Pitfalls in the CT Diagnosis of Atlantoaxial Rotary Subluxation

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Pitfalls in the CT Diagnosis of Atlantoaxial Rotary Subluxation

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CT was used to examine six patients with clinically evident atlantoaxial rotary fixation, two patients with torticollis, and six normal subjects who had turned their heads to the side as far as voluntarily possible. The CT appearances of the atlantoaxial complex were identical in all three groups. To differentiate these groups, we propose a functional scan through C1–C2 in which patients are scanned initially as they present, with their heads fixed in lateral rotation. Subsequent scans are obtained with their heads turned to the maximum contralateral rotation. CT scans in patients with atlantoaxial rotary fixation demonstrate no motion at C1–C2 during this maneuver, while those in patients with transient torticollis show a reduction or reversal of the rotation of C1 on C2.

Atlantoaxial rotary fixation is a clinical syndrome consisting of rotation with lateral tilt of the head, painful limitation of motion, and inability to turn the head voluntarily to the contralateral side. The condition often follows insignificant cervical trauma or upper respiratory infection [1, 2]. It is distinguished from torticollis by its failure to resolve within a few weeks. Radiographic evaluation of the patient with this condition is difficult because of the patient's rotated head position. Before the advent of CT, radiologic diagnosis traditionally required careful functional examination with cineradiography [2, 3].

Axial CT scans through C1–C2 in patients with the clinically diagnosed atlantoaxial rotary fixation demonstrate the rotated position of C1 on C2 [4–6]. However, when we evaluated the CT scan of a patient with transient torticollis, the atlantoaxial complex appeared as it would in atlantoaxial rotary fixation. We performed this study to attempt to distinguish between these two conditions.

Subjects and Methods

Eight patients with symptoms referable to the occipitoatlantoaxial joint complex were studied by cervical CT. Six of these patients were diagnosed as having atlantoaxial rotary fixation and represent all the cases of this type seen between 1984 and 1986. The other two patients, diagnosed as having torticollis, were the only patients with this condition admitted to the neurosurgery service during this period. Atlantoaxial rotary fixation was diagnosed clinically when the signs and symptoms of torticollis did not resolve within 3–4 weeks. Six normal volunteers had no symptoms referable to the cervical spine.

Scans were obtained from the base of the skull to the top of the vertebral body of C3 by using 3- or 5-mm contiguous sections at a gantry angulation of 0°. The hard palate was included in the examination whenever possible as a reference point for determining the orientation of the skull. A functional examination was performed in both patients with torticollis and in one patient with rotary fixation by scanning the patient's cervical spine with the head in the rotated position in which it was fixed and in the maximum voluntary contralateral rotation. The other patients were studied at rest. The normal volunteers were scanned with their heads turned as far as possible to the side. Bone- and soft-tissue windows were obtained in all examinations. The degree of rotary displacement was quantitated by comparing the anteroposterior axes of the head (line congruent with the nasal septum), atlas (line

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connecting the anterior tubercle to the spinous process), and axis (line connecting the base of odontoid to the spinous process). Occipitoatlantal rotary subluxation was defined as malalignment of the axes of the head and atlas.

Results

All eight patients had histories of mild to moderate neck trauma with neck pain, stiffness, and rotational deformity (Table 1). They all held their heads in varying degrees of lateral rotation and lateral tilt ("cock-robin" position) with painful limitation of motion and an inability to rotate their heads to the oppostie side. Cranial nerve deficits were present in two patients, both of whom also had occipitoatlantic rotary subluxation, defined as malalignment of the axes of the head and atlas [5]. Duration of symptoms before presentation varied from hours in patients with torticollis to 4 years in one patient with C1–C2 rotary fixation. The initial treatment consisted of skeletal traction and muscle relaxants in all symptomatic patients. Arthrodesis was recommended in three patients.

Plain films, available in three patients, demonstrated asymmetry of the distance between the odontoid and the lateral masses of C1 on the open-mouth view. The lateral view did not aid in diagnosis. Functional examinations were not performed with plain-film techniques.

Axial CT easily established the diagnosis of occipitoatlantic rotary subluxation in two patients (Fig. 1) and demonstrated rotational displacement of the atlantoaxial complex in all patients. The spatial relationship of the vertebral bodies was appreciated better in those patients who were studied with 5-mm rather than 3-mm sections. This difference was most pronounced in patients with a significant lateral tilt of the cervical spine.

