The ''Fat'' C2: A Sign of Fracture

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Rotational and lateral bending injuries may cause oblique fractures of the centrum (body) of the second cervical vertebra below the odontoid and plane of the superior articular facets. These fractures are often obscure because the fracture lines are frequently not perpendicular to the plane of the radiograph on either anteroposterior or lateral views. The fracture fragments may shift in relation to one another, causing the body of C2 to appear enlarged or "fat" in relation to C3. We discuss the basis of the "fat" C2 sign and illustrate a variety of fractures that can produce this change.

Because they are so uncommon, C2 body fractures have received little attention in the literature. In a recent review of 107 axis fractures encountered over a period of 8 years, Hadley et al. [1] identified only eight (7.5%) fractures of the body of the axis. The purpose of the present study is to draw attention to the fact that enlargement of the C2 centrum on plain lateral radiographs may be the only indication of an unstable axis injury.

The "Fat" C2

Vertical fractures in the coronal plane with little oblique component but with fragment displacement facilitate our understanding of the "fat" C2 sign (Fig. 1). The fracture lines are clearly visible, and there is interruption of both the anterior and posterior tangent lines.

If the fracture courses obliquely through the body of the axis, the fracture lines (fragment separation) may not be visible on lateral radiographs. Displacement of the fracture fragments, however, will cause the body of C2 to appear fat in relation to C3. The enlargement of C2 may be rather obvious (Fig. 2) or it may be extremely subtle (Fig. 3). Although only the anterior or posterior tangent line may be interrupted, most commonly both lines are affected. Predominant anterior tangent-line interruption indicates a primary hyperflexion injury (Fig. 4), while predominant posterior tangent-line interruption is indicative of a hyperextension injury (Fig. 5). Interruption of both lines may be secondary to a combined hyperflexion-hyperextension injury (Figs. 6 and 7).

Discussion

We have found that the centrum of the C2 vertebrae in males may differ from that in females. In males, the anteroposterior dimension is often greater than the vertical dimension, producing a rectangular configuration. (The superior margin of the centrum is considered to be at the plane of the superior articular facets.) In females, the anteroposterior and vertical dimensions may be almost equal, producing a square configuration. Normally, lines drawn tangent to the anterior and posterior surfaces of C3 fall tangent to the anterior and posterior surfaces of C2 (Fig. 8) [2].

"Complex" fractures involving the body of the axis may result from a combination of forces during injury. Rotation-extension, rotation-flexion, right or left lateral bending with flexion and/or extension, and long-axis force applications produce

