

## STUDY ON THE MORPHOLOGICAL VARIATIONS OF THE ADULT HUMAN ATLAS VERTEBRAE

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### ABSTRACT

**Background:** The knowledge of the anatomical variations of atlas plays very important role in neurosurgery where the surgical manipulation of the cervical spine is needed to decompress the vertebral artery as the variations of atlas leads to cause cervico-basilar insufficiency.

**Materials and methods:** Study was carried out on 50 dry adult human atlas vertebrae of unknown sex which are collected from department of Anatomy. All the specimens were observed for presence of any morphological variations.

**Results:** Among the 50 atlases studied. The following morphological variations were observed. Incomplete foramen transversarium was observed in 2 (4%) cases. Retroarticular canals or ponticles were present in 10 (20%) of cases. Among that the complete posterior ponticles was seen in 2 (4%) atlases, one with bilateral complete retroarticular canal, and one with unilateral retroarticular canal. Incomplete posterior ponticles was seen in 8 (16%) atlases, and the incomplete lateral ponticle was seen in 1 (2%) atlas. Bilobed superior articular facet was observed in 7 (14%) of cases. Spur on the anterior arch was observed in 10 (20%) of cases. Abnormal groove around the superior articular facet on left side was observed in one atlas.

**Conclusion:** The knowledge of the absence of costal element or incomplete formation of foramen transversarium is important for radiologists, neurologists, neurosurgeons who deal with diagnosis and treatment of head and neck region. Extreme rotation of cervical spine in an individual with retro-articular canal may lead to the compression of the third part of vertebral artery and may cause vertebro-basilar insufficiency. Hence the knowledge of the anatomical variations is very important for neurosurgeons dealing with surgical manipulation of the cervical spine to decompress the vertebral artery.

**KEY WORDS:** Atlas, Retroarticular canal, Foramen transversarium, Ponticles, Cervico basilar insufficiency.

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DOI: 10.16965/ijar.2016.360

**Web site:** International Journal of Anatomy and Research  
ISSN 2321-4287  
[www.ijmhr.org/ijar.htm](http://www.ijmhr.org/ijar.htm)

Received: 06 Aug 2016      Accepted: 06 Sep 2016  
Peer Review: 27 Aug 2016    Published (O): 30 Sep 2016  
Revised: None                Published (P): 30 Sep 2016

### INTRODUCTION

The atlas, the first cervical vertebra, supports head. It is unique in that it fails to incorporate a

centrum (Body of the vertebra). It consists of two lateral masses which are connected by short anterior arch and longer posterior arch. The

anterior arch of atlas forming one-fifth of the ring is convex, and presents at its centre the anterior tubercle. Posteriorly it is concave, and marked by a smooth, oval or circular facet (fovea dentis) for articulation with the odontoid process (dens) of the axis. The lateral masses carry two articular facets, a superior and an inferior. Atlas is usually ossified from three centres. Of these, one appears in each lateral mass about the seventh week of foetal life. At birth, the anterior arch consists of cartilage; in this a separate centre appears about the end of the first year after birth, and joins the lateral masses from the sixth to the eighth year and transverse process with foramen transversarium. Bony spurs may arise from the anterior and posterior margins of the groove for the vertebral artery. These spurs are named as ponticles. The superior border of posterior arch of atlas gives attachment to posterior atlanto-occipital membrane. The membrane is deficit in lateral border to permit way for the vertebral artery and the first cervical spinal nerve. The lateral edge of the membrane may ossify and convert the groove into canal [1]. This formed neurovascular bony ring is called as retroarticular vertebral ring, retroarticular canal or retroarticular vertebral artery ring [2-4].

Third part of vertebral artery passes through the foramen transversarium of atlas and runs backwards and medially behind the lateral mass of the atlas, and lies in the neurovascular groove on posterior arch of atlas. It then enters into the foramen magnum and continues as fourth part of vertebral artery [5]. Vertebral artery in its course over the posterior arch of atlas may get compressed by the ponticles or bridges. Literature suggests that the presence of retroarticular canals or the ponticles especially complete and incomplete ones predispose to vertebro-basilar insufficiency and Barre-Lieou and cervicogenic syndromes especially in neck movements [6]. The present study was aimed to observe the variations of the atlas vertebra which can help in the diagnosis and treatment of cervical spine lesions.

