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W C Thomeier, D C Brown and S E Mirvis

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The Laterally Tilted Dens: A Sign of Subtle Odontoid Fracture on Plain Radiography

William C. Thomeier[1]
Douglas C. Brown[1]
Stuart E. Mirvis[2]

Type III (low) odontoid fractures may be subtle on initial plain film radiographic examination. We describe a sign on the routine open-mouth view, the laterally tilted dens, which has not been previously stressed in the radiologic literature, and is an important diagnostic sign of type III fractures of the odontoid process of the axis. In a series of 82 nontraumatized patients, no odontoid angle of less than 87° (3° from perpendicular) was observed. In a series of type III odontoid fractures, tilting of the dens in excess of 5° was present in eight (67%) of 12 cases. This may be the only readily apparent finding on the initial cervical spine series. Of eight type III odontoid fractures in which an abnormal odontoid angle was identified, it was the only definite abnormality that could be recognized prospectively in two cases (25%) and that supported very subtle findings in two other cases (25%).

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Fractures of the odontoid process of the axis comprise 7–13% of cervical spine injuries and have been classified as types I–III [1]. Type I is a rare avulsion of the tip of the dens; type II occurs through the base of the dens, and has been described as a "high" fracture; and type III or "low" fractures are those extending into the body of the axis [2]. These injuries result from complex flexion, extension, rotation, or shearing stress, and are most commonly caused by high-velocity impacts such as motor vehicle accidents or significant falls [3–5]. Radiographic signs of odontoid fractures have been previously described [2, 4, 6–8]. These include disruption of the "axis ring" of C2, which has been described as a specific sign of type III (low) odontoid fracture [1]. However, in the absence of displacement or subluxation of C1 on C2, fractures of the dens can be "most difficult to recognize" [9]. Lateral tilting of the dens on an anteroposterior open-mouth view has been mentioned as a sign of odontoid fracture [8, 10]. However, the importance of a laterally tilted dens in the initial diagnosis of type III fractures has not been stressed, and no specific criteria for the measurement of the odontoid angle in normal or pathologic cases have been described. We have found that a tilt of the dens to one side of more than 5° from perpendicular (an odontoid angle of 85° or less) is an important sign of type III odontoid fracture, and may be the only clearly evident radiologic abnormality.

Materials and Methods

Normal Odontoid Angle

To determine the normal range of the odontoid angle, 361 consecutive cervical spine series over a 3-month period at Walter Reed Army Medical Center were retrospectively reviewed. Of these, 275 involved a history of trauma (either acute or remote), and were excluded. Of the remaining 86, four were excluded because the odontoid angle could not be determined as a result of poor positioning or overlying dental work. The age, history, and odontoid angles

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[1] Department of Diagnostic Radiology, Walter Reed Army Medical Center, 6825 16th St., N.W., Washington, DC 20307-5001. Address reprint requests to W. C. Thomeier.

[2] Department of Radiology, University of Maryland, Maryland Institute of Emergency Medicine, Baltimore, MD 21201.

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were recorded for the remaining 82 patients. Using the standard open-mouth view, we calculated the odontoid angle by measuring the intersection of a horizontal line connecting the lateral-most aspect of the superior edges of the lateral masses of C2 and a vertical line exactly bisecting the shaft of the dens (Fig. 1). All measurements were made with a protractor calibrated to 0.5°. The odontoid angle was recorded as 90° or as the acute angle between the shaft of the dens and the body of C2. To evaluate the effect of rotation on odontoid angle measurement, open-mouth views were obtained in nine normal volunteers in the standard straight anteroposterior projection and with 10° of tube rotation.

Type III (Low) Odontoid Fractures

Thirteen cases of type III odontoid fractures were reviewed retrospectively. The cases were located by review of a computerized data base and/or a plain film tomographic log book. Of these, 12 cases had open-mouth views adequate for determination of the odontoid angle. The angle of the odontoid and the patients' age, history, and other pertinent findings were recorded, particularly, displacement of the odontoid on lateral view, obvious involvement of the lateral masses by the fracture, and abnormalities of the "axis ring" of C2.

Results

Normal Odontoid Angle

Of 86 cases with no history of trauma, the odontoid angles in four (4.7%) could not be measured because of positioning or overlying dental work that obscured the landmarks. Of the remaining 82 patients, cervical spine series were ordered for pain, radiculopathy, or arthritis. There were 43 men and 39 women, ranging in age from 18 to 81 years (mean, 51.9 years). Angles ranged from 87° to 90°. The most commonly measured angle was 90°. The mean angle was 89.9° with a standard deviation of 1.2°. As a range of normal, we chose the acute angle measured from 85° to 90°. This represents greater than four standard deviations from the mean odontoid angle measured in our series of nontraumatized patients.

