Content available at: https://www.ipinnovative.com/open-access-journals

Indian Journal of Clinical Anatomy and Physiology

Journal homepage: https://www.ijcap.org/

Original Research Article

A morphological study of ponticuli of the human atlas vertebrae

Mohini Madhukarrao Joshi[1], Sandeep Pakhale[1], Kamal Pawar[1]*

[1]Dept. of Anatomy, Dr Balasaheb Vikhe Patil, Rural Medical College, Loni, Maharashtra, India.

Abstract

Background: Dried human atlas vertebrae have been used in this study on ponticuli. Knowing these anatomic variations may help interpret radiological findings, prevent vertebral artery damage during posterior atlas instrumentation, and prevent craniovertebral manipulation as the number of surgeries on the atlanto-axial junction has increased.
Aim and Objectives: The following observations about the specimens were the focus of the present study.
The presence of unilateral or bilateral ponticuli, right or left side ponticuli, posterior, lateral posterolateral, complete, or incomplete ponticuli.
Materials and Methods: For the present study, 60 dried human atlas vertebrae were used. The following parameters were noted: the presence of ponticuli, whether they were complete or incomplete, and whether they were on the right or left side.
Inclusion Criteria: The study included human atlas vertebrae that appeared to be normal and devoid of any acquired or congenital abnormalities.
Exclusion Criteria: The study did not include human atlas vertebrae that were fractured or distorted, occipitalized, or joined with axis vertebrae.
Results: 18 (30%) of the 60 human atlas vertebrae that were examined in this study exhibited ponticuli. The ponticulus was complete in four (6.66%) atlas vertebrae and incomplete in fourteen (23.33%) vertebrae. 13% were bilateral, and 5% were unilateral. Three of the eighteen ponticuli were located on the right side, two on the left, and thirteen on each side.
Conclusion: The current study contributes to our understanding of the anatomy and variations of the atlas vertebra. Neurologists, neurosurgeons, and the medical community at large must be familiar with the normal anatomy and variations of the atlas.

Keywords: Atlas vertebra, Ponticuli, Incidence

Received: 02-05-2025; **Accepted:** 05-06-2025; **Available Online**: 05-07-2025

1. Introduction

Atlas, the first cervical vertebra, is an atypical vertebra. Greek mythology states that its name is based on "ATLAS," who carried the earth on his shoulders.[1] The atlas vertebrae, the first cervical vertebra, is characterised by its lack of a body, two lateral masses, concave superior articular facets, circular inferior articular facets, and two transverse processes with foramen transversaria. Variations in the cervical spine are widespread. A facet for articulation with dens of axis on the inner surface is present on the anterior arch, which joins the two lateral masses. A groove on the superior surface of the greater posterior arch accommodates the first cervical nerve, the venous and sympathetic plexus, and the third segment of the vertebral artery. Under the lower boundary of the posterior atlanto-occipital membrane, the vertebral artery normally leaves the foramen transversarium side, travels posteromedially, penetrates the posterior arch of atlas, and enters the foramen magnum.[2]

The dorsal edges of the vertebral artery groove may develop bony spurs termed ponticle, which can compress the vertebral artery and change it into a complete or incomplete foramen.[3] Ponticulus posticus, which translates to "posterior bridge," is the name given to the foramen thus created. The vertebral artery becomes dangerous and liable to vertebrobasilar insufficiency if there is a posterior or lateral vertebral artery foramen, whether it is unilateral or bilateral, complete or incomplete.[4] Vertigo, headaches, nausea, and dizziness are among the symptoms of vertebrobasilar insufficiency brought on by this pressure. This foramen is also known as an arcuate foramen, Kimmerly's abnormality, etc.[5]

Corresponding author: Kamal Pawar
Email: atharvamohini@gmail.com

http://doi.org/10.18231/j.ijcap.2025.013

In some cases another bony bridge extends laterally from the lateral mass to the posterior root of the transverse process, thus forming an additional foramen for the vertebral artery, above and behind the transverse foramen. This is the ponticulus lateralis.[6] With this information in mind, the present study was taken up to find out the occurrence rate of ponticuli in atlas vertebra so as to correlate with its clinical significance.