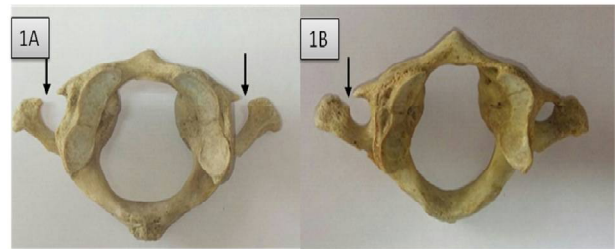
### MATERIALS AND METHODS

Study was carried out on 50 dry adult human atlas vertebrae of unknown sex which are collected

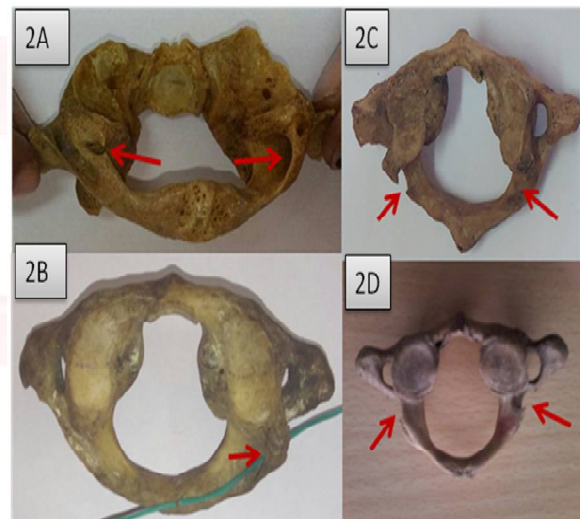
from department of Anatomy. All the specimens were observed for presence of any morphological variations and the observed variations were noted. Atlases with pathological features and damage were excluded.

### RESULTS

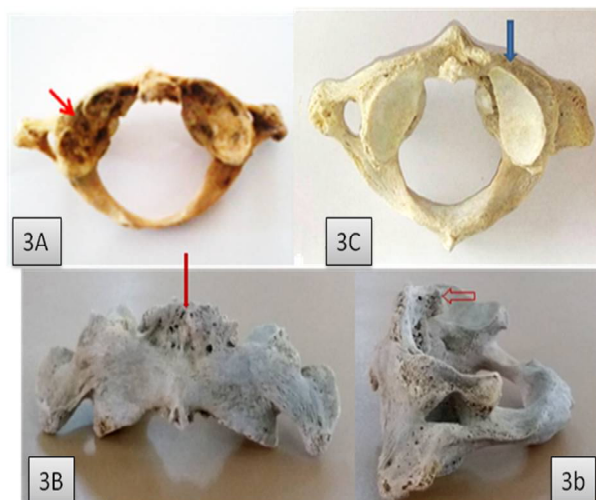
**Fig. 1:** Showing the incomplete foramen transversarium bilaterally (1A) and left unilaterally (1B).



**Fig. 2:** Showing the bilateral retroarticular canal (2A), unilateral retroarticular canal (2B), Bilateral incomplete ponticles (2C) and Bilateral incomplete lateral ponticles (2D).



**Fig. 3:** Showing the bilobed superior articular facet (3A), Spur on the anterior arch (anterior view 3B, lateral view 3b), Groove around the superior articular facet (3C).



All the 50 atlas vertebrae were observed for any morphological variations. In 2 (4%) atlases incomplete foramen transversarium was observed. Among that, anterior margin of foramen transversarium was absent on left side in one atlas (Unilateral) and in another atlas anterior margin of foramen transversarium was absent on both sides (Figure 1A & 1B).

Retroarticular canals or ponticles were present in 10 (20%) atlases. Among that the complete posterior ponticles was seen in 2 (4%) atlases, one with bilateral complete retroarticular canal, and one with unilateral retroarticular canal. Incomplete posterior ponticles was seen in 8 (16%) atlases, and the incomplete lateral ponticle was seen in 1 (2%) atlas (Figure 2A, 2B, 2C & 2D).