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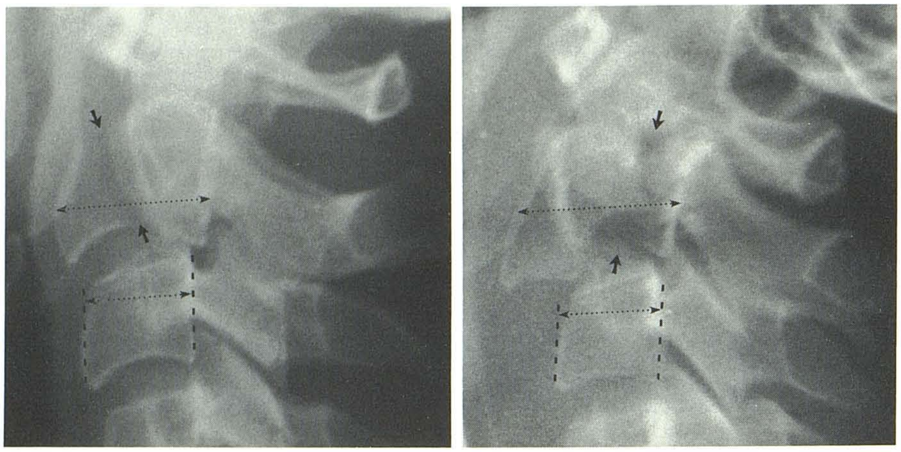
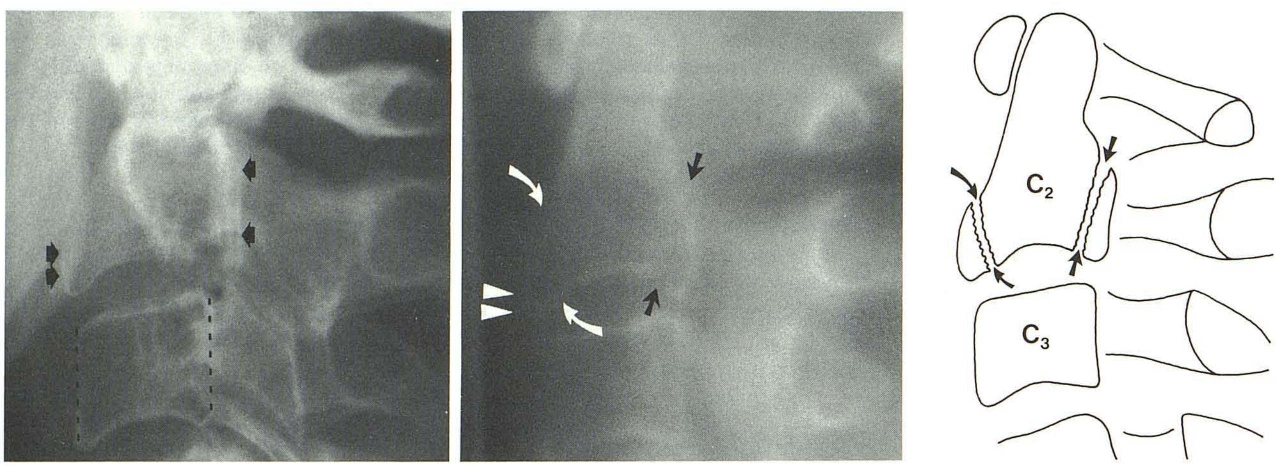


A B

Fig. 1.—Fat C2 in two patients (*A* and *B*, respectively) resulting from obvious vertical oblique fractures (*arrows*). Both anterior and posterior tangent lines are interrupted. Anteroposterior dimensions of C2 are much greater than those of C3.



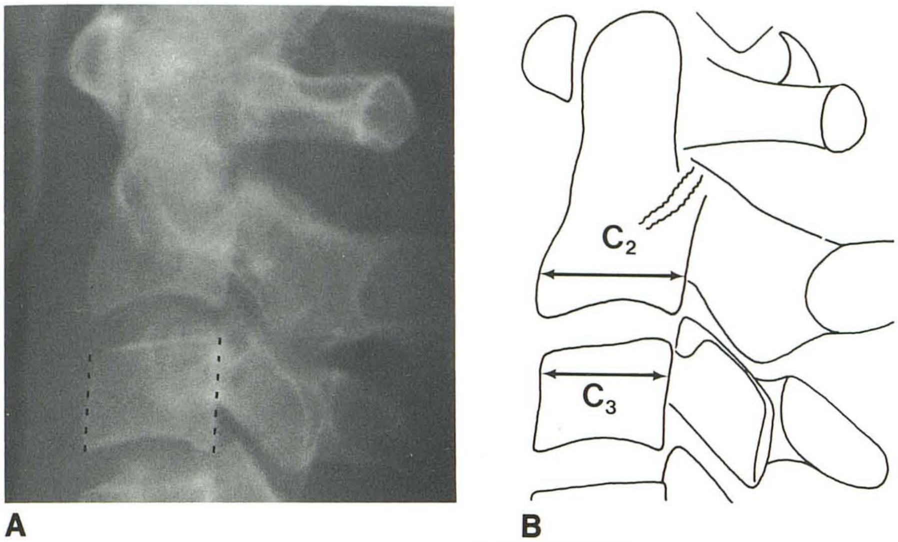
A B C

Fig. 2.—*A*, Lateral radiograph—obvious fat C2 resulting from compound oblique fracture. Fracture line is not clearly visible. Midsagittal tomogram (*B*) and line diagram (*C*) demonstrate anterior (*curved arrows*) and posterior (*straight arrows*) extent of fracture. Parasagittal tomograms (not illustrated) revealed a vertical oblique fracture extending through left foramen transversarium and a horizontal oblique fracture extending across right neural arch.

