</td>
<td>Running</td>
</tr>
<tr>
<td></td>
<td>Siemens</td>
<td>1942</td>
<td>1</td>
<td>L and R</td>
<td>16 12</td>
<td>M</td>
<td>(Infant)</td>
<td>Reputedly very lively</td>
</tr>
<tr>
<td></td>
<td>Leveton</td>
<td>1946</td>
<td>1</td>
<td>L</td>
<td>19</td>
<td>M</td>
<td>Recruit</td>
<td>Training</td>
</tr>
<tr>
<td></td>
<td>McPhee and Franklin</td>
<td>1946</td>
<td>1</td>
<td>L</td>
<td>--</td>
<td>M</td>
<td>University athlete</td>
<td>Running</td>
</tr>
</tbody>
</table>

\textit{Vol. 30 B, No. 2, May 1948}
Case 1. Fig. 1 shows the radiographic appearances twenty-three days after the first symptoms and sixteen days after the first acute symptoms. A band of slightly increased density and subperiosteal ossification is just discernible. A week before, no radiographic abnormality could be detected. Fig. 2 shows the appearances five weeks later than those in Fig. 1. Calcified callus is much increased but no fracture line is evident.
Association with strenuous running in at least five cases may throw new light on two examples of fibular fracture which were reported many years ago. Gruner (1910) reported a fracture at the junction of the lowest and middle thirds of the fibula in a recruit who complained of pain after running, but he ascribed it to forced supination. Finny (1924) told of a soldier who was running in an inter-regimental cross-country race and twisted his left foot inwards on a lump of earth; as he stumbled the other foot was twisted in a similar manner. He completed the remaining three miles of the race and finished twelfth out of a large field. Radiographs showed a fracture two inches above the lower end of each fibula.

Further Personal Cases

Five additional cases of fatigue fracture of the fibula at this site are here reported.

Case 1. Medical student, aged 20 years. Nine years before being seen he won a seven-mile inter-club cross-country race in 40 mins. 44 secs. As he jogged back to the pavilion, which was about a mile distant, the lower end of the right fibula became painful and the ankle felt stiff. After being supported with elastic adhesive strapping it improved each day and four days later, with the ankle still strapped, a gentle three-mile run caused no discomfort. Two days before being seen he had taken part in an inter-university cross-country run of more than six miles. After running three and a half miles sudden pain at the same site made him stumble but not fall. There was no audible snap. He had to walk home, covering three miles of frozen rough ground in about an hour. The strapping became tight and the painful area throbbed. Change of strapping and a hot bath brought relief, but he was awakened at about 2 a.m. with much pain which was relieved by removal of the strapping. There was no further improvement. Pain increased on resuming activity after rest, or moving the limb forwards against gravity. There had been no injury and the pain had preceded the stumble. On examination the fibula was tender over a length of about one and a half inches, centred at a point of maximum tenderness two and a half inches above the tip of the lateral malleolus. No swelling was visible or palpable and there was no redness or increased skin temperature. Active and passive tarsal and ankle movements were full except that active dorsiflexion was limited at the right ankle; passive dorsiflexion alone gave slight pain at the site of tenderness. Similar pain was produced by jarring or "springing" the tibia and fibula. Radiographs showed no bone abnormality even on close scrutiny with a lens, but the clinical diagnosis of fatigue fracture of the lowest third of the fibula was made with confidence. Elastic adhesive strapping was applied from the metatarsal heads to the top of the calf with steady improvement in the pain. Seven days later there was still no radiographic change; but seven days later, when a slight hard swelling had appeared at the tender site, further radiographs (Fig. 1) showed a band of slightly increased density about three-sixteenths inch broad, with very slight subperiosteal ossification situated two and a half inches above the tip of the lateral malleolus. By the end of the next three weeks the range of movement had returned fully, the radiographic changes were substantially increased, and the strapping was discarded. After yet another fortnight, walking, standing and running were painless though followed by throbbing; movements were full; and radiographs showed increased subperiosteal opacity but still no fracture line (Fig. 2). After another fortnight there were no symptoms or signs except slight local tenderness and bony swelling. These were still evident fifteen weeks after the onset when radiographs showed that the new bone was well organised and with some indication of a transverse, relatively clear, band. Twenty-two weeks from the onset he was free of all symptoms and won the inter-hospitals three miles race in 16 mins. 34secs. A bone ridge was still palpable clinically and visible radiographically. At no time was wasting of the calf demonstrable. Control radiographs of the hand showed no evidence of porosis.