Bilobed superior articular facet was observed in 7 (14%) atlases (Figure 3A). Spur on the anterior arch was observed in 10 (20%) atlases (Figure 3B). Abnormal groove around the superior articular facet on left side was observed in one atlas (Figure 3C)

## DISCUSSION

The morphological variations present in the atlas vertebrae may confuse the surgeons and radiologists while dealing with diagnosis and treatment of the atlanto-axial and atlanto occipital complexes. The present study results were compared with the previous studies. Qudusia Sultana et al., reported absence of costal element in five atlas vertebrae in that 2 of the vertebrae showed incomplete unilateral foramen transversarium. Among that one vertebra showed absence of anterior margin of the foramen transversarium on the right side, in another case posterior margin deficient on right side was observed. In 3 vertebrae anterior margin was absent bilaterally [7]. Renu Chauhan & Jugesh Khanna reported absence of costal element in five atlas vertebrae (10%) out of 50 atlas vertebrae. Anterior margin of the foramen transversarium was absent on the right side in three cases out of 100 foramina transversaria (3%). This margin was absent bilaterally in two cases out of 100 foramina seen (2%) [8]. Unilateral absence of foramen transversarium, on the left side has been reported by Vasudeva and Kumar.

Bilateral absence of foramen transversarium was observed by Nayak et al., [9, 10]. In the present study out of 50 atlas vertebrae only 2 vertebrae (4%) showed variations in the formation of foramen transversarium. In one case absence of anterior margin of foramen transversarium was observed bilaterally and in another case absence of anterior margin of foramen transversarium was observed on left side only. The occurrence of incomplete foramen transversarium can be confused with fractures and other anomalies and hence should be known to radiologists for accurate interpretation of radiographs and computed tomographic scans [11, 12].

Taiz & Nathan had observed the incidence of complete posterior ponticle, incomplete posterior ponticles and the lateral ponticles as 7.8%, 25.9% and 3.8% respectively [13]. Mitchell J reported the incidence of complete posterior ponticles, incomplete posterior ponticles and lateral ponticles as 9.80%, 29.6% and 12.24% respectively which was much higher than the incidences observed in the present study [14]. We also compared the present study results with other Indian studies. Krishnamurthy et al., reported the incidence of complete posterior ponticle, incomplete posterior ponticles and the lateral ponticles as 13.8%, 8.33% and 5.5% respectively. The incidence of complete posterior ponticles and lateral ponticles were higher than the present study and the incidence of incomplete posterior ponticles was observed lower than the present study [15]. Zambare BR & Reddy BB, Nitixa P. Patel et al., study results were closely matching with the present study [16, 17].

The potency of existing osteogenic cells in the region of cranio-vertebral junction is activated leading to formation of retroarticular canal and others believe that the pulsation of the vertebral artery itself could induce the bridging with ossification of oblique ligament of atlas [18]. Bilobed superior articular facet is found in 14 % of cases. Division of the articular facets may be due to the presence of constriction or a groove. These grooves may give rise to pressure facets. The presence of pressure facets indicates the great pressure in atlanto-occipital joint during movements [19].

## CONCLUSION

Absence of costal elements of foramen transversarium may cause the dislodgement of vertebral artery or damage to the vertebral artery during any traumatic conditions. The knowledge of the absence of costal element or incomplete formation of foramen transversarium is important for radiologists, neurologists, neurosurgeons who deal with diagnosis and treatment of head and neck region. Extreme rotation of cervical spine in an individual with retro-articular canal or ponticles may lead to the compression of the third part of vertebral artery and may cause vertebro-basilar insufficiency presenting with dizziness, fainting and transient diplopia. Hence the knowledge of the anatomical variations are very important for neurosurgeons dealing with surgical manipulation of the cervical spine to decompress the vertebral artery.

**Conflicts of Interests: None**

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### How to cite this article:

B Sadananda Rao, M Yesender, S Saritha, B H Shiny Vinila. STUDY ON THE MORPHOLOGICAL VARIATIONS OF THE ADULT HUMAN ATLAS VERTEBRAE. *Int J Anat Res* 2016;4(3):2873-2877. DOI: 10.16965/ijar.2016.360