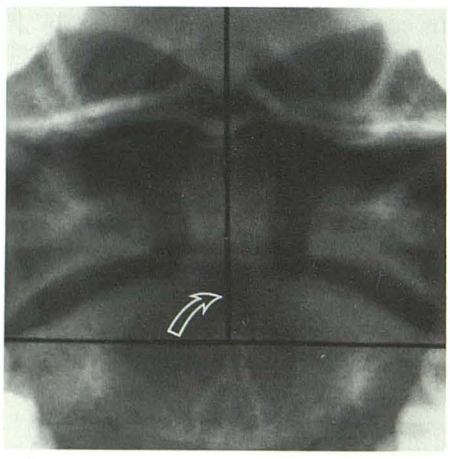

Fig. 1.—The odontoid angle is measured as the acute angle formed by the intersection of a vertical line bisecting the dens with a horizontal line through the lateral-most aspect of the superior edges of the lateral masses of the axis. This angle measures 89° with a slight tilt to the right (*arrow*).

Effects of Tube Angulation

The odontoid angles of nine normal volunteers were determined by using both the standard straight anteroposterior view and with 10° of tube angulation to the right. Of the nine straight anteroposterior films, the mandible or dental work obscured the superolateral aspect of the lateral masses, and the horizontal line could not be drawn in two cases (22%). However, in both these cases the rotated view allowed measurement of the odontoid angles, which were normal. In only one case were the landmarks obscured on the rotated view, when a normal angle was measured on the straight anteroposterior view. The measured odontoid angle changed in four of six cases in which the odontoid angle could be measured in both the straight anteroposterior and rotated views. However, the mean difference was only 1.1°, and both measurements were normal in all cases. In the remaining two cases the odontoid angles did not change with rotation and were normal.

The Odontoid Angle in Type III Fractures

In one (7.7%) of the 13 cases of type III (low) fracture, the odontoid angle could not be measured because of positioning. The remaining 12 patients included eight men and four women ranging in age from 18 to 78 years (mean, 43 years). All fractures were the result of motor vehicle accidents. Eight (67%) of these 12 had significant tilt of the dens with odontoid angles measuring less than 85° on the anteroposterior open-mouth view. Of these patients, only two (25%) showed significant displacement of fragments on the lateral view. The "axis ring" was clearly disrupted in four (50%) of the patients with a tilted dens, and there was subtle disruption of the ring seen in two patients (25%) (Fig. 2). No definitely identifiable disruption was seen in two cases (25%). In these two patients the tilt of the dens on the open-mouth view was the only definite abnormality noted on the initial cervical spine series. In retrospect, after planar tomography, a subtle lucency near the base of the dens was identified as a fracture in one of these patients (Fig. 3).

Discussion

In general, type III odontoid fractures have a better prognosis with a low rate of nonunion when recognized and immobilized [2, 4–6, 10–12]. This finding has been attributed to improved vascular supply at the fracture site because the fracture involves cancellous bone of the C2 vertebral body.

Appropriate treatment of any form of odontoid fracture is incumbent on its recognition in the acutely injured patient. Appuzzo et al. [6] state "There is little doubt that these are potentially lethal lesions or that, if improperly treated or unrecognized, they may be a cause of significant neurological injury." Since acutely traumatized patients are difficult to position optimally, the radiologist is frequently presented with less than perfect films for evaluation. Therefore, one must take into account any and all signs of abnormality, and, if needed, suggest further evaluation such as CT or plain film