complex obliquity of the fracture planes as they extend through the body of the axis. This may lead to separation of the axis body into two or more fracture fragments. Anterior tangent-line interruption occurs when a fracture fragment is displaced anteriorly, whereas posterior fragment displacement will result in interruption of the posterior tangent line. A "bursting" type of fracture, or a combined hyperflexion-hyperextension injury, may produce anterior shift of one fragment and posterior shift of the other fragment, resulting in simultaneous anterior and posterior tangent-line interruption. This pattern of tangent-line displacement is the type we have encountered most commonly. Similarly, Davis et al. [3] found combination anterior and posterior ligamentous disruption to be most common in autopsy series. In all three conditions, the anteroposterior diameter of the axis vertebral body, as seen on plain radiographs, will be larger than the anteroposterior diameter of the subjacent normal C3 vertebral body; hence, the fat C2 as a term suggesting a complex fracture involving the axis. The horizontal shift in fragment position results in an increased anteroposterior diameter of the centrum axis on plain lateral radiographs.

We have illustrated with complex-motion tomography the very oblique direction of the fracture planes in these rare injuries. This obliquity is such that the actual separation of bone is in neither the coronal nor the lateral plane so that the associated separation one customarily expects to see with a fracture is not evident on plain frontal or lateral radiographs.

CT may be helpful for further evaluation of "complex" axis fractures [4, 5]. If the fracture plane is predominantly coronal, the principal fracture fragments will be separated in an anteroposterior direction and one may see the anterior and posterior fragment displacement that interrupted the appropriate



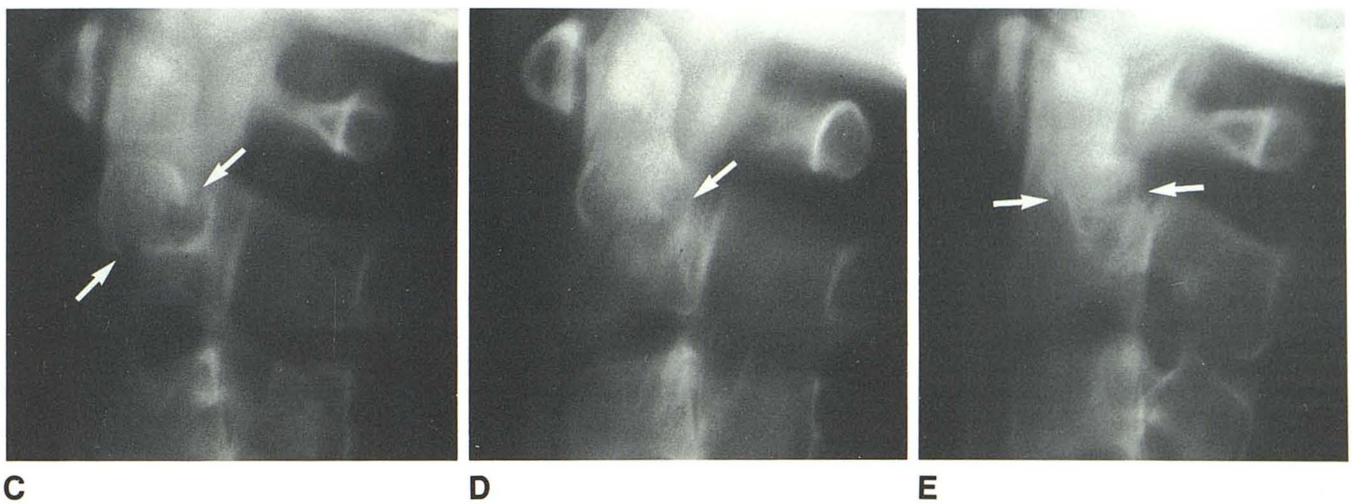


Fig. 3—Lateral radiograph (*A*) and line diagram (*B*) reveal subtle increase in anteroposterior diameter of C2. Both anterior and posterior tangent lines are interrupted.

C, Left parasagittal tomogram.

D, Midsagittal tomogram.

E, Right parasagittal tomogram. Note change in position of compound oblique fracture as it crosses from left to right (*arrows*).