Without functional imaging, scans through C1–C2 in the patients with clinically fixed C1–C2 rotary fixation (Figs. 1–3) were radiographically indistinguishable from either the patients with reversible torticollis (Fig. 4) or a group of normal subjects who were scanned with their heads turned as far as possible to the side (Fig. 5). No one finding on the static examination appeared to be helpful in the CT diagnosis of fixation. An eccentric location of the odontoid with respect to the anterior arch of C1 was seen in one patient with torticollis and in one with rotary fixation. The extent of rotational displacement did not correlate with fixation, as was evidenced by two of the patients who had minimal rotation by CT examination. In one, whose inability to rotate his head resolved, the minimal rotation demonstrated on CT appeared no different from that of the other patient, whose CT rotation remained unchanged despite halo traction.

We performed functional examinations by scanning the occipitoatlantoaxial complex in the rotated position in which the patient presented and in maximum voluntary contralateral rotation. In a patient with rotary fixation there was no change in the relationship of the atlas and axis during this maneuver (Fig. 3). In the two patients with torticollis the functional scan resulted in reduction and actual reversal of the subluxation (Fig. 4). In the normal volunteers, scanning with the head turned yielded a range of motion of 29–44° (average, 34°) at the atlantoaxial joint (Table 2).

TABLE 1: Clinical Summary in Rotary Subluxation

Cause: Case No.	Age	Gender	Neurologic Findings	CT Appearance	Pre-CT Duration	Treatment	Follow-up
Motor vehicle accident:							
1	16	F	Pain	C1–C2 rotation	4 mo	Halo traction; fusion C1–C2	Diminished pain
2	30	F	Pain	C1–C2 rotation	4 yr	Cast immobilization	No change
3	22	F	Pain	C1–C2 rotation	3–4 days	Traction for 2 weeks	Diminished pain; CT unchanged
4	34	M	Transient left hand weakness	Fracture of C2; lateral mass; C1–C2 rotation	6 mo	Halo traction	Limitation of motion
Head turning:							
5	17	F	Cranial nerves X and XII	Occiput–C1 dislocation; C1–C2 rotation	5 mo	Traction C1–C2; fusion occiput–C2	Improved nerve function
Fall:							
6	7	M	Pain	C1–C2 rotation	2 mo	Halo traction	Diminished pain
7	9	M	Pain	C1–C2 rotation; able to turn head	3–4 days	Muscle relaxants	Resolved
8	12	F	Pain	C1–C2 rotation	Hours	Collar	Resolved

Note.—All patients had limited rotational head movement when initially evaluated. mo = months; yr = years.