Case 2. Nurse, aged 45 years, working in an old-fashioned nursing home, who had not recently increased her activities or suffered any injury. One afternoon, four weeks before examination, pain and swelling developed suddenly in the region of the right lateral malleolus. Both were worse by day than by night. She managed her duties for two weeks, and the swelling diminished gradually. On examination, oedema and a slightly raised cutaneous temperature were found over the lower part of the right fibula which was tender at a level about one and a quarter inches above its lower end. Ankle and tarsal movements were full and painless. Radiographs (Fig. 3) showed a fracture of the fibula one and a half inches above the tip of the lateral malleolus. Displacement was minimal. In the antero-posterior view the fracture appeared transverse but the lateral view showed that it passed obliquely forwards and downwards for a quarter to half an inch. Scarcely any callus was visible. Strapping, which had been applied to the foot, ankle, and calf, was removed by the patient within a week because she had become quite comfortable. When seen again three and a half weeks after the first occasion, and seven and a half weeks...
from the onset, she was quite comfortable and the oedema had disappeared; but there was still slight tenderness and by then some bony swelling at the site of fracture. Further radiographs showed a fairly pronounced cuff of callus (Fig. 4).

Fig. 3
Fig. 4

Case 2. Fig. 3 shows the radiographic appearances at first examination, four weeks after the onset of symptoms. A small amount of ossified callus is present. Fig. 4 shows the appearances three and a half weeks later than those in Fig. 3 and seven and a half weeks after the onset of symptoms. Ossified callus has increased considerably.

Case 3. Housewife, aged 56 years, who was "on the go all the time" and "did everything" for a husband and four bachelor sons. She liked walking, and five weeks before being seen she took an unnecessary walk of two miles in addition to ordinary activities. On rising next morning she had great difficulty in carrying on because of pain in the left ankle which soon became swollen, shiny, and hot, but not redigened. The pain was relieved by rest but it was particularly severe when activity was first resumed. Walking was worse than standing. There had been no injury. Slight spontaneous improvement occurred slowly. The diagnoses of gout and thrombophlebitis had been made at different times. On examination, five weeks after the onset, diffuse pitting oedema of the left ankle region was found with tenderness just proximal to the lateral malleolus, and with about ten degrees limitation of plantar flexion movement. The feet were supple but were flat both longitudinally and transversely. Radiographs showed a broad transverse fracture line, one and a half inches above the tip of the lateral malleolus, without displacement and with little callus (Fig. 5). Control radiographs of the hand showed no psoriasis. Elastic adhesive strapping was applied from the metatarsal heads to the upper calf for three weeks with improvement. The pain did not disappear completely, nor did plantar flexion return fully for twenty-five weeks. Even then very slight local tenderness and bony swelling persisted. Further radiographs (Fig. 6) taken nine months after the onset showed complete restoration of bone texture, the only indications of the old fracture site being a band of slightly increased density and very slight bony thickening.

Case 4. Housewife, aged 51 years—a very energetic woman. Besides caring for a husband and two children aged twenty-one years and thirteen years, she worked five hours a day as inspector in an engineering works—a sitting job which involved a brisk twenty minutes' walk each way over a rough country road. On getting out of bed thirteen days before being seen she found that the lower right tibial region was painful. She went to work but increasing pain during the afternoon drove her to her doctor who diagnosed "sepsis." She remained off work (but continued housework) and applied kaolin poultices for a week, and then a crépe bandage, without improvement. Walking was more painful than standing, and rest from weight-bearing brought improvement. Nocturnal aching did not interfere with sleep. The pain was not aggravated on first resuming activity after rest. There had been no relevant injury. On examination
Case 3. Fig. 5 shows the radiographic appearances five weeks after the onset. Though the fracture zone is distinct, callus is scant. Fig. 6 shows the radiographic appearances nine months after the onset. The structure of the bone is fully restored but the site of fracture is still marked by a dense band.

