Cone beam computed tomography imaging of ponticulus posticus: prevalence, characteristics, and a review of the literature

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Objective. The aim of this study was to investigate the frequency of ponticulus posticus (PP) using cone beam computed tomography (CBCT) and to describe the radiologic characteristics of the detected cases.
Study Design. The presence and types of PP were investigated on 730 CBCT images.
Results. PP was found in 17.4% (127) of the 730 CBCT scans. Of these 127 patients, 79 (10.8%) had bilateral PP and 48 (6.6%) had unilateral PP. Male predominance was found with a prevalence of 19.5% (54 of 277) and female prevalence was 16.1% (73 of 453). The prevalence of PP increased with age; the highest prevalence of PP was seen in those who were 49 to 81 years of age.
Conclusions. This study shows that PP is not an uncommon anatomic variation and is a natural incidental finding on CBCT.
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The atlas is the first cervical vertebra of the spine. This cervical vertebra has several morphologic features that differentiate it from other vertebrae, including the absence of a vertebral body; a unique ring-shaped arrangement surrounding the dens of the axis, which is called the *second cervical vertebra*; and a unique articulation with the cranium on its cephalad perspective. Ponticulus posticus (PP) is a variation occurring on the atlas vertebra. Ponticulus posticus, a Latin term that means "the little posterior bridge," is a bony bridge between the posterior part of the superior articular process and the posterolateral part of the superior margin of the posterior arch of the atlas.[1,2] In the literature, there are many terms that describe this anomaly, including ponticulus posticus, foramen sagittale, foramen atlantoideum posterior, Kimmerle's anomaly, foramen retroarticulare superior, canalis vertebralis, retroarticular vertebral artery ring, retroarticular canal, foramen arcuale, and retrocondylar vertebral artery.[1-5]

PP can be evaluated radiographically. Although lateral cephalography[1,2,5-17] and computed tomography (CT)[12,18-20] have been used to evaluate PP, cone beam computed tomography (CBCT) has been previously used only in one study.[21] CBCT has low doses of radiation, a short imaging time, and better image resolution compared with CT. CBCT also produces data from all of the 2D images, including panoramic radiography, lateral cephalography, and others, and it can also create 3D images.[22] The aim of this study was to determine the prevalence of PP using CBCT, to categorize the variation (absent, partial and complete) of the detected cases, to suggest an imaging protocol for PP on CBCT, and to present a review of the literature on PP.

METHODS

Study population

We designed a retrospective cohort study using the CBCT images from 730 patients who presented to the Oral Diagnosis and Radiology service at Ataturk University's Faculty of Dentistry between January 2010 and December 2013. Cases in which the cervical vertebrae could not be seen properly, for technical or anatomic reasons, were not included in this study.

Imaging procedures

Cone beam imaging was performed using a NewTom 3G (Quantitative Radiology, Verona, Italy) flat panel–based CBCT machine. The patient was placed in a

Statement of Clinical Relevance

Ponticulus posticus (PP) can have a significant effect in the management of cervical spine surgery, especially surgery that involves lateral mass screw placement. Cone beam computed tomography (CBCT) may be used to assess this anatomic variation.