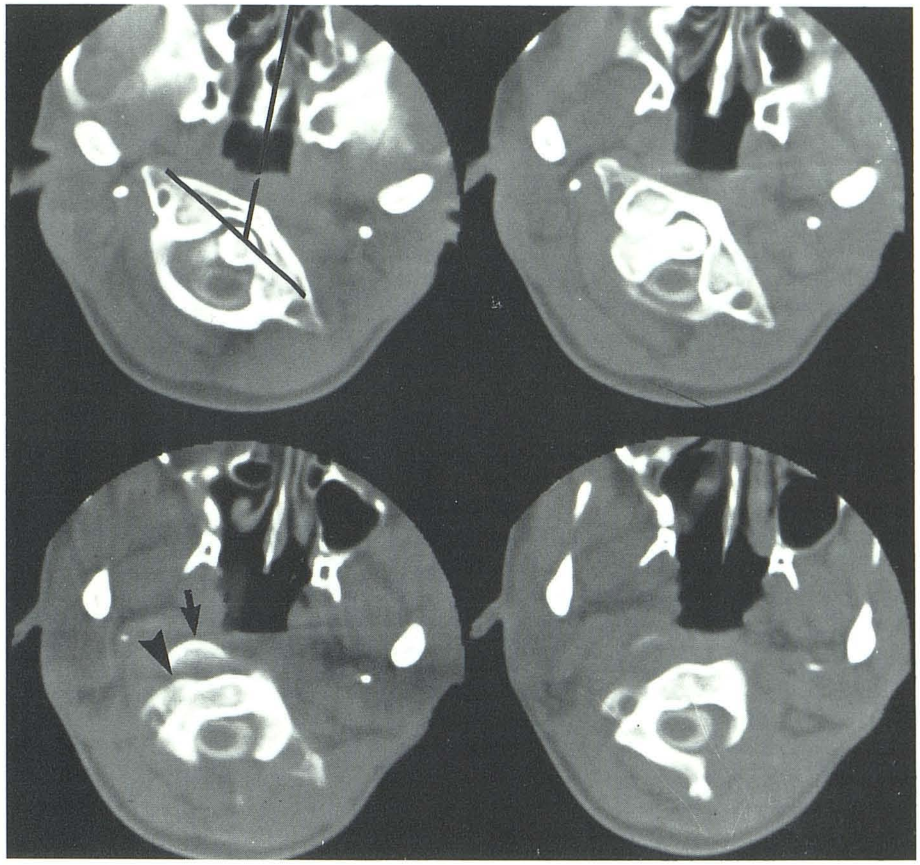
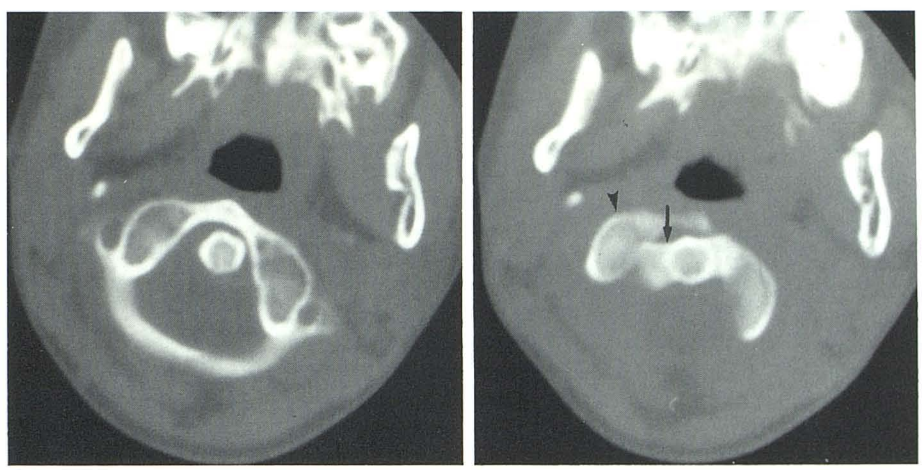


Fig. 1.—Case 5: 17-year-old girl with no history of trauma. Her head was fixed in rotation to the left and she had difficulty swallowing. Sequential CT scans from metrizamide myelogram show occipitoatlantal dislocation and atlantoaxial rotary fixation. Septal axis forms acute angle with transverse axis of atlas. Right lateral mass of C1 (*arrow*) is displaced anterior to superior articular surface of C2 (*arrowhead*). Odontoid remains in normal relationship to anterior arch of atlas, suggesting that transverse ligament remains intact.



A B

Fig. 2.—Case 6: 7-year-old boy whose head was fixed in rotation to the left.
A, Septal axis remains perpendicular to transverse axis of C1. Odontoid lies eccentrically between lateral masses of C2.
B, Right lateral mass of C1 (*arrowhead*) lies anterior to anterior articular surface of C2 (*arrow*). Transverse axis of C1 is no longer perpendicular to axis of C2.

Discussion

Atlantoaxial rotary fixation was described extensively in the pre-CT literature [1–3, 7, 8]. It occurs after minor neck trauma or an upper respiratory tract infection. The atlas, which normally rotates 45° in either direction on a relatively immobile axis [9, 10], is fixed in a position that could be attained during normal rotation. At initial presentation, the patient with atlantoaxial rotary fixation may be indistinguishable from someone with torticollis. In both conditions there may be neck pain, an inability to turn the head, and fixation of the head in a "cock-robin" position [1–3]. Clinical recognition of atlantoaxial rotary fixation depends on failure of the symptoms to resolve after a short period of time. Although the cause of rotary fixation