Case 4. Radiographic appearances twenty-five days after first examination. Horizontal fracture one and a half inches above the tip of the lateral malleolus with substantial callus.
non-pitting oedema was found over the outer part of the right ankle region without redness or increased cutaneous temperature. Localised tenderness was elicited about one and a half inches above the tip of the lateral malleolus. Dorsiflexion and plantar flexion were about half the normal range, inversion and eversion about three-quarters. Moderate hallux valgo-rigidus was present. Radiographs showed an almost horizontal fracture, one and a half inches above the tip of the lateral malleolus with slight posterior displacement of the distal fragment. Control radiographs of the hand revealed no porosis. A plaster-of-Paris walking cast was worn for eleven days, followed by elastic strapping. After twenty-five days' treatment there were still some pain, local tenderness, and swelling. The girth of the calf was diminished by a quarter of an inch. Movements were full and painless except that inversion caused pain at the fracture site. Further radiographs (Fig. 7) showed substantial callus. Thereafter she had practically no discomfort, and returned to work nine days later. After another five days there was still a hard, slightly tender swelling on the fibula and still a quarter of an inch wasting of the calf, but movements were full and painless.

Case 5. Housewife, aged 63 years, with only a husband to look after but nevertheless on her feet almost all day. Twenty-four days before being seen she was walking about on household duties when she noticed severe pain in the outer side of the lower part of the right fibula. The pain, which drew attention to swelling, was aggravated by standing or walking, especially out-of-doors, and was improved by rest. There had been no injury. On examination the right fibula presented a bony hard, tender swelling, one and a half inches from its lower end, with adjacent non-pitting oedema but with no redness or raised temperature. There was a full range of painless tarsal and ankle movement and no measurable wasting of the calf. Radiographs (Fig. 8) showed an almost transverse fracture about one and a half inches above the tip of the lateral malleolus without displacement. A little calcified callus was present. There also appeared to be diminished density of all bones, the same being so on the left side but without fracture. Control radiographs of one hand (Fig. 9) showed evidence of slight generalised porosis which, however,
was not considered to be of pathological degree. Elastic adhesive strapping was applied from the base of the toes to just below the knee. It was continued for five weeks by which time all pain, tenderness and oedema had subsided. The patient reported that twenty years earlier swelling of one foot had appeared spontaneously and without injury. It had lasted about one month and no radiographs had been taken. Radiographs now show evidence of a united fracture of the distal third of the second left metatarsal bone (Fig. 10).

![Radiograph of hand showing slight relative porosis](image)

**Fig. 9**

Case 5. Control radiograph of hand. The patient’s hand (which was taken simultaneously with that of a control subject on the same film) shows very slight relative porosis which, if of pathological degree, would negative the diagnosis of fatigue fracture.

![Radiograph of hand showing united fracture](image)

**Fig. 10**

Case 5. Radiographic evidence of old fatigue fracture of the second left metatarsal bone, of which a possible twenty-year-old history was given.

**Comment**—From this review, two groups of fatigue fracture of the lowest third of the fibula may be defined: 1) fractures in young male runners and skaters; 2) fractures in women of middle age or over, who have much to do on their feet. The example of the second group recorded by the writer (1940) was ascribed by Hartley (1943) to “spontaneous fracture due to age.” But even if sixty-one be old, age is not a disease, and moreover there was a history of much activity and no obvious evidence of osteoporosis. The same is true of the cases here described, with the sole exception of the last which did show some generalised porosis, but apparently not of pathological degree so that there was little justification for the diagnosis of pathological fracture rather than that of fatigue fracture.

Vol. 30 B, No. 2, May 1948
Clinical Features

A study of published and personal cases has yielded some knowledge of the clinical features of fatigue fracture of the lowest third of the fibula.

Age, sex, side affected, and activities of the patients are indicated in Table I (Section i). The natural grouping into young male runners and less young active women has already been mentioned. Four of twenty-one patients had bilateral fractures of the lowest third.

Site of fracture in the lowest third—The fracture was one and a half inches above the tip of the lateral malleolus in the five women observed by the author, whereas it occurred at a higher level in each of the two male patients. Study of other cases reported in the literature shows a similar distinction (Table II). It shows that most male patients (all the cross-country runners and skaters) suffered fractures two inches or more above the lateral malleolus, but that this was true of only one woman. If the difference in level is significant it may depend upon sex, age, or type of stress. Let it suffice at present to record that elderly, hard-pressed women tended to have fractures one and a half inches above the tip of the lateral malleolus through mainly cancellous bone at a level immediately below the interosseous ligament, whereas young male runners and skaters tended to have fractures at a higher level where the bone is slender but largely cortical. In this region the character of the bone, both as to thickness and composition, changes very rapidly with level (Fig. 11).

