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Original Research Article

Prevalence and Demographic Distribution of C1 Ponticulus Posticus in Southern India: A Prospective Observational Study

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Abstract:

Objectives: To determine the prevalence and demographic distribution of C1 ponticulus posticus (arcuate foramen).

Methods: This was a hospital based prospective observational study conducted in the Department of Radiology and Department of Neurosurgery, Government Stanley Medical College, Chennai between April 2019 and December 2019 among patients presenting to the department for CT neck and upper cervical spine in the course of evaluation for diseases including thyroid and parathyroid diseases, diseases of the cervical spine, oropharyngeal diseases, nasopharyngeal and laryngeal diseases.

Results: The present study included a total of 120 patients. The overall prevalence of C1 ponticulus posticus was 5.8%; 3.3% presented with unilateral, and 2.5% with bilateral C1 ponticulus posticus; in the right and left sides, 95.8% had no C1 ponticulus posticus, 3.3% had complete and 0.9% had partial C1 ponticulus posticus. Of the 120 cases enrolled in the present study, 84 cases (70.0%) were less than 60 years of age; and 66.7% (80 cases) were males. Of the 7 cases with ponticulus posticus, majority (6 cases, 85.7%) were more than or equal to 60 years of age; whereas, of the 113 cases without ponticulus posticus, 26.5% were more than or equal to 60 years of age. This difference was found to be statistically significant ($p<0.05$). However, no statistically significant association was found between gender and the presence of C1 ponticulus posticus.

Conclusion: Awareness of the prevalence and demographic distribution of C1 ponticulus posticus can help guide preoperative planning and intraoperative decision-making, potentially reducing the risk of iatrogenic injuries and improving surgical outcomes.

Keywords: Ponticulus posticus, arcuate foramen, cervical spine, Computed tomography, India.

Introduction

One of the structural variations observed in the atlas is known as ponticulus posticus (PP), characterized by the presence of a bony bridge within the posterior arch.[1] This bridge forms a pathway for the vertebral artery and the C1 nerve root.[2] Although various terms such as pons posticus, arcuate foramen, and Kimmerle anomaly have been used to describe this anatomical variant, "ponticulus posticus" is presently the most commonly accepted term.[3] The anomaly can manifest as complete or incomplete (partial) and may occur unilaterally or bilaterally. Miki et al.[4] classified it into three morphological types: full type (a complete bony ring), incomplete type (with some portions missing from the bony ring), and calcified type. In order to establish a clearer correlation between morphological features and clinical manifestations, Nedelcu et al.[5] proposed a new classification based on anatomical and radiological criteria, comprising five types: type I (unilateral incomplete), type II (bilateral incomplete), type III (unilateral complete), type IV (mixed type, involving unilateral complete bridge with contralateral incomplete bridge), and type V (bilateral complete). This classification contrasts with Stubbs' 1992 proposal.[6]In terms of symptomatology, early research by Chitroda et al.[7] Identified migraines and chronic headaches as predominant manifestations of ponticulus posticus. Other clinical presentations include

vertigo, diplopia, shoulder, or neck pains, attributed to compression of the vertebral artery as it traverses from the foramen transversum of the atlas to the foramen magnum of the skull. Tambawala et al.[8] Noted that certain symptoms contribute to the onset of cervicogenic headache, which originates from the neck but radiates to the head. These symptoms, often mistaken for migraine or tension headache, are specifically associated with cervicogenic headache: reduced neck motion, one-sided facial pain or eye discomfort, light and noise sensitivity, nausea, and blurred vision. This type of headache is highly indicative of ponticulus posticus, resulting from structural damage in the neck region, particularly at the upper spine level.[9, 10]

Diagnostic methods include lateral radiographs, computed tomography (CT), and possibly Cone Beam Computed Tomography (CBCT) due to its reduced radiation exposure and shorter scanning time.[11] Awareness of this anatomical anomaly is crucial during preoperative assessment of CT images to prevent vertebral artery injury when inserting a first cervical vertebra (C1) lateral mass screw for cervical spine stabilization.[12] Notably, the complete form of ponticulus posticus can be mistakenly identified as a thickened posterior arch, potentially leading to artery damage during instrumentation.[13]

The overall incidence of ponticulus posticus is reported at 16.7%. Literature indicates a higher prevalence in females compared to males, with occurrence also influenced by age.[14, 15] However, comprehensive studies on the prevalence and morphological characteristics of PP from southern India are limited. Against this background, the objective of this prospective radiological computerised tomographic study was to determine the prevalence and demographic distribution of C1 ponticulus posticus (arcuate foramen).