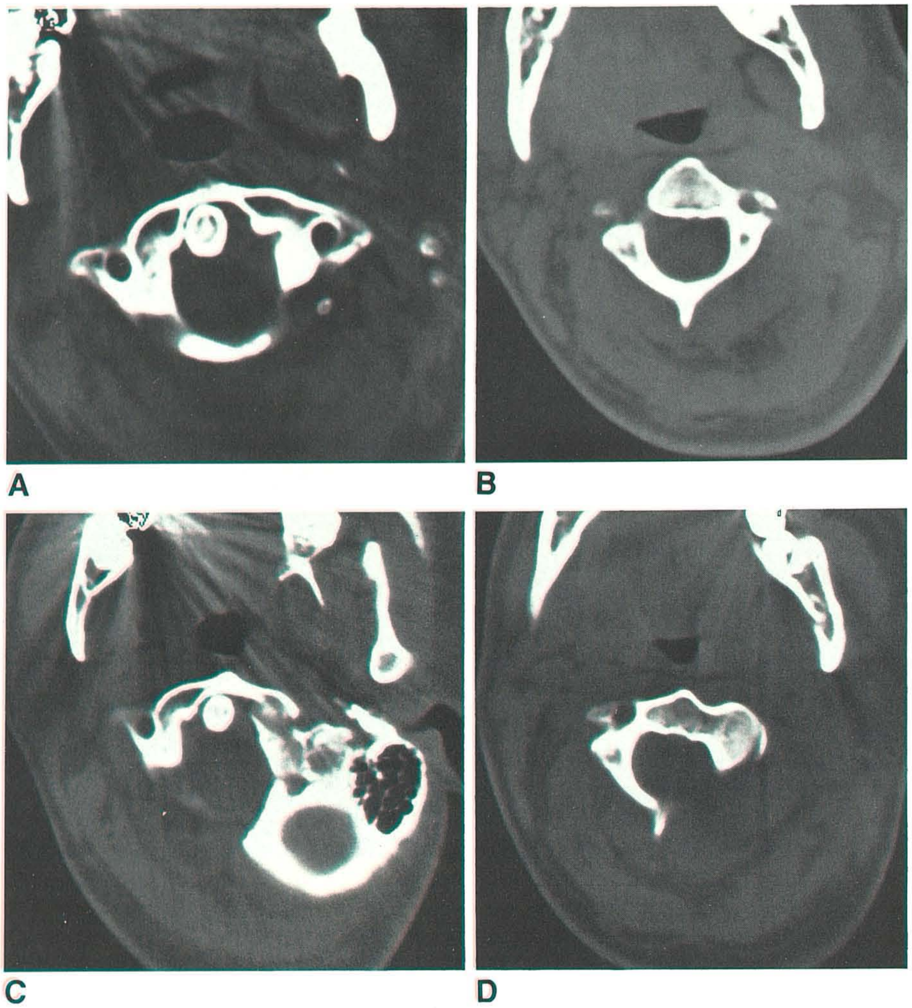


Fig. 3.—Case 2: 30-year-old woman 4 years after automobile accident.

_A_ and _B_, Patient lies normally. She presented with her head fixed in rotation to the right. Odontoid lies eccentrically between lateral masses of atlas. Transverse axis of C1 is no longer perpendicular to axis of C2, indicating rotation at atlantoaxial joint.

_C_ and _D_, After trying to turn her head as far as possible to the left. No change in relationship between transverse axis of C1 and axis of C2, confirming rotary fixation.

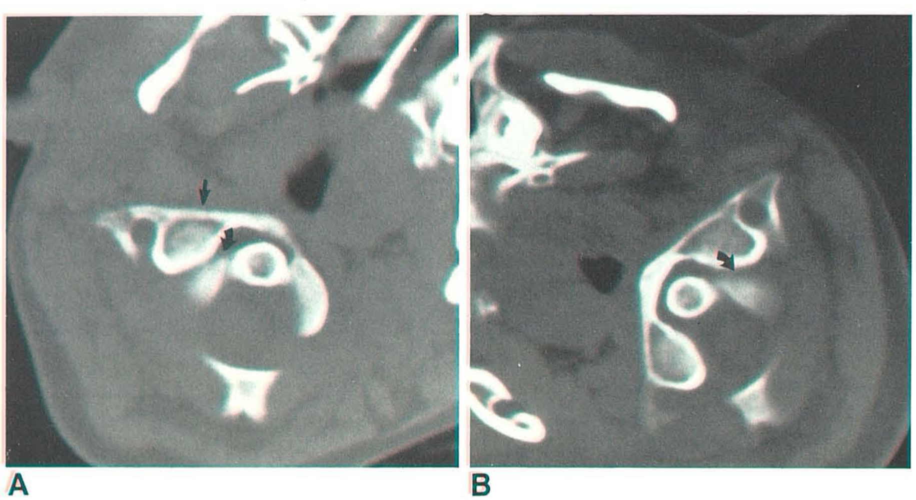


Fig. 4.—Case 8: 12-year-old girl with transient torticollis who presented with her head turned to the left.

_A_, With head in comfortable "neutral" position. Right lateral mass of C1 (_straight arrow_) lies anterior to articular surface of C2 (_curved arrow_).