2. Materials and Methods

A total of 60 (120 sides) complete dry human atlas vertebrae obtained from dry skeletal collection from Pravara Institute of Medical sciences Loni, Maharashtra Department of Anatomy and from undergraduate students. Every vertebral bone was completely cleansed, and assigned a number between 1 and 60. Exostosis from the posterior margin, lateral margin, and posterolateral boundary of superior articular facet was inspected in the posterior arch of the atlas. Specimens displaying these bony outgrowths were categorised as having a complete or incomplete bony ring. Atlas bone bridge morphology, including posterior, lateral, and posterolateral bridges, was examined, and observations were made.

3. Results

18 (30%) of the 60 human atlas vertebrae that were examined in this study exhibited ponticuli.(**Table 1**) The ponticulus was complete in four (6.66%) atlas vertebrae and incomplete in fourteen (23.33%) vertebrae.(**Table 3**) 13% were bilateral, and 5% were unilateral.(**Table 4**) Three of the eighteen ponticuli were located on the right side, two on the left, and thirteen on each side.(**Table 5**)

Table 1: Incidence of ponticuli

Incidence of ponticuli	Number	Percentage
Total number of Human atlas vertebrae examined	60	100%
Number of human Atlas vertebrae without ponticuli	42	70%
Number of human Atlas vertebrae with ponticuli	18	30%

Table 2: Incidence of posterior, lateral and posterolateral ponticuli

Incidence of ponticuli	Number n=60	Percentage
Posterior	13	21.66%
Lateral	1	1.66%
posterolateral	4	6.66%

Table 3: Incidence of complete and incomplete ponticuli

Incidence of ponticuli	Number	Percentage
Complete	4	6.66%
Incomplete	14	23.33%

Table 4: Incidence of unilateral and bilateral ponticuli

Incidence of ponticuli	Number	Percentage
Unilateral	5	8.33%
Bilateral	13	21.66%

Table 5: Incidence of right side, left side and right side and left side (bilateral) ponticuli

Incidence of ponticuli	Number	Percentage
Right side	3	5 %
Left side	2	3.33%
Bilateral	13	21.66%

Table 6: Distribution of complete ponticuli

Type of complete ponticuli	Number (n=60)	Percentage
Posterior	2	3.33%
Lateral	1	1.66%
Posterolateral	1	1.66%

Table 7: Distribution of incomplete ponticuli

Type of incomplete ponticuli	Number (n=60)	Percentage
Posterior	8	13.33%
Lateral	1	1.66%
Posterolateral	5	8.33%

Table 8: Distribution of unilateral ponticuli and bilateral ponticuli

Type of unilateral ponticuli & bilateral ponticuli	Number (n=60)	Percentage
Unilateral complete posterior ponticuli	2	3.33%
Unilateral complete lateral ponticuli	1	1.66%
Unilateral incomplete posterior ponticuli	2	3.33%
Bilateral complete posterior ponticuli	3	5%
Bilateral incomplete posterior ponticuli	7	11.66%
Bilateral incomplete lateral ponticuli	1	1.66%
Bilateral incomplete posteriolateral ponticuli	2	3.33%

Figure 1: Atlas vertebra showing right complete posterior ponticulus

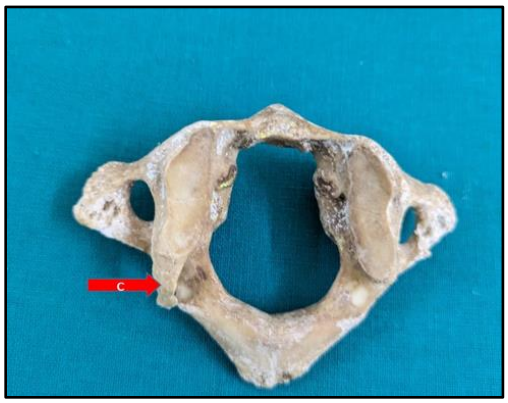

Figure 2: Atlas vertebra showing left complete posterior ponticulus

Figure 3; Atlas vertebra showing bilateral complete posterolateral ponticuli

Figure 4: Atlas vertebra showing bilateral complete posterior ponticuli

Figure 5: Atlas vertebra showing bilateral incomplete posterolateral ponticuli

Figure 6: Atlas vertebra showing right incomplete lateral ponticulus

Figure 7: Atlas vertebra showing right incomplete posterolateral ponticulus

Figure 8: Atlas vertebra showing left incomplete posterolateral ponticulus

4. Discussion

The progression of numerous congenital, neoplastic, and traumatic diseases necessitates a thorough understanding of the anatomy surrounding the cervical area.[7] Many theories have been proposed about the development of these ponticuli, therefore the method of formation is up for debate. and add that a regressive and vanishing morphological feature is what causes this kind of bony ring creation rather than the ligament's ossification alone.[8]

