The Sacral Arcuate Lines in Upper Sacral Fractures

The upper sacrum is a common site of fractures that are frequently overlooked because of the complex configuration of the sacrum and the superimposed soft-tissue shadows. The incidence of sacral involvement in pelvic fractures is reported to range from 7 to 74% (1-4), and the incidence of missed sacral fractures is reported to be as high as 70% (5, 6). These observations prompted a review of patients with pelvic fractures in our institution. As a result, we have recognized abnormalities of the arcuate lines that are indicative of fracture. These arcs, sometimes called struts or costal arcs, are easily visible on anteroposterior radiographs of the pelvis and abdomen. They represent the inferior surfaces of the costal elements that form the roofs of the anterior sacral canals (foramina) and neural grooves. Usually the arcs of the first three segments are radiographically visible, but occasionally only two may be seen. The arcs are strikingly symmetrical, and any departure from this symmetry is likely to indicate an abnormality.

MATERIAL AND METHODS

The anteroposterior radiographs of 50 patients with multiple fractures of the pelvic ring constituted the basis of this study. The radiographs were analyzed and the results were compared with the initial interpretation made at the time of admission (TABLE I). Other cases, which are not included in the series, and in which nearly all of the fractures had initially been overlooked, are also used to illustrate the diagnostic features.

RESULTS

The structure of the sacrum is such that there are few anatomic features that are readily detectable on the plain radiograph, particularly as seen through the superimposed bowel. The trabecular pattern is difficult to evaluate. Only the borders and the costal arcs are relatively easy to see, and, of these, the arcs are the more perceptible. We would emphasize that the evaluation of the arcuate lines is facilitated by their remarkable normal symmetry (Fig. 1a). The criteria used for the diagnosis of fracture are those common to fractures at other sites, i.e., discontinuity, deformity, displacement, and a change in density of defined anatomic structures (the costal arcs). We think that the usual injunction "to examine the arcuate lines carefully" can usefully be elaborated and we therefore define and illustrate these signs of fracture in detail:

1. Discontinuity (Figs. 2-4, 6)
2. Displacement (Fig. 6), often shown by an alteration in the distance between two arcs (Figs. 2-4, 6, 7)
3. Deformity, be it due to a torus (Figs. 1, 2, 5), angulation (Fig. 6), irregularity and loss of definition (Figs. 5, 8), and/or other change in contour (Figs. 4-8)
4. Density changes, due to angulation (Figs. 5, 6), compression (Fig. 2), and, somewhat later, to callus (Figs. 5, 8), and finally to consolidation.

Of these signs, discontinuity, a torus, and angulation are diagnostic;

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1 From the Department of Diagnostic Radiology, The University of Texas Medical School at Houston, Houston, TX. Received Jan. 19, 1982, and accepted June 29.
the simple presence of the fracture. Nerve deficits associated with pelvic fractures are most common when there is sacral involvement (11). Sacral fractures commonly pass through the anterior sacral canals and the adjacent neural grooves, and the neurological signs are thought to arise at root level (11, 12). The neurological sequelae of sacral fractures are well documented (1,
11–14), and may include aching and weakness in the ipsilateral leg and disturbances in micturition, defecation, and sexual function (13), although this may also be a function of the severity of the injury. Furthermore, displaced fractures of the upper sacrum may be unstable, and if not recognized and managed appropriately, may result in protracted neurological damage (1, 13, 14). Unrecognized sacral fractures may also explain otherwise obscure, disabling, and persistent back pain following pelvic trauma (12). Despite this evidence of the potential seriousness of sacral fractures, it is clear that their true significance cannot be adequately assessed as long as the high rate of undiagnosed cases indicated by our observations and those previously published continues. Therefore, we cannot confirm or refute the alleged incidence of serious clinical sequelae.

The sacral arcs are consistently well seen on adequately exposed anteroposterior pelvic or abdominal radiographs. The latter are sometimes better because they bring the surfaces of the costal elements into profile, accentuating the arcuate lines. The same effect can be achieved in an anteroposterior pelvic radiograph with a slight caudad tilt. Too great a caudad tilt will superimpose the arcs on each other, which is disadvantageous. The standard anteroposterior view of the sacrum with a cranial tilt tends to obliterate the arcs and is therefore more difficult to interpret than an anteroposterior radiograph of the pelvis. The lateral view is of little value in the detection of upper sacral fractures even when it can be obtained under optimum conditions. Both tomography, preferably pluridirectional, and computed tomography reveal the extent of sacral fractures and are invaluable in evaluating the deformities of the sacral canals and the more posterior elements. However, neither is essential to making the diagnosis of a sacral fracture.

Harris Jackson, M.D.
Department of Diagnostic Radiology
The University of Texas Medical School at Houston
6431 Fannin
Suite 2130 MSMB
Houston, TX 77030

Figure 3

Acute fracture of the left sacral wing associated with left sacroiliac joint separation. The LS1 is disrupted (arrowhead) and elevated, resulting in an increased distance between the S1 and 2 (black arrows). The inferior portion of the left sacroiliac joint is abnormally widened, resulting in a "naked" sacral surface (open white arrow).

Figure 4

Acute sacral fracture is evidenced by discontinuity of the RS2 (arrow) and asymmetry of the arcuate lines on the left. The LS2 is slightly convex inferiorly and the distance between the LS1 and 2 is increased, with a commensurate decrease in the distance between S2 and 3 (arrowheads). This patient was examined 17 years later, and the deformity of the left arcs was unchanged.

Figure 5

One-month-old fracture of right sacral wing. There is considerable loss of definition of the right upper arcuate lines. The RS1 is irregular and disrupted (small arrows). There is a torus of the RS2, with increased density representing callus (large curved arrows). An oblique density between S1 and 2 (arrowheads) probably represents an impacted angulated fragment.
Comminuted acute left sacral fracture with left sacroiliac joint separation. The LS1 is disrupted and fracture fragments are seen "end-on" (arrowheads). An oblique fracture extends medially through the body of the sacrum (arrows). Asymmetry of the contiguous inferior margins of the left sacroiliac joint indicates its separation.

Healed fractures of the right sacral wing. This antegrade urogram was obtained in a patient who had had pelvic fractures several years previously. Healed anterior pelvic fractures are evident. Asymmetry of the right sacral arcuate lines manifested by elevation and alteration of the contours of RSI, 2, and 3 (arrows) and by an increase in the distances between them is consistent with an old healed fracture.

References
Figure 8

Left sacral wing fracture. The L5 is slightly convex inferiorly (small arrow). The S2 is disrupted laterally (arrowhead), with a medial increase in density representing impaction and/or callus. The S3 is disrupted, distorted, and caudally displaced (large curved arrow). The distance between S2 and 3 is abnormally wide.