FRACTURES OF THE CALCANEUM

With an Atlas Illustrating the Various Types of Fracture

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Divergence of opinion still exists about the merits of the various methods of treatment of fractures of the calcaneum. We consider that a necessary preliminary to the application of any form of treatment is an accurate description of the course of the main lines of fracture and the displacement of the principal fragments. With this in view we have classified a large series of recent fractures of the calcaneum and studied particularly the mechanism of the compression-shearing injuries and the fracture patterns which these usually produce.

RADIOGRAPHIC EXAMINATION

As we have said elsewhere (Bremner and Warrick 1951) we subject cases of suspected fracture of the calcaneum to radiography in the lateral and axial projections and in Anthonson's oblique projection. The technique employed for taking the axial projection is that in which the Potter-Bucky diaphragm is used (Fig. 1). The resulting radiograph should demonstrate clearly the subtalar joint and with care such a radiograph can be produced without undue discomfort to the patient in almost every case of recent fracture of the calcaneum. In Anthonson's (1943) oblique view the bone is projected as shown in Figure 2. The dorsiflexed foot is placed in the lateral position on the film and the ray is directed to a point just below the medial malleolus with an angulation of 25 degrees towards the foot of the table (cranio-distally) and 30 degrees towards the toes (dorsi-ventrally). The ray strikes the posterior articular facet tangentially and passes in the direction of the long axis of the sulcus calcanei (Fig. 3).

MECHANISM OF FRACTURE

Three hundred fractures of the calcaneum have been classified, as shown in Table I, into two main groups. Much remains to be learned concerning the mechanism of fracture of Group I. It is proposed here, however, to confine discussion to the mechanism of those fractures which constitute Group II.

The compressional force and shearing strain to which the calcaneum is subjected when the heel strikes the ground as a result of a fall from a height are much greater than the forces of normal weight bearing. If the impact is sufficient to fracture the bone the fracture will run forwards and laterally from a point on the medial side a variable distance behind the sustentaculum tali. We call this the *primary fracture* and it may extend in three ways: It may traverse the posterior articular facet; it may enter the sulcus calcanei medial to the facet and then pass towards the lateral side of the bone; or it may reach the lateral side of the bone by passing behind the posterior articular facet. The primary fracture thus divides the bone into two main fragments. The main lateral fragment lies postero-lateral and the main medial fragment antero-medial to the primary fracture.

If the primary fracture is unassociated with a secondary compression fracture (described below) of the main lateral fragment the following variations of fracture may be recognised. 1) Fracture of the posterior articular facet without displacement (Fig. 19). 2) Fracture of the posterior articular facet with lateral displacement of the main lateral fragment (Figs. 21 and 22). 3) Fracture with diminution of the salient angle but without involvement of the

posterior articular facet—the “retrothalamie” fracture of Continental writers. Here the primary fracture passes behind the posterior articular facet (Figs. 23 and 24).

The above fractures do not constitute the majority of compression fractures, because the continued action of the forces which produce the primary fracture will drive the main lateral fragment and that part of the articular surface which it bears against the under surface of the talus, and a *secondary compression fracture* of the main lateral fragment may be produced.

FIG. 1

Position for radiography of calcaneum in axial projection using Potter-Bucky diaphragm.

FIG. 2

FIG. 3

Figure 2—Photograph of the calcaneum as it lies in Anthonsen's projection. Observe that the ray strikes the posterior articular facet tangentially and passes along the long axis of the sulcus calcanei. Figure 3—Radiograph of normal calcaneum in Anthonsen's projection. (Reproduced from the Journal of the Faculty of Radiologists.)

This results in depression and rotation of that part of the articular surface which lies lateral to the primary fracture. Depending upon whether the primary fracture runs across the posterior articular facet or enters the sulcus calcanei one of the following fractures is produced. 1) Fracture with depression of the lateral part of the posterior articular facet. 2) Fracture with depression of the entire posterior articular facet.

Further study of the last two fractures—those in which there is a secondary compression

fracture of the main lateral fragment—shows that each is met with in two types (Palmer 1948). In the first (Type 1), the part of the articular facet which lies lateral to the primary fracture (this includes the entire facet when the fracture enters the sulcus calcanei) is depressed into the underlying bone (Figs. 25 to 27 and Figs. 31 to 33). In the second type (Type 2) the depressed articular surface is continuous with the upper part of the main lateral fragment, which is split horizontally (Figs. 28 to 30 and Figs. 36 to 38). The lateral wall of the bone is frequently comminuted in these fractures and this comminution may run forwards to involve the lateral part of the calcaneo-cuboid joint.

DISCUSSION

Watson-Jones (1943) has pointed out that fractures of the calcaneum include as many varieties of injury as fractures of the knee or fractures of the ankle. For the detailed

TABLE I
ANALYSIS OF 300 FRACTURES OF THE CALCANEUM TREATED AT THE
ROYAL VICTORIA INFIRMARY 1947-1952

Group I	
Isolated fracture of the anterior end of the bone	40
Isolated fracture of the sustentaculum tali	1
Fractures of the tuberosity	35
"beak" fracture	4
vertical fracture	31
Group II. Compression-shearing fractures.	
<i>With division of the bone into two main fragments only</i>	86
Involving but not displacing the posterior articular facet	28
Involving the posterior articular facet and accompanied by lateral displacement of the main lateral fragment	9
With diminution of the tuber-joint angle but no involvement of the posterior articular facet	49
<i>With division of the bone into two main fragments and secondary compression fracture of the main lateral fragment</i>	138
Fracture with displacement of the lateral part of the posterior articular facet	
Type 1	63
Type 2	34
Total	97
Fracture with displacement of the entire posterior articular facet	
Type 1	23
Type 2	18
Total	41

description of most of the fractures of this bone we consider that a study of the appearances in all three radiographic projections is usually required.