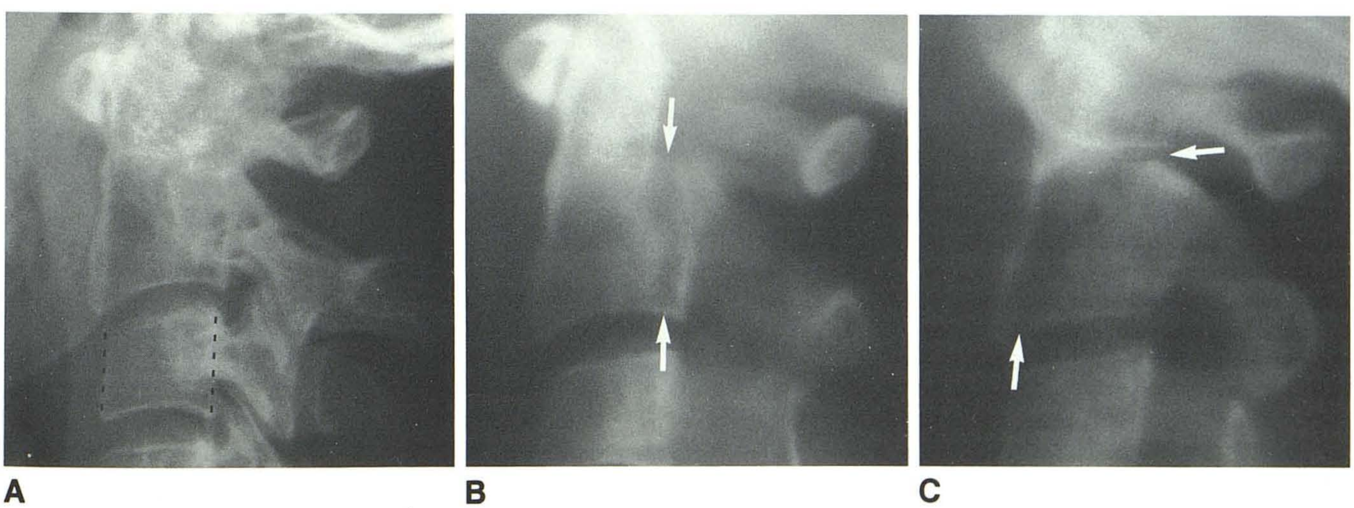
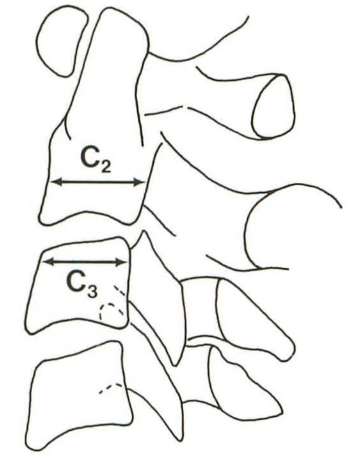


Fig. 4.—*A*, Lateral radiograph—predominant interruption of anterior tangent line produces a fat C2. Fracture line is not visible.

B, Midsagittal tomogram reveals posterior component of vertical oblique fracture (*arrows*).

C, Right parasagittal tomogram shows anterior component of same fracture (*arrows*). Left half of C2 and odontoid process have been displaced anteriorly, producing a fat C2.

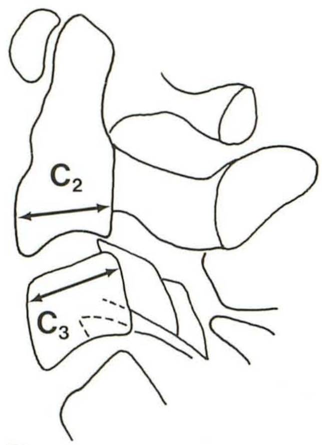
A



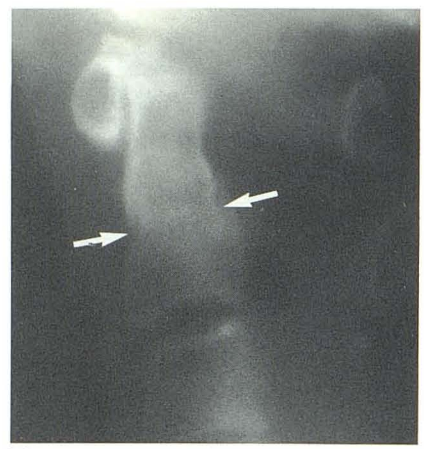
B

Fig. 5.—Lateral radiograph (*A*) and line diagram (*B*)— isolated posterior tangent line interruption without visualization of fracture. Previous normal lateral radiograph (*C*) and line diagram (*D*) for comparison. Midsagittal tomogram (*E*) shows horizontal fracture of axis body below odontoid (*arrows*).