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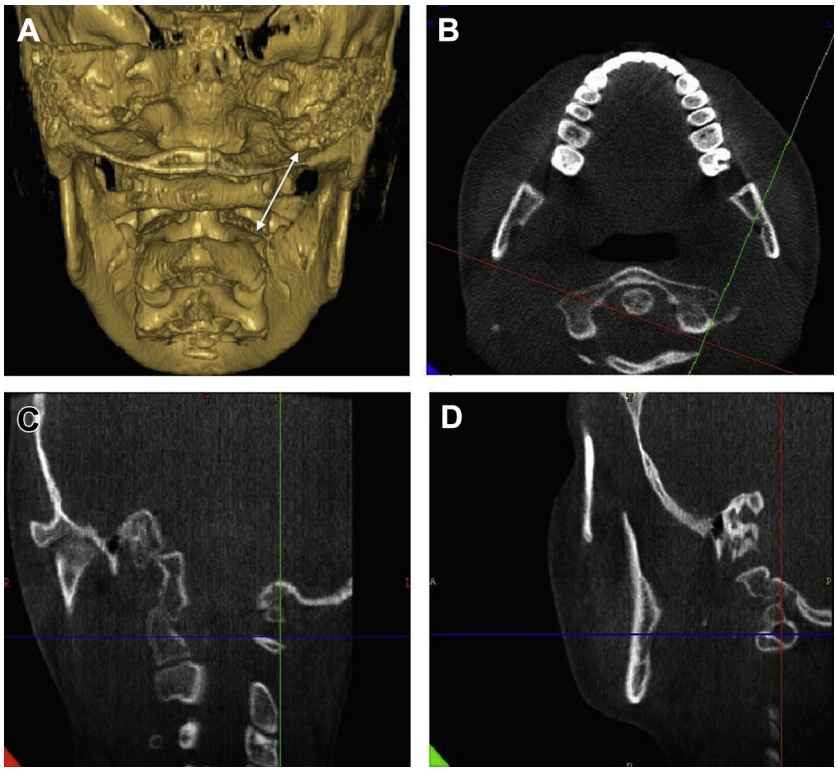

Fig. 1. Imaging protocol. 3D, axial, coronal, and sagittal images.

horizontal position so that the Frankfort horizontal plane was perpendicular to the table, with the head within the circular gantry housing of the X-ray tube-detectors system; a 360-degree rotation around the head of patient was performed, and the scanning time was 36 seconds. The scanner operated with a maximum output of 110 kV and 15 mAs, 0.16 mm voxel size, and had a typical exposure time of 5.4 seconds. The QR-NNT version 2.21 (Quantitative Radiology) software program was used for analyses. After raw data were obtained, the patient left the examination room, and the clinician was able to perform the primary reconstruction. The atlas vertebra was defined on 0.5 mm−thick axial slices. One of the axial views on which the atlas vertebrae were seen with the widest latero-lateral extent was used as a reference view for the secondary reconstruction. The sagittal slice of atlas vertebrae was performed perpendicular to the long axis of the atlas vertebrae with 1-mm thickness, and the coronal slices were performed parallel to the long axis of the atlas vertebrae with 1-mm thickness, on the selected axial image. After the secondary reconstruction 3D images were obtained, the direction of the PP was determined on 3D images. Then the direction of the PP was adjusted on the axial images by using the multiplanar rendering mode. Sagittal images were used for the detection of the PP because of the direction of the PP on the atlas vertebrae (Figure 1).

Evaluation of the images

A complete PP is one continuous bridge that extends from the posterior aspect of the lateral mass to the anterior aspect of the posterior tubercle. A partial PP is one that does not extend fully from the posterior lateral mass to the posterior tubercle. It is possible to identify a PP incorrectly as a broad dorsal arch of the atlas. A normal posterior arch of the atlas thins out laterally and does not curve up cranially, whereas a PP broadens laterally and extends cranially. Radiologists examined each image for the presence of PP in any of its forms: complete, partial, unilateral, or bilateral. Each image was assessed by two radiologists, who noted whether any type of PP (i.e., partial or complete) was present. There were some cases where the radiologists disagreed about the presence of partial PP, and only images that both radiologists agreed upon with regard to the presence or absence of PP in any of its forms (i.e., complete or partial) were included in the calculation of the prevalence.

Literature review

The study included a detailed search of the reported literature using the PubMed database for the years 1955 through to June 2014. The search strategy used the keywords “ponticulus posticus,” “posticus ponticus,” “foramen arcuate,” “foramen arcuale,” “foramen sagittale,” “foramen atlantoideum posterior,” “Kimmerle’s