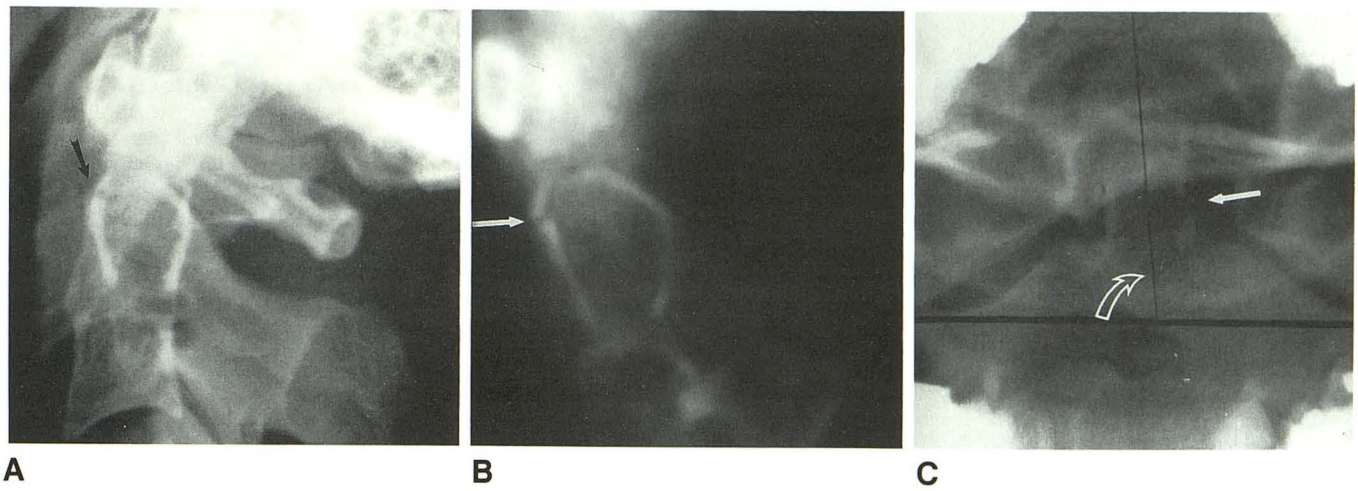

Fig. 2.—*A*, Lateral cervical spine with subtle disruption of "axis ring" (*arrow*). This was only identified retrospectively after plain tomography. Incidently noted is congenital fusion of posterior elements of C2 and C3.

B, Sagittal plain tomographic slice through right side of C2 confirms extension of fracture into body of axis (*arrow*).

C, Open-mouth view demonstrates the odontoid angle, which measures 84° with a slight tilt to the right (*curved arrow*). Plain tomography later showed the lucency of the cortex of the dens (*straight arrow*) to be part of the fracture.

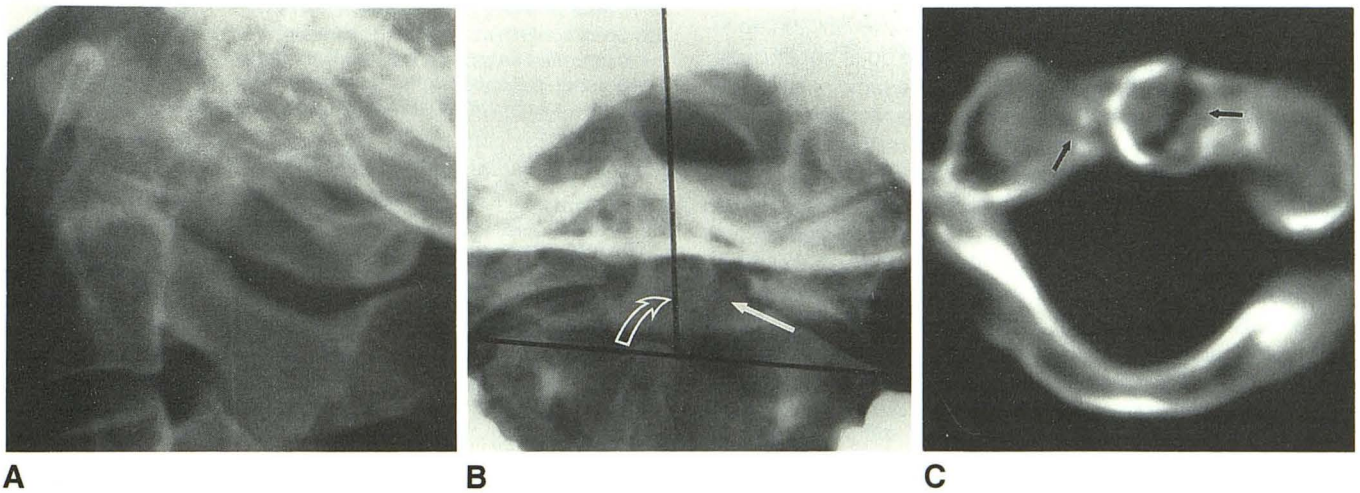

Fig. 3.—*A*, Lateral cervical spine coned down to C2 demonstrates poor definition of the dens, but no definite disruption of the "axis ring."

B, Open-mouth view of tilted dens; the odontoid angle measures 83° with a tilt to the right (*curved arrow*). The subtle lucency at the left base of the dens (*straight arrow*) was not identified prospectively as a fracture.