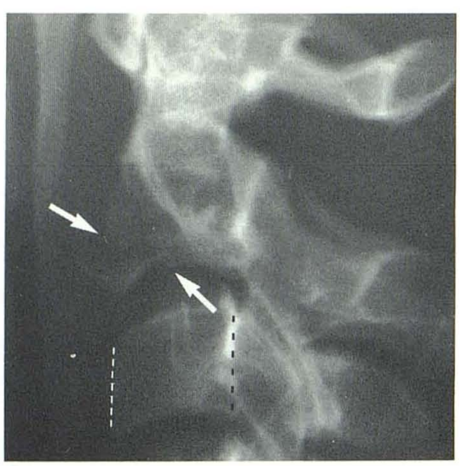
C



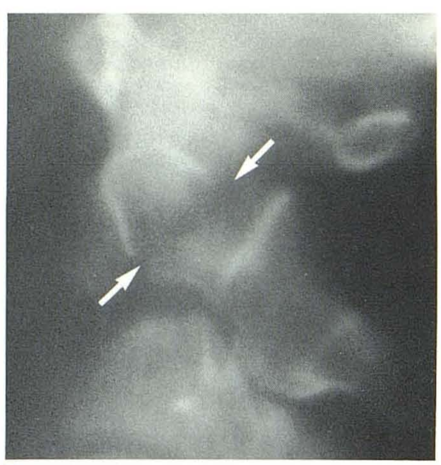
D



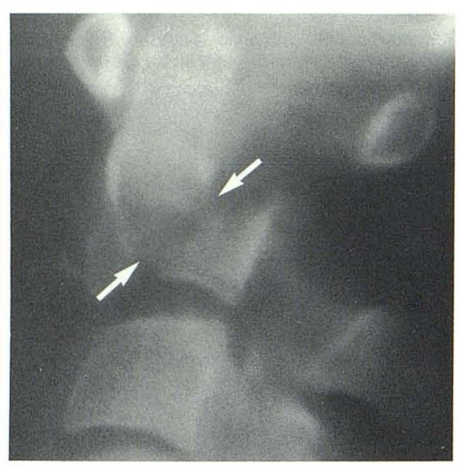
E



A



B



C

Fig. 6.—*A*, Lateral radiograph—a small anterior avulsion fracture is identified (*arrows*) that does not explain tangent line interruption and fat C2 appearance. Left parasagittal (*B*) and midsagittal (*C*) tomograms show C2 body fracture (*arrows*).

tangent lines on plain radiographs (Fig. 7). If, however, the fracture plane is largely in the horizontal axis, it may be extremely difficult to see the fracture on CT unless high-quality sagittal or coronal reconstructed images are obtained. Patients with cervical spine injuries are often in pain and, in our experience, frequently move during scanning, making reconstructed images difficult to obtain. We have found that sagittal polytomography can be performed in less than half