In addition to differentiating between fractures that are associated with articular injury from those that are not, it is important also to recognise the two sub-groups (Types 1 and 2) of the injuries that involve the posterior articular facet. The incidence of the Type 2 injury is less than that of Type 1 (Table I), but in the treatment of these Type 2 cases restitution

of the depressed articular surface by traction on the upper fragment of the horizontally split tuberosity may be successful. In the Type I cases traction on the tuberosity cannot elevate the depressed articular surface. In either variety it may be considered justifiable to elevate the displaced facet at open operation and to maintain it in place by inserting a bone graft beneath it.

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AN ATLAS ILLUSTRATING FRACTURES OF THE CALCANEUM

FIG. 4

FIG. 5

FIG. 6

FIG. 7

Figure 4—Fracture of the anterior end of the bone involving the calcaneo-cuboid joint.

Figure 5—Vertical fracture of the tuberosity.

Figure 6—Isolated fracture of the sustentaculum tali.

Figure 7—"Beak" fracture of the tuberosity.

FIG. 8

FIG. 9

FIG. 10

FIG. 11

FIG. 12

FIG. 13

FIG. 14

Figure 8—Fracture involving but not displacing the posterior articular facet.

Figure 9—Fracture with diminution of the tuber-joint angle but no involvement of the posterior articular facet.

Figure 10—Fracture involving the posterior articular facet with lateral displacement of the main lateral fragment.

Figure 11—Fracture with depression of the lateral part of the articular surface (Type 1).

Figure 12—Fracture with depression of the lateral part of the articular surface (Type 2).

Figure 13—Fracture with depression of the entire posterior articular surface (Type 1).

Figure 14—Fracture with depression of the entire posterior articular surface (Type 2).

FIG. 15

FIG. 16

Figure 15—Isolated fracture of the anterior end of the calcaneum (see Fig. 4). The fracture involves the anterior talo-calcaneal and calcaneo-cuboid joint surfaces. Figure 16—Vertical fracture of the tuberosity (see Fig. 5).

FIG. 17

FIG. 18

Figure 17—Isolated fracture of the sustentaculum tali (see Fig. 6). The fracture isolates the sustentaculum tali from the rest of the bone. This fracture must not be confused with that in which the primary fracture enters the sulcus calcanei and there is depression of the entire posterior articular surface as illustrated in Figures 36 to 38. Figure 18—The so-called "beak" fracture of the tuberosity (see Fig. 7).

FIG. 19

FIG. 20

Fracture dividing the calcaneum into two main fragments. Two examples of this fracture are shown by radiographs taken in Anthonsen's oblique projection and in the lateral projection respectively. In neither is there any significant displacement to be seen nor is there any compression of the main lateral fragment. In Figure 19 the fracture enters the sulcus calcanei and the entire posterior articular facet is situated on the main lateral fragment. In Figure 20 the fracture runs from the medial to the lateral side behind the posterior articular facet.

The model illustrated in Figure 8 shows the fracture crossing the articular surface.

FIG. 21

FIG. 22

Fracture involving the posterior articular facet with lateral displacement of the main lateral fragment (see Fig. 10). In this variety there is no secondary compression fracture of the main lateral fragment.

FIG. 23

FIG. 24

Fracture with diminution of the tuber-joint angle but no articular injury (see Fig. 9). Here the primary fracture passes behind the posterior articular facet. There is no secondary compression fracture of the main lateral fragment since this is not compressed against the talus.

FIG. 25

FIG. 26

FIG. 27

Fracture with depression of the lateral part of the posterior articular facet. Two types of this fracture are met with. In the Type 1, illustrated by these radiographs taken in the lateral, Anthonsen's oblique, and axial projections, and in the model shown in Figure 11, it will be seen that the lateral part of the articular surface is driven into the underlying bone.

FIG. 28

FIG. 29

FIG. 30

Fracture with depression of the lateral part of the posterior articular facet. These radiographs and the model shown in Figure 12 illustrate the Type 2 variety of this fracture. It will be seen that the lateral part of the joint surface is depressed in continuity with the upper part of the horizontally split main lateral fragment.

FIG. 31

FIG. 32

FIG. 33

Fracture with depression of the entire posterior articular facet. This fracture is also met with in two types. In Type I, illustrated here and in Figure 13, the primary fracture is usually complex, radiating from its point of origin on the medial wall of the bone and sending a branch into the sulcus calcanei and another across the facet. The articular surface is depressed into the underlying bone and is usually comminuted.

FIG. 34

FIG. 35

Fracture with depression of the entire facet (Type 1) may also occur with no comminution of the depressed articular surface. This unusual fracture is illustrated by these radiographs taken in the lateral and in Anthonsen's oblique projections.

FIG. 36

FIG. 37

FIG. 38

Fracture with depression of the entire posterior articular facet, Type 2. This fracture is also illustrated in Figure 14. The primary fracture will be seen to enter the sulcus calcanei and horizontal splitting of the main lateral fragment is evident. The entire articular surface is depressed in continuity with the upper part of the split tuberosity.