_B_, After trying to turn her head to the right. Left lateral mass of C1 now lies anterior to articular surface of C2 (_curved arrow_).

remains uncertain, postulated mechanisms include entrapment of inflamed synovium combined with muscle spasm or a tear and invagination of capsular ligaments between the articular facets of C1 and C2 [1, 3, 4].

Plain films in all patients whose heads are rotated, whether voluntarily or pathologically, as in atlantoaxial rotary fixation or torticollis, show a rotated appearance of C1 on C2, with asymmetry of the distance between the odontoid and the

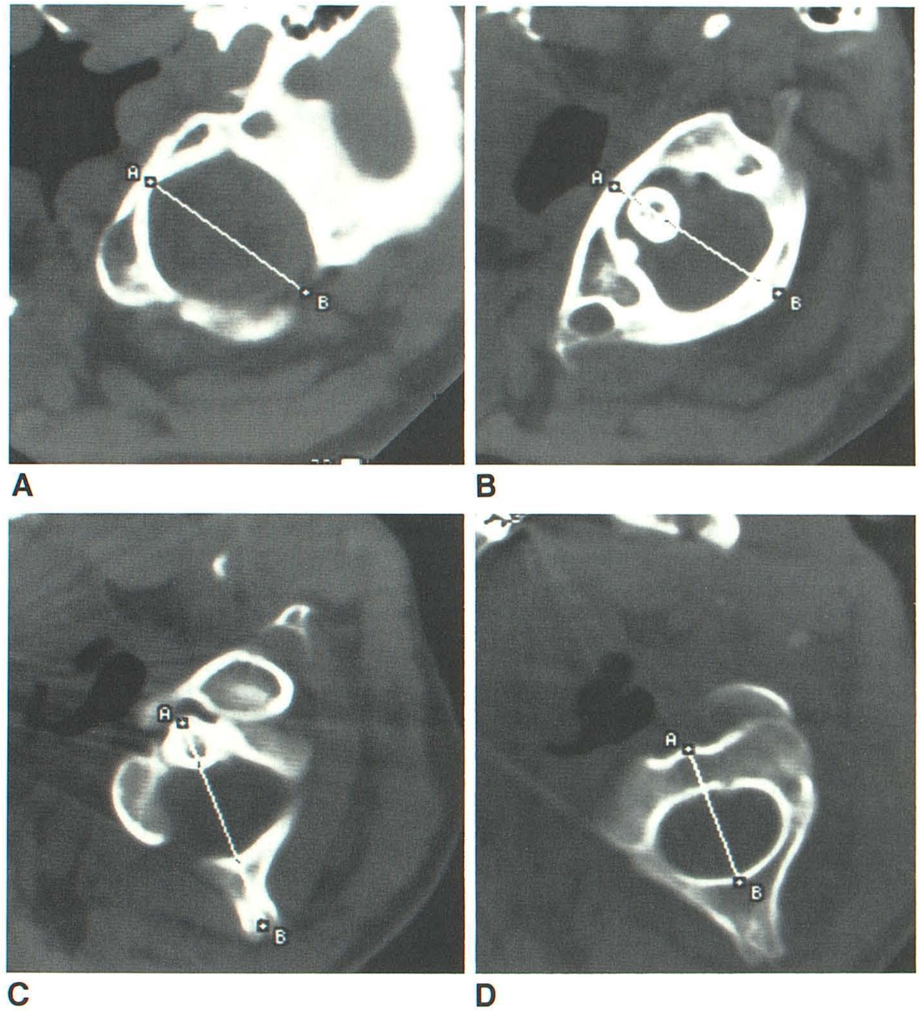


Fig. 5.—Normal volunteer asked to turn his head as far as possible to the right.

***A*, Through foramen magnum. Anteroposterior axis of head is parallel to nasal septum.**

***B*, Through atlas. Anteroposterior axis line of C1 remains parallel to anteroposterior axis of head.**

***C* and *D*, Through C2. Anteroposterior axis of C2 is no longer parallel to anteroposterior axis of C1. Lateral mass of C1 is rotated anteriorly on articular surface of C2.**

TABLE 2: Maximum Rotation at the Atlantoaxial Joint in Normal Volunteers

Age	Gender	Rotation (degrees)
2	M	34
32	M	32
37	M	41
72	M	24
66	F	36
67	F	39

Note.—The average rotation was 34°.

lateral masses of C1 [2, 3]. Cineradiography of the atlantoaxial joint during turning of the head from side to side has been proposed as a method of diagnosis because actual fixation at the atlantoaxial joint could be demonstrated [9, 11]. Reports of the CT appearance of patients with the clinical syndrome of atlantoaxial rotary fixation have consisted of case studies [4, 5] or of discussions of the efficacy of CT in delineating the rotation of C1 on C2 [6]. The problem of distinguishing relatively normal head turning (torticollis) from pathologic fixation has not been addressed.