Materials and Methods

This was a hospital based prospective observational study conducted in the Department of Radiology and Department of Neurosurgery, Government Stanley Medical College, Chennai for a duration of eight months, between April 2019 and December 2019. The study was approved by the Institutional Human Ethics Committee (IHEC). The present study included patients presenting to the Department of Radiology for CT neck and upper cervical spine in the course of evaluation for diseases including thyroid and parathyroid diseases, diseases of the cervical spine (cervical spondylosis, subaxial cervical spine fractures, cervical disc disease), oropharyngeal diseases (carcinoma oral cavity, carcinoma tongue, submandibular abscess, neck masses), nasopharyngeal diseases and laryngeal diseases. Importantly, patients were included after obtaining informed written consent to participate in the study. However, patients less than 20 years of age, patients with fractures, tumours and infections of upper cervical spine, patients with prior upper cervical spine surgery, with congenital anomaly at craniovertebral junction, metallic and movement artifacts were excluded.

The present study enrolled a total of 120 participants using nonprobability sampling – convenience sampling technique in accordance with prespecified inclusion and exclusion criteria. This radiological study employs the conventional CT scans of cervical spine reformatted to 1mm thickness and 1mm slice interval in axial and sagittal views. The sagittal image was along the plane perpendicular to the coronal plane of the body and the slice that was 3.5mm lateral to lateral border of spinal canal was selected. The presence of arcuate foramen was identified in sagittal image of C1.

The data obtained was manually entered into Microsoft Excel, coded, recoded, and analysed using Statistical Package for Social Sciences (SPSS) v23. All the categorical variables were summarised using frequencies and percentages. Continuous variables were summarized using mean (standard deviation) and/or median (interquartile range). To test for statistical significance, Chi square test or Fisher exact test (for categorical variables) was used. Statistical significance was considered at p value less than 0.05.

Results

The present study included a total of 120 patients presenting to the Department of Radiology for CT neck and upper cervical spine. The overall prevalence of C1 ponticulus posticus (arcuate foramen) was 5.8%. Four cases (3.3%) presented with unilateral, and three cases (2.5%) presented with bilateral C1 ponticulus posticus (arcuate foramen). In the right side, 95.8% cases had no C1 ponticulus posticus, whereas 3.3% cases had complete C1 ponticulus posticus, and 0.9% had partial C1 ponticulus posticus. Similarly, in the left side, 95.8% had no C1 ponticulus posticus, 3.3% had complete and 0.9% had partial C1 ponticulus posticus. Of the 120 cases enrolled in the present study, more than two thirds (84 cases, 70.0%) were less than 60 years of age; and 66.7% (80 cases) were males. Of the 7 cases with ponticulus posticus, majority (6 cases, 85.7%) were more than or equal to 60 years of age; whereas, of the 113 cases without ponticulus posticus, 26.5% were more than or equal to 60 years of age. This difference was found to be statistically significant ($p<0.05$). Of the 7 cases with ponticulus posticus, majority (6 cases, 85.7%) were males; whereas, of the 113 cases without ponticulus posticus, 65.5%

were males. This difference was not found to be statistically significant (p>0.05).

Figure 1: Arcuate foramen of atlas

Table 1: Prevalence of ponticulus posticus (arcuate foramen)

Prevalence of ponticulus posticus (arcuate foramen)		Number (n) N = 120	Percent (%)
C1, Overall	Absent	113	94.2
	Present	7	5.8
C1, Right	Absent	115	95.8
	Present – completely	4	3.3
	Present – partially	1	0.9
C1, Right	Absent	115	95.8
	Present – completely	4	3.3
	Present – partially	1	0.9
Laterality	Unilateral	4	3.3
	Bilateral	3	2.5

Table 2: Demographic distribution of ponticulus posticus (arcuate foramen)

		Ponticulus posticus (arcuate foramen)		Total N = 120	P value
		Present (N = 7)	Absent (N = 113)		
Age (in years)	Less than 60	1 (14.3)	83 (73.5)	84 (70.0)	0.003*
	>60	6 (85.7)	30 (26.5)	36 (30.0)	
Gender	Female	1 (14.3)	39 (34.5)	40 (33.3)	0.420
	Male	6 (85.7)	74 (65.5)	80 (66.7)	
*Statistically significant at p<0.05					