Number of symptoms could result from the presence of posterior and lateral ponticles, which increase the risk of vertebrobasilar vascular insufficiency. When there is a foramen arculae, the vertebral artery may be vulnerable during neurosurgical procedures and could create the erroneous impression that the posterior arch of the atlas is significantly broader. Neurosurgeons, general surgeons, radiologists, and chiropractors can all benefit from knowing how common this is when it comes to patient care.[9]

Four (8%) of the 50 human atlas vertebrae that were examined in the Berjina et al. study showed ponticuli.[10] Twelve 18 (30%) of the 60 human atlas vertebrae that were examined in this study exhibited ponticuli. Two (4%) vertebrae had partial ponticulus, while two (4%) atlas vertebrae had complete ponticulus.

Akhtar et al were reported 21.17% of cases with ponticulus posterior, with 7.62% of specimens having a complete ring and 13.55% having an incomplete ring. Males were more likely than females to have both the ponticulus posterior and lateralis. While incomplete ponticulus posterior and ponticulus lateralis were more frequently found bilaterally, complete ponticulus posterior was more prevalent on the right side.[11] According to Kintukumar Vyas et al. the ponticulus posticus was incomplete in 33 (33%) of the vertebrae. Out of these, the incomplete ponticulus posticus was observed on the right side of 7 (7%) vertebrae and on the left side of 3 (3%) vertebrae. The incomplete ponticulus posticus was observed on both sides. Of the remaining 23 (23%) vertebrae. Four (4%) vertebrae had complete ponticulus posticus.[12] In present study Ponticulus was incomplete in 14(23.33%) vertebrae(**Table 3** & **Figure 6**) and was complete in 4 (6.66%) atlas vertebrae.(**Table 3** & **Table 4**) ponticulus lateralis was reported only in 5.93% cases (unilateral: 2.54% & bilateral: 3.39%) (**Table 7** & **Figure 6**).

Vyas Kintukumar et al. looked at the incidence of ponticulus posticus on the superior surface of the posterior arch of 100 atlas vertebrae was determined. Of these, just one (1%) vertebrae on the right side had entire ponticulus posticus, while three (3%) vertebrae on the left side did the same.[12] In the current study, 13% were bilateral(**Table 8** & **Figure 2**) and 5% were unilateral.(**Table 8** & **Figure 1**) Three of the eighteen ponticuli were located on the right side, two on the left, and thirteen on each side.(**Table 5** & **Figure 2**,**Figure 6**)

It was bilateral in 2% and unilateral in 6%, according to Berjina et al. Two of the five ponticuli were located on the right side, one on the left, and two on each side. With the exception of one lateral ponticulus, all were posterior ponticuli. Four atlas vertebrae contained five ponticuli in total.10[10]

Some studies believed that the creation of these ponticles was caused by the ossification of the posterior atlantooccipital membrane.[13] There are two types of pathological calcification: ectopic calcification (soft tissue mineralisation) and heterotopic ossification (bone production). Whether the PP is an ectopic calcification or a heterotopic ossification has not been reported.[14]

Tubbs et al. pointed out that since ossification centres have not been found in ligaments, it is doubtful that ossification will result in the creation of a PP.[15] Since ligamentous calcification happens years after the complete creation of bone and subsequently after prolonged stress, Crowe's findings on PP in patients under the age of 15 indicate that the PP is not a calcified ligament and is not associated with ligamental stress.[16]

The partial and complete PPs were found to differ statistically significantly by Hong et al. (2008), indicating that the production of a PP would seem to be comparable to the formation of osteophyte, a condition that is likewise associated with age. Because this was an orthodontic study, the majority of the participants were under the age of 18, and the age-related changes revealed are consistent with findings by Tubbs et al. and Crowe and Hong et al.