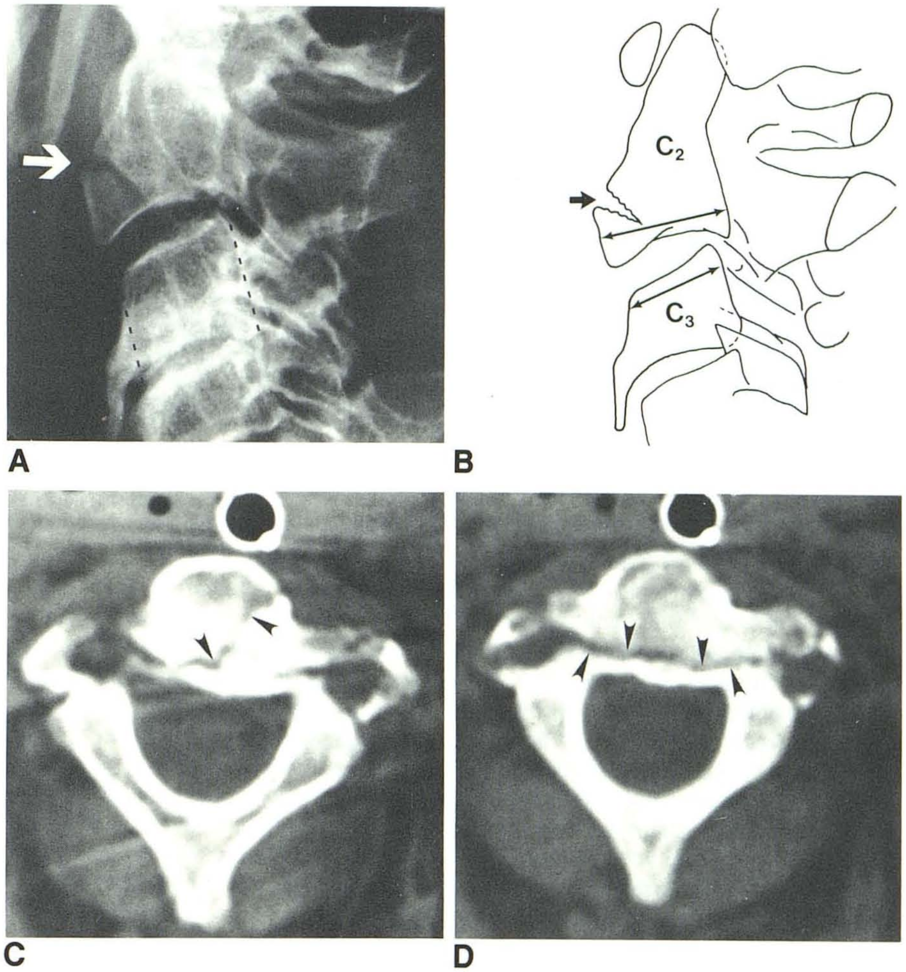


Fig. 7.—Lateral radiograph (*A*) and line diagram (*B*) reveal sizable anterior avulsion fracture (*arrow*) and a fat C2. Axial CT cuts (*C* and *D*) demonstrate oblique and vertical components of axis fracture (*arrowheads*). (Reprinted with permission from [8]).

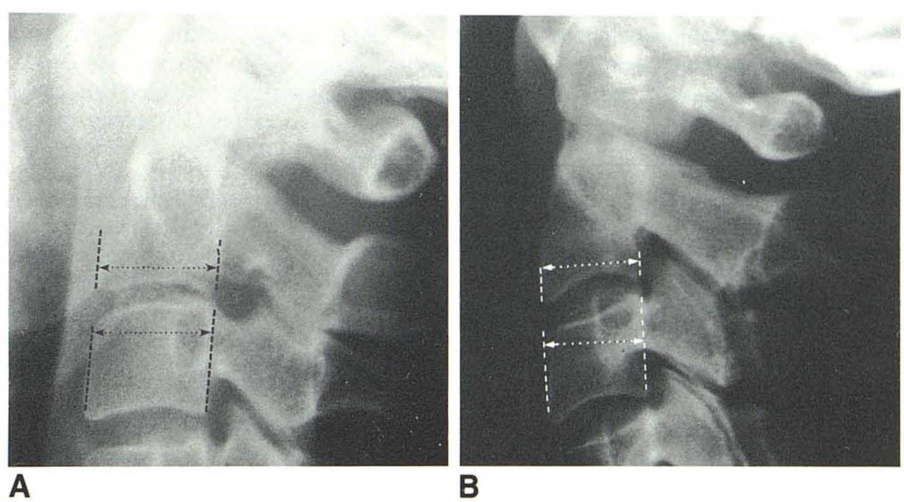


Fig. 8.—Normal male (*A*) and female (*B*). Lines drawn tangent to anterior and posterior surfaces of C3 fall tangent to anterior and posterior surfaces of C2. Anteroposterior dimensions of C2 and C3 are the same.

the time required to obtain thin overlapping axial CT cuts necessary for high-quality sagittal CT reconstructions. Depending on the condition of the patient and the findings on sagittal polytomography, coronal polytomograms may additionally be obtained.