Symptoms—There has always been much activity involving repetition of the same resisted movement—walking, running, skating, and in one instance depression of a vibrating pedal. Usually the symptoms started during such activity but two patients here recorded first noticed pain on rising one morning. As a rule, customary activities are continued with difficulty for some days or weeks.

The first complaint has been pain and in the case of two patients a sensation of "stiffness." Occasionally the onset has been sudden, making one patient stumble and another fall. The site is described as the ankle, the lateral side of the ankle, the lateral malleolus, above the malleolus, or the outer part of the leg. There is relatively little information in the literature as to the characters of the pain, but in general it seems to be improved though not necessarily abolished by rest and to be increased by weight-bearing, especially weight-bearing with movement. It is sometimes worse on first resuming activity after a period of rest. As in fatigue fractures elsewhere, there is not only an absence of violence but also of any audible snap, so that no suspicion of fracture ever occurs to the patient.

Signs—Localised tenderness is usually present, but its absence was recorded specifically in three cases which were seen from three to eighteen days after the onset of symptoms (Hamilton and Finklestein 1944, Ingersoll 1943). Localised swelling was reported in all cases but five.
At first there is pitting or non-pitting oedema. This diminishes, and about three weeks from the onset of symptoms, a hard swelling of the tender area of the fibula becomes palpable. Slight redness has been reported twice (Hamilton and Finklestein 1944, McPhee and Franklin 1946). Increased local cutaneous temperature of slight degree has been recorded four times (McPhee and Franklin 1946, Burrows 1948). Limp was mentioned exceptionally. Wasting of the calf was found in one only of the writer's patients, the girth being diminished by half an inch. Ankle and tarsal movements are often undiminished. Most writers have failed to comment on movement but its freedom was remarked in six cases, from seven days to five weeks after the onset (Burrows 1940 and 1948, Detlefsen 1941, Hamilton and Finklestein 1944). Three patients in this series showed slight limitation of ankle movement but in no other known cases has limitation been recorded.

Radiographic Examination

During the first fifteen days or more no radiographic change may be discernible. On the other hand a fracture line may be evident after a week; sometimes none appears till the end of the second or third week. At first it is difficult to see, and even after four weeks it may be recognised only with the aid of a lens. A band of rarefaction may be seen at twelve to eighteen weeks. Callus has been observed in a child as early as the eighth day. In adults it appears during the third week, steadily consolidating and becoming organised at twelve to sixteen weeks when it forms a spindle-like thickening crossed by a less dense stripe at the site of fracture. At forty-seven weeks it may still be just possible to distinguish thickening. A dense band is often the first indication of the fracture site and almost the last to disappear. (See Figs. 1 and 6.) The plane of fracture is almost horizontal; slight deviations from this are not always in the same direction so that little can be concluded about the fracturing stresses.
Diagnosis

Since the condition is unfamiliar, and therefore unsuspected, it seems probable that it is often overlooked altogether. The freedom of joint movement and the site of tenderness help to distinguish it from sprains, but the absence of tenderness may be misleading. Radiographic examination must be the chief safeguard. In early suspected cases, if no abnormality is revealed with the aid of a lens the films should be repeated after three weeks. Competent interpretation is no less important than good radiography. Such diagnoses as osteomyelitis, tuberculosis, congenital syphilis, sarcoma and myositis ossificans have been made, and such errors may prove far more damaging than failure to recognise any lesion at all.

Treatment and Results

Provided that the exciting activity is discontinued, normal pursuits may be allowed with the comfort afforded by elastic adhesive bandage from the metatarsal heads to the upper calf. Physiotherapy is not required. With such treatment pain diminishes or disappears within a week, but tenderness may remain for as long as eight to sixteen weeks. Bone thickening persists still longer. It is difficult to be certain when the promoting activity may be resumed with safety; but too early resumption may cause recurrence of symptoms, or occasionally fatigue fracture of the opposite fibula or another bone.

