Variable Morphology of the Axis Vertebrae in 100 Specimens: Implications for Clinical Palpation and Diagnostic Imaging

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Abstract

Objective: The purpose of this study was to investigate and measure the variable morphologies of axis vertebrae and explore the clinical significance of variations as it may pertain to clinical palpation and diagnostic imaging.

Methods: The common variable morphologies in 100 specimens of intact dry adult axis vertebrae (Chinese) were investigated and measured. The frequencies in deviation of odontoid processes, deviation of spinous processes, and presence of bifid spinous processes were observed. The distances between the apices of transverse processes and inferior articular facets were also measured.

Results: Variable morphologies of C2 that we observed were deviation of odontoid processes (14 cases, 14.0%), deviation of spinous processes (3 cases, 3.0%), and bifid spinous processes (95 cases, 95.0%). Of the bifid spinous processes, 56 had a process on the left side equal to the right side, 21 were longer on the left, and 18 were longer on the right. The distances between apices of transverse processes and inferior articular facets in the left side of C2 were 17.67 ± 2.47 mm, and that of the right side were 17.81 ± 2.55 mm.

Conclusions: Because variable morphology of the axis is common, congenital deviation of the odontoid process, deviation of the spinous process, and asymmetrical bifid spinous processes should be taken into account during clinical palpation and diagnostic imaging. (J Manipulative Physiol Ther 2010;33:125-131)

Key Indexing Terms: *Morphology; Axis; Atlantoaxial Joint*

Diseases of the atlantoaxial joint have been a topic of general interest in clinical research due to the high risk of myelopathy and life-threatening neurologic injuries,[1] and atlantoaxial subluxation (AAS) or instability is a commonly encountered disease in this regard. Plain film radiographs (including open-mouth views, posterior-anterior views, and lateral views) are usually suggested as a tool for evaluating the neck when atlantoaxial rotatory subluxation is considered.[2] Karhu et al[3] also recommended the use of conventional radiographs first in diagnosing AAS. Several reports state that odontoid-lateral mass asymmetry or lateral-atlantodental space asymmetry and lateralized odontoid are considered as radiological criteria for the diagnosis of AAS[4-9] in open-mouth anteroposterior radiographs. However, some authors found evidence of odontoid-lateral mass asymmetry in standard cervical radiograph series in healthy volunteers or as a normal variant in minimally symptomatic patients requiring no treatment.[10-12] As a result, controversy exists as to the clinical significance of this finding in patients with few or no symptoms. Some believe this asymmetry is a normal variant, whereas others suggest that pathologic rotation of the

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atlas on the axis may be present.[10,13,14] It is possible that doctors might misdiagnose these because of their similarities. Moreover, some authors mention that abnormalities of the odontoid process may cause significant loss of stability of the atlantoaxial articulation.[15-17] However, few morphologic details have been offered.[18] Therefore, a direct knowledge about the variable morphology of the axis is important.

In clinical manipulation courses, some doctors report that they have treated AAS successfully with manipulation.[2,19-21] Some authors suggest that when the spinous process of the axis palpated in the neck and it feels like it is pointing away from the midline toward the affected side (Sudeck sign, spine of the axis points in the direction of head tilt), it is also a clinical finding in AAS.[22-25] In addition, some reports state that deflection of spinous processes and/or transverse processes of the axis during palpation was used to determine the orientation and degree of AAS and provide useful information to cervical rotatory replacement manipulation treatment.[19,20,26] However, is there any relationship between variable morphology of the axis and these physical signs? Are all palpated deflections of the spinous processes of C2 (Sudeck sign) really clinical signs of AAS? Can such deflections determine the orientation of AAS?

As of the writing of this study, we found no other studies measuring variations in morphologies of the axis vertebra, especially about the deviation of the odontoid or spinous processes. To reduce the rate of misdiagnosis of AAS and improve the manipulation treatment process, a thorough knowledge of the unique anatomical variants of the axis is of importance. To provide useful and detailed morphologic information to clinical doctors, the frequency of variable morphology of axis vertebrae, especially of the odontoid and the spinous processes, was investigated and measured.

Methods

Subjects

The Department of Anatomy, School of Basic Medical Science, Southern Medical University, China, provided 108 dry adult axis (Chinese) specimens for this study. Eight cases were excluded because of damage and being incomplete, leaving 100 cases that were used in the study. The identities (sex and birth details) of those axes were unknown. Ethical approval to undertake this study was obtained from Southern Medical University's Human Research Ethics Committee.

Anatomical Observation

We have consulted other specialists' articles regarding variations.[27,28] The common variable morphologies of axis vertebrae were investigated and observed, such as deviation of odontoid processes, deviation of spinous processes, and the presence of bifid spinous processes. Furthermore, their frequencies and features of variability were observed and recorded.

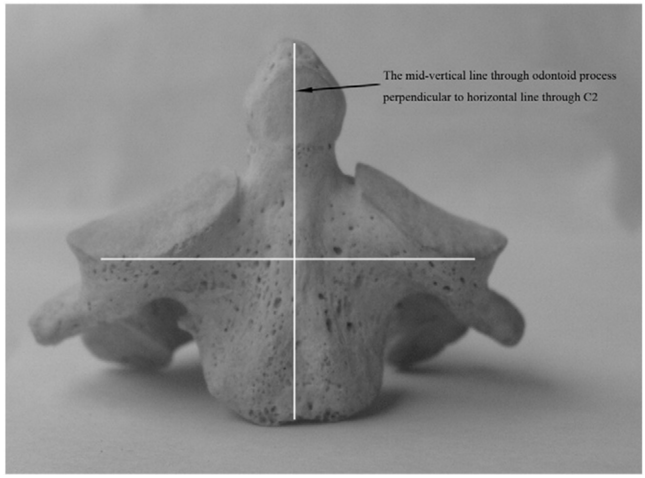

Fig 1. *Normal morphology of the axis. The midvertical line through the odontoid process was coinciding with a midvertical line through C2. This was judged as no deflection of the odontoid process.*

Measurement Methods

The specimens were fixated on the measuring platform during observation and measurement. The distance between 2 points was measured with a Vernier caliper (the minimum scale was 0.02 mm; China National Machinery Import & Export Corp, Beijing, China). Each specimen was measured 3 times, and the mean was recorded. While measuring the required angle, we took pictures of the vertebrae with a camera (Olympus Corporation, Nagano, Japan) in a given plane; and the captured images were imported into image-processing software (Able Software, Lexington, Mass). The minimum angle was 0.01°. Each specimen was also measured 3 times, and the mean was recorded.

Observation and Measurement of Deviation of Odontoid Processes. To reduce the error in the measured angle, the camera lens was placed against the anterior surface of C2 (Fig 1). In the image-processing software, we drew a midvertical line through the odontoid process (the axial line of the odontoid process), a midvertical line through C2 (the axial line of the vertebral body), and a horizontal line through C2 (parallel to the picture's horizontal border) on each specimen picture. We drew a horizontal line through C2 only to observe image better. The relationship between those 3 lines was observed. If the midvertical line through the odontoid process did not coincide with the midvertical line through C2 and if the angle between the midvertical line through the odontoid process and the midvertical line through C2 was bigger than 4° (t test: $t = 2.035$, $P < .05$), we judged the odontoid process to be deflected. The angle between the midvertical line through the odontoid process and the midvertical line through C2 was named the *angle of deviation of the odontoid process*. In contrast, if the midvertical line through the odontoid process was coinciding with the midvertical line of C2, no deflection of the odontoid process was judged.