MR imaging may be helpful for evaluating patients with complex-angle axis fractures [6, 7]. The vertebral marrow, spinal cord, size and shape of the spinal canal, and adjacent soft-tissue structures may all be directly imaged in multiple planes without patient manipulation (Fig. 9). The presence or absence of subarachnoid space or spinal cord compression by a posteriorly displaced fracture fragment or an associated

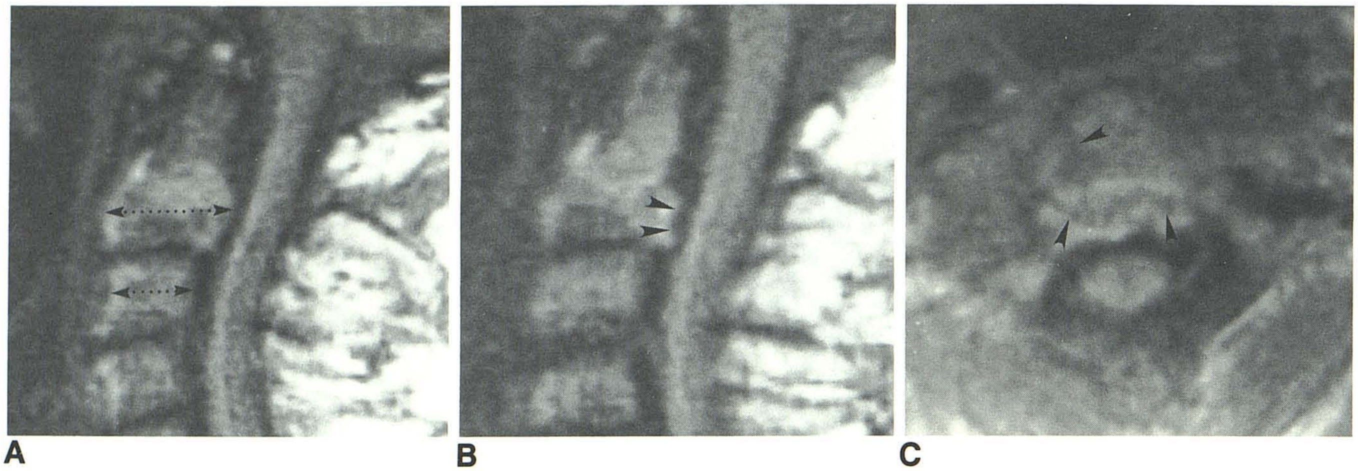


Fig. 9.—*A*, Midsagittal T1-weighted MR scan shows a fat C2. In midline, expansion of C2 is noted to be both anterior and posterior.

***B*, Right parasagittal MR scan—right portion of fragment is displaced more posteriorly (*arrowheads*). No significant cord compression is identified, although ventral subarachnoid space is compromised.**

***C*, Axial T1-weighted MR scan shows components of fracture (*arrowheads*).**

epidural hematoma is easily assessed without the necessity of intrathecal contrast material. For optimal evaluation, T1- and T2-weighted images in both the sagittal and transverse planes are recommended. The T1-weighted images better delineate the presence of spinal cord compression. In the absence of cord compression, we have found compromise of the subarachnoid space more accurately depicted on the T2-weighted images.

The main purpose of the fat C2 sign is to provide an easily recognizable sign of axis injury when the geometric complexity of an oblique fracture makes recognition by means of fracture-line separation difficult. The main implication of a fat C2, identified on plain radiographs, is that an unstable fracture with fragment displacement is present and that further imaging assessment is necessary to evaluate the effect of the fracture on the adjacent spinal cord and meningeal structures.

We have illustrated a variety of axis centrum (body) fractures that can produce anteroposterior displacement of the fracture fragments and lead to apparent "enlargement" of the axis vertebral body on plain radiographs. The fat C2 sign should be a helpful radiographic means for identifying these injuries.

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