FATIGUE FRACTURES IN THE UPPERMOST THIRD

Weaver and Francisco (1940) reported what were described as "pseudo-fractures," first in the lowest third of one fibula and then in the uppermost third of the other, in a student; but most recorded fractures at this higher level have been in soldiers. Hopfengärtner (1907) recorded military fractures of the uppermost third of the fibula in infantrymen during their first year of service. In twelve of the eighteen cases pain was first produced by jumping. The regimental records included twenty-one other cases, thirteen of them ascribed to jumping. Dreist (1909) reported fractures of the fibula at about the junction of the uppermost and middle thirds in two fusiliers during their first year of service. One sustained his fracture in landing from a vault and must be excluded because of the obvious trauma. The other noticed gradually increasing cramp-like pain during practice in attacking from the kneeling position. Radiography revealed an incomplete fracture which was attributed to strain from the nature of the exercise. Fractures in recruits reported by Grunert (1910) included one situated seven centimetres below the head of the fibula, sustained without apparent cause but interpreted as a torsion fracture. Scherf (1933) described fracture of the fibula at the junction of its uppermost and middle thirds, without direct injury and with little or no displacement, in nine artillery recruits who were required to carry out jumping exercises from a double-knees-bend position for about five minutes several times daily. Pain in the calf would start suddenly during the exercise. The author was uncertain whether the lesions were to be regarded as fractures or "transformation zones" (umbauzonen). Wachsmuth (1937a) emphasised jumping and repeated double-knee-bending as exhausting the "working efficiency of bone," the commonest effect being fracture of the fibula, usually at the junction of middle and uppermost thirds. Tibial march fracture, affecting mostly infantrymen and confined to the training period, might be accompanied by a corresponding fracture of the fibula. In the records of the German Army hospitals covering the year 1935–36, Asal (1936, 1937) found 590 cases ascribable to "overloading injury" and distributed as follows: metatarsals 488, tibia 70, femoral shaft 7, femoral neck 6, fibula 12, oscalci 4, and pelvis 3. The fibular fractures, mostly affecting the junction of middle and uppermost third, occurred mainly in artillerymen and were ascribed to intensive gun exercises, particularly jumping on and off the limber over long periods. Wachsmuth also saw several such cases. Detlefsen (1937) described a case in a compulsory industrial worker. McPhee and Franklin (1946)
recorded one in a middle-distance runner. The frequent association with jumping is most striking. As the metatarsal fracture is the typical "march fracture," and the low fibular fracture is perhaps a running fracture, so the high fibular fracture appears to be typically a jump fracture.

It is interesting to compare fractures in the uppermost third of the fibula among infantry and artillery recruits with another series of fractures at the same site which constituted one of two typical leg injuries at a parachute school (Lord and Coutts 1944). These followed either parachute landings or platform jumps of four to six feet (Lord 1945). Pain was slight and patients often reported only after a delay of several days. Watson-Jones (1945) informed the writer that fifty-six fractures and dislocations sustained by a group of parachutists under training included "eleven cases in which a crack in the upper shaft of the fibula was suspected, or a fatigue fracture developed subsequently."

Former cases in artillery recruits and infantrymen, and more recent cases in parachutists, may be regarded as either: 1) traumatic fractures caused by jumps but often masked by painlessness; or 2) fatigue fractures; or 3) a combination of the two. Andreasen (1946) told the writer that the incidence of fracture of the fibula in its uppermost third amongst Indian parachute troops varied at different stages of their training but not in such a way as to suggest that fatigue was a material influence. Until further knowledge is available we cannot doubt the current view that high fibular fractures in infantry and artillery recruits are exclusively fatigue fractures, and that parachute fractures are exclusively traumatic fractures, but nevertheless the resemblance between these groups which each occur in young men undergoing severe training cannot be ignored, and it may be that trauma and fatigue both play a part in each group. A link would thus be forged between traumatic fracture due to a single adequate stress (abnormal stress), and fatigue fracture due to a summation of minimal stresses (abnormal incidence)—an interpretation which might be written thus:

<table>
<thead>
<tr>
<th>FATIGUE FRACTURE (e.g., lowest third of fibula)</th>
<th>Stress</th>
<th>Incidence of stress</th>
</tr>
</thead>
<tbody>
<tr>
<td>RECRUITS’ FRACTURE OFTEN ASSOCIATED WITH JUMPING (uppermost third of fibula)</td>
<td>Minimal</td>
<td>++++ etc.</td>
</tr>
<tr>
<td>PARACHUTE SCHOOL FRACTURE (uppermost third of fibula)</td>
<td>+</td>
<td>+++ etc.</td>
</tr>
<tr>
<td>TRAUMATIC FRACTURE</td>
<td>++</td>
<td>+</td>
</tr>
</tbody>
</table>