We began using functional CT studies after encountering a patient with transient torticollis whose initial static CT scan demonstrated C1–C2 rotation indistinguishable from that of previous patients with clinically proven rotary fixation. On functional examination the rotary deformity reversed, prompting further investigation of both the limitations of static scans and the utility of functional examinations. In our experience, the static CT examination is quite adequate for demonstrating the pathology in patients with either occipitoatlantal subluxation or atlantoaxial subluxation with associated anterior displacement of the atlas on the axis. However, the static examination cannot differentiate between patients with *isolated* C1–C2 rotary fixation, patients with reversible torticollis, and normal volunteers who are scanned with their heads held in rotation. By using a functional examination we were able to demonstrate reduction and reversal of the subluxation in the patients with torticollis, thereby excluding the diagnosis of rotary fixation. Conversely, this maneuver did not produce any change in the relationship of the atlas and axis in the patients with clinical rotary fixation who were thus studied, radiographically proving fixation. A similar method of proving fixation radiographically in a patient whose head was fixed in rotation for 9 months was described by Rinaldi et al. [4];

however, they did not comment on the use of functional CT to exclude a transient rotational deformity. Functional scanning has also been used in children with congenital abnormalities of C1–C2 to evaluate stability before surgical immobilization [12]. The advantage of CT over cineradiography is the ease of performance and interpretation.

Additional investigation of the functional examination in the diagnosis of atlantoaxial rotary fixation is still necessary. Our sample size was small and we did not investigate the option of a single set of CT scans with the patient's head turned to the side opposite the deformity. The latter procedure would offer the advantage of decreased radiation and scanning time; however, it is possible that a patient might be unable to turn his head fully past midline because of muscular discomfort rather than actual fixation. We postulate that the demonstration of cervical rotation without movement at C1–C2 is necessary to establish the diagnosis of rotary fixation.

REFERENCES

1. Fielding JW, Hawkins RJ. Atlanto axial rotatory fixation. *J Bone Joint Surg [Am]* **1977**;59:37–44
2. Fielding JW, Hawkins RJ, Hensinger RN, Francis WR. Atlantoaxial rotary deformities. *Orthop Clin North Am* **1978**;9:955–967
3. Wortzman G, Dewar FP. Rotary fixation of the atlantoaxial joint: rotational atlantoaxial subluxation. *Radiology* **1968**;90:479–487
4. Rinaldi I, Mullins WJ Jr, Delaney WF, Fitzer PM, Tornberg DN. Computerized tomographic demonstration of rotational atlanto-axial fixation. *J Neurosurg* **1979**;50:115–119
5. Fielding JW, Stillwell WT, Chynn KY, Syropoulos EC. Use of computed tomography for the diagnosis of atlanto-axial rotatory fixation. *J Bone Joint Surg [Am]* **1978**;60:1102–1104
6. Baumgarten M, Mouradian W, Boger D, Watkins R. Computed axial tomography in C1–C2 trauma. *Spine* **1985**;10:187–192
7. Jacobson G, Adler DC. Examination of the atlantoaxial joint following injury. *AJR* **1956**;76:1081–1094
8. Akbarnia BA, Vafaie M. Atlantoaxial rotary fixation. *Spine* **1983**;8:907–909
9. White AA, Panjabi MM. The clinical biomechanics of the occipitoatlantoaxial complex. *Orthop Clin North Am* **1978**;9:867–878
10. Dvorak J, Panjabi M, Wichman C. CT functional diagnostic instability of the upper cervical spine. Presented at the annual meeting of the Cervical Spine Research Society, Cambridge, MA, December **1985**
11. Fielding JW. Cineradiography of the normal cervical spine. *J Bone Joint Surg [Am]* **1957**;39:1280–1288
12. Roach JW, Duncan D, Wegner DR, Maravilla A, Maravilla K. Atlanto-axial instability and spinal cord compression in children—diagnosis by computerized tomography. *J Bone Joint Surg [Am]* **1984**;66:708–714