C, Axial CT scan through base of dens demonstrates the fracture through the base and extending into right articular pillar (*arrows*). Identification of this fracture was delayed 4 days after initial presentation.

tomography. In this series, the odontoid angle could be measured in 12 of 13 cases despite difficulties in positioning these acutely injured patients. Further, the angle was abnormal in two-thirds of these cases.

Although not previously stressed in the literature, a tilted dens can be a sign of subtle acute type III fracture and should warrant further evaluation when identified. In only one of our 12 cases was this sign described prospectively. In this case, the diagnosis was delayed by 4 weeks in a patient with other serious injuries including posttraumatic encephalopathy. However, except for subtle tilting of the dens, other obvious signs of fracture were absent, although the "axis ring" was abnormal (Fig. 4). In one other patient in which there was abnormal tilt of the dens, the type III odontoid fracture was initially unrecognized for at least 4 days. This patient had no disruption of the "axis ring" or other obvious signs of fracture (Fig. 3).

Recognition of an abnormal odontoid angle is dependent on the ability to measure it. In our initial series to determine the normal odontoid angle, we identified four (4.7%) of 86 cases in which the angle could not be measured owing to overlying mandible, teeth, or dental artifacts. Rotational distortion was found to change the angle in most cases; however, in our small sample, rotation did not make the measurement abnormal, and in one case it uncovered the landmarks needed for measurement that were obscured on the nonro-

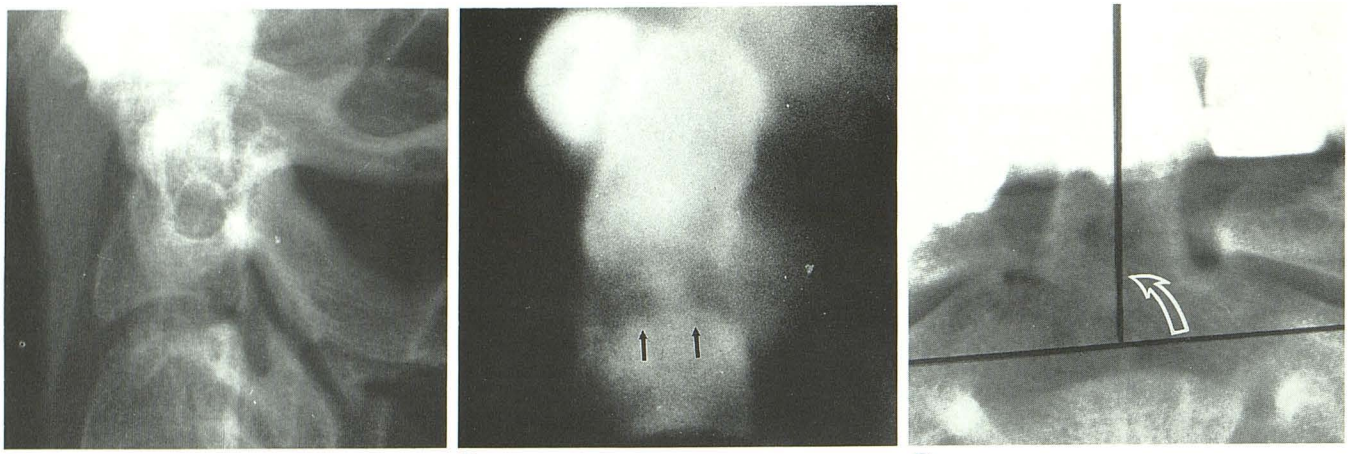

Fig. 4.—*A*, Coned-down lateral view of C2 demonstrates poor definition of the dens, with no gross displacement and no well-defined "axis ring."
***B*, Sagittal plain tomogram through dens demonstrates fracture extending into body of C2 (*arrows*). The ill-defined borders and bony bridging represent healing of the fracture.**
***C*, Open-mouth view with the odontoid angle measuring 83.5° with a tilt to the left (*arrow*). This fracture was unrecognized initially, and diagnosis was delayed by 4 weeks.**

tated view. We would stress the need for well-positioned films, but it would seem that small rotational distortions would be unlikely to change a normal odontoid into an abnormal one. Further, while a normal odontoid angle does not exclude fracture, an abnormal angle should alert the radiologist to the need for further imaging methods to rule out fracture.

In summary, a laterally tilted dens is a relatively common finding in type III fractures of the odontoid process. Along with other signs of fracture, such as displacement or disruption of the "axis ring," it can be an important sign in the recognition of acute fracture. Therefore, if tilting of the dens is suspected, the odontoid angle should be measured. If it is 85° or less (in excess of 5° tilt from perpendicular) further radiologic evaluation should be pursued. This may be one of the subtle signs or the only sign of type III fracture on initial plain film evaluation.

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