**FATIGUE FRACTURE OF THE MIDDLE OF THE FIBULA**

Siemens (1942) observed condensation and disintegration of bone structure in the middle of each fibula of a healthy boy aged sixteen months who complained of pain in the left leg when tired, and who limped. The right fibula showed periosteal new bone formation. Though the child was very lively the diagnosis of bilateral fatigue fracture of the fibula must, at this age, be accepted with reserve. Leveton (1946) described a fatigue fracture slightly above the middle of one fibula in a recruit aged nineteen years, and McPhee and Franklin (1946) reported a similar fracture just below the middle of the bone in a runner.

**MULTIPLE FRACTURES**

Multiple fractures naturally suggest general bone disease, which would exclude a diagnosis of fatigue fracture. The suspicion may prove false; multiple fractures sometimes occur without evident bone disease and they present all the typical characteristics of fatigue fractures and none of those of pathological fractures.
Fractures of both fibulae (at the same level or at different levels)—Bilateral low and high fatigue fractures have been mentioned. Low fracture of one fibula has been followed by high fracture of the other (Weaver and Francisco 1940).

Fractures of fibula and metatarsal—An infantry recruit, with bilateral low fatigue fracture of the fibula, later suffered a metatarsal march fracture (Hamilton and Finklestein 1944). Fatigue fracture of the third metatarsal bone in an infantry soldier under training was followed by a low fatigue fracture of the corresponding fibula (Richmond 1945).*

Except in their multiplicity these fractures differ in no respect from typical fatigue fractures. It is possible that although no pathological cause has been found there may be predisposition in some individuals. Poor neuro-muscular co-ordination may play a part, as suggested by the observation of non-commissioned officers that recruits who developed such fractures had been awkward from the first (Wachsmuth 1937b). Moreover, Case 5 of this series shows that otherwise typical fatigue fractures at multiple sites (fibula and metatarsal) may in fact be associated with slight non-pathological osteoporosis.

* Wachsmuth (1937b) mentioned an infantry recruit with fractures of one tibia and fibula between middle and uppermost thirds, who was found to have an old united high fracture of each fibula; it is possible, however, that the recent fractures were traumatic. High fracture of the fibula sometimes complicates fatigue fracture of the corresponding tibia, but it is possible that the fibular fracture is a traumatic complication of displacement of the tibial fracture, as in a case of Hartley (1942).

SUMMARY

1. A hope expressed in 1940, that further cases of spontaneous fracture of the lowest third of the apparently normal fibula would be described, has been fulfilled. The literature is here reviewed. Five further personal cases are added.
2. The clinical and radiographic features, diagnosis, treatment and results are considered in the light of the information so far available. Special note is made of misleading freedom of ankle and tarsal movements and the occasional absence of tenderness.
3. It is established that fractures of the lowest third occur particularly in two groups of subjects: 1) young male runners and skaters; 2) active and hard-pressed women of middle age and over.
4. In male runners and skaters the fracture usually occurs through slender, mainly cortical bone, two inches or more above the tip of the lateral malleolus; in middle-aged women the fracture is usually distal to the interosseous ligament through thicker, mainly cancellous bone, one and a half inches from the tip of the lateral malleolus.
5. The most convenient name for both groups of fractures in the lowest third is low fatigue fracture of the fibula.
6. A review of the literature of fatigue fracture of the uppermost third of the fibula shows that it is very often precipitated by jumping. The most convenient name for it is high fatigue fracture of the fibula.
7. Like all clinical classifications this distinction between low and high fractures has exceptions (a low fracture of one fibula in a runner was followed later by a high fracture of the other; most military fractures were high, but a few may have occurred at other levels).
8. Fatigue fracture of the fibula, high or low, may be bilateral.
9. A fracture similarly situated to the high fatigue fracture of the fibula has been frequent in parachute schools. It is a speculative possibility that military and parachutist fractures of the upper third of the fibula indicate the link between true fatigue fractures (as exemplified by march fractures with minimal trauma often repeated) and purely traumatic fractures (with adequate trauma applied once only).

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