Letter to the editor concerning: “Subdental synchondrosis and anatomy of the axis in aging: a histomorphometric study on 30 autopsy cases by M. Gebauer et al. (2006) Eur Spine J 15(3):292–298”

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Dear Editor:

Our serial clinic adult patients (age ranging from 23 to 68 years) cervical MRI studies on the existing remnants of the subdental synchondrosis in the axis body (see Fig. 1) caused us to postulate that remnants of the subdental synchondrosis can persist into adulthood, and that if this structure does exist, it will influence the fracture type and/or the healing of dens fractures. We therefore reviewed related papers concerning the subdental synchondrosis and the internal structure of the axis. Surprisingly, little information is available concerning this issue [1–3, 8–10, 12, 13]. Gebauer et al. [8] are to be commended for their initial study focusing on the morphology of the subdental synchondrosis in human cadaveric cervical spines. As they have pointed out [8], the remnants of the subdental synchondrosis could contribute to the high number of Type II fractures (according to the classification of Anderson and D’Alonzo [4]) and to the frequency of nonunion of these fractures. After carefully reading the authors’ paper, we questioned their methods and results. We have identified

several items of contention in regard to this project and would like to put the results in proper context.

First, we argue that Gebauer et al. inaccurately characterized the regions on the samples of the axis in the sagittal plane [8]. In the sagittal plane they have distinguished three regions in the axis sample: the odontoid process, the base of the odontoid process and the body of the axis. We believe this distinction is incorrect. Their identification of the base of the odontoid process is much too low. This region actually belongs to the body of the axis, immediately in the center of the axis body. The junction of the dens with the axis body (described by most authors as the base of the odontoid or the dens, according to the classification of Anderson and D’Alonzo [4]), should be between the level of the transverse ligament and the superior articular facets of the second cervical vertebrae, C2. The incorrect classification of the samples is a basis for incorrect statistical calculations. Therefore all statistical conclusions made by the authors are flawed.

Second, in the “Materials and methods” section of this paper the authors described a method to demonstrate the existing location and the location of the remnants of the subdental synchondrosis below the C1–C2 articulation by using coronally reformatted CT images through the axis. Gebauer et al. considered the location of the subdental synchondrosis as being in the base of the odontoid. In the discussion section, the authors argued that the subdental synchondrosis is regularly located at the transition from the dens to the body of C2, in the center of the base. Here, we would like to provide evidence to contradict their results. After carefully studying the cervical CT images of our clinic patients, we found that most of them have persistent remnants of the subdental synchondrosis in the axis. This finding is quite similar to the authors’ observation, made on the cadaveric cervical spine. However, with coronal and

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Fig. 1 Sagittal T1-weighted magnetic resonance image of a 32-year-old male showing a dark band (*arrow*) beneath the base of the dens that is a remnant of the subdental synchondrosis

sagittal reformatting of the cervical CT slices and by further three dimensional reconstruction of the axis, we clearly observed that the remnants of the subdental

synchondrosis were below the C1–C2 articulation and located at the center of the axis body (Fig. 2).

The authors might argue that it was difficult to precisely classify the base of the dens region in the sagittal plane of the axis. However, by carefully reviewing the studies of Amling et al. [1–3] on the internal anatomy of the axis, we found that the same classification of the sample was utilized. Much earlier work of the trabecular anatomy of the axis has been done by Heggeness and Doherty in 1993. In their published paper, Heggeness and Doherty [12] first identified that a prominent feature of the external anatomy of C2, that is, the ridge present on the axis anterior surface which underlies the insertion of the anterior longitudinal ligament of the spine. This particular anatomic feature is an important landmark of the axis. It can be easily observed (Fig. 2b, c) even in the sagittal reformatted CT image or in the sagittal-plane slices of the odontoid process. We believed that it should be a much more suitable marker for the inferior boundary of the base of the dens. We also propose a more definitive classification of the dens (see Fig. 2f).

Since different classification schemes have been used in the region of the base of the dens, Heggeness and Doherty [12] obtained the contradictory data to the results from Gebauer et al. [8] and Amling et al. [1–3]. Gebauer et al. [8] stated that the base of the dens was the region of low bone mass within the axis at all ages. The descriptions of the low bone density region in the axis were almost the same in the

Fig. 2 **a, b** Coronal and sagittal reformatted images of a 25-year-old female cervical spine, showing that the subdental synchondrosis is beneath the base of the dens (*ellipse*), below the center of C1–C2 articulation in the horizontal plane (*red line*). **b–e** *Arrow* shows the “promontory” on the axis anterior surface. **c** Three dimensional reconstructed image of the axis showing the “promontory” (*arrow*) of the axis is at the same level of the superior articular facets of C2 (*red*

line). **d** *Green* pseudocolor mask of the axis and a *red* mark, which represents the same level of the subdental synchondrosis (*ellipse*), are made before 3D reconstructing of the axis. **e** The subdental synchondrosis of the axis (at the same level as the *red* mark) is beneath the base of the dens, located in the center of the axis body. **f** A proposal for a modified classification of the axis regions according to Anderson and D’Alonzo [4]

sample of Heggeness et al. [12] and Gebauer et al. [8], but were classified as different regions. Gebauer et al. [8] argued that this markedly weaker trabecular region within the base of the dens is a region of least biomechanical resistance that might explain the development of Type II fractures. However, Heggeness and Doherty [12] believed that the observed void or hypodense area beneath the odontoid would seem to be the area through which Type III fractures are normally produced.

From the results of our 3D reconstruction of the axis and the remnants of the subdental synchondrosis (Fig. 2d, e), we clearly found that the subdental synchondrosis is located in the center of the axis, not in the center of the base of the dens. Thus, we question the authors' conclusions that the poor integration of the synchondrosis into the trabecular network and the reduced bone mass with the base of the dens offer an explanation for the occurrence of Type II odontoid fractures and their association with pseudoarthrosis.

Although the classification scheme for odontoid process fractures proposed by Anderson and D'Alonzo [4] is the most commonly used among researchers and clinicians, there exist two clear limitations. First, there is no precise distinction between Type II and Type III fractures. It can be difficult to precisely determine when a Type II fracture extends inferior enough to be considered as a Type III fracture. Second, Type II fractures represent a broad anatomic spectrum of injury patterns which should be managed differently, depending on the fracture patterns. There is no guideline for the treatment options for the fracture types. Thus, more and more authors [6, 11, 13] argue that the classification of odontoid fractures should be modified.

In the latest published article by Gebauer et al. [9] concerning the subdental synchondrosis, a sagittal reformatted CT image of an odontoid fracture shows a fracture line obviously extending from anterosuperior to posteroinferior into the axis body. However, the authors still identified this as Type II fracture. Thus, we question how many Type III odontoid fractures were erroneously diagnosed as Type II fractures? If so, recently published rates of nonunion in Type II fractures are to be questioned [5, 7, 14–16].

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