5. Conclusion

Incomplete or complete foramens are common variations in the vertebral artery groove on the superior aspect of the posterior arch of the atlas vertebrae. For orthopaedic and neurosurgeons, this anatomical understanding is crucial. The fact that this study was conducted on dry bones of undetermined sex and age in is one of its drawbacks. For improved support, extensive radiological, clinical, and anatomical research from different areas are needed.

6. Source of Funding

None.

7. Conflict of Interest

The authors declare no conflict of interest.

8. Ethical No:

PIMS/DR/RMC/2020/354.

References

1. Keith L Moore. The back. Satterfield TS. Clinically Oriented Anatomy. 3rd ed: Baltimore, Williams and Wilkins. 1992; p.331.
2. Standing S, Borely NR, Collins P, Crossman AR, Gatzoulis MA, Healy GC, et al. Gray's anatomy: the anatomical basis of clinical practice. 40th ed. London: Churchill Livingstone, 2008. p. 1530
3. Tubbs RS, Johnson PC, Shoja MM, Loukas M, Oakes WJ. Foramen arcuale: anatomical study and review of the literature. *J Neurosurg Spine*. 2007; 6(1): 31-34
4. Gopal K, Kumar V, Kumar V, Agrawal J. Anatomical variations in conduit of vertebral artery in atlas. *J Evol Med Dent Sci*. 2013;2(42):8030-37.
5. Santhi B, Dhanlakshmi V, Esther Yamuna N, Manoharan C. Study of arcuate foramen of atlas vertebrae. *Int J Anat Res.* 2017;5(1):3367-71.
6. Taitz C, Nathan H. Some observations on the posterior and lateral bridge of atlas. *Acta Anatomica*. 1986;127:212-7
7. Akhtar MJ, Fatima N, Ritu, Kumar V. A morphological study of ponticuli of the human atlas vertebrae and its clinical significance. *Int J Anat Res*. 2015;3(4):1597-602
8. Lalit M, Piplani S, Arora AK, Kullar JS, Sharma T. Incidence of atlas bridges and tunnels: Their phylogeny, ontogeny and clinical implications. *Rev Arg de Anat Clin.* 2014;6(1):26-34.
9. Munawar S, Jafri F, Qureshi F, Fatima D, Zahid A. Posterior and lateral ponticles of atlas: An osteological study at Fatima Jinnah Medical University, Lahore. *J Fatima Jinnah Med Univ.* 2020;14(2): 91-6.
10. Berjina Farooq Naqshi, Adil Bashir Shah, Sangeeta Gupta. Ponticuli in atlas vertebrae and its clinical aspect. Int J Anat Res. 2018;6(1.2):4880-3.
11. Md. Jawed Akhtar, Nasreen Fatima, Ritu, Vinod Kumar. A Morphological Study of Ponticuli Of The Human Atlas Vertebrae And Its Clinical Significance. *Int J Anat Res.* 2015;3(4):1597-602.
12. Kintukumar Vyas, HG Joshi, Shital Patel, Bhavesh Shroff. Study of Ponticulus Posticus in Dry Atlas Vertebrae in Central Gujarat Region and its Clinical Significance. *Int J Anat Radiol Surgery.* 2017;6(4):38-41.
13. Chummy S, Sinnatamby. Last's anatomy. 12th edition. London: Churchill Livingstone. *Edinburgh*. 2011. p. 426.
14. Vanden Bossche L., Vanderstraeten G. Heterotopic ossification: a review. *J Rehabil Med*., 2005;37(3):129-36.
15. Tubbs R.S., Johnson P.C., Shoja M.M., Loukas M., Oakes W. J. Foramen arcuale: anatomical study and review of the literature. *J Neurosurg Spine.*, 6(1):31-4.
16. Hong J.T., Lee S.W., Son B.C., Sung J.H., Yang S.H., Kim I.S. Analysis of anatomical variations of bone and vascular structures around the posterior atlantal arch using three-dimensional computed tomography angiography. *J Neurosurg Spine*. 2008;8(3):230-6.

Cite this article: Joshi MM, Pakhale S, Pawar K. A morphological study of ponticuli of the human atlas vertebrae. *Indian J Clin Anat Physiol*. 2025;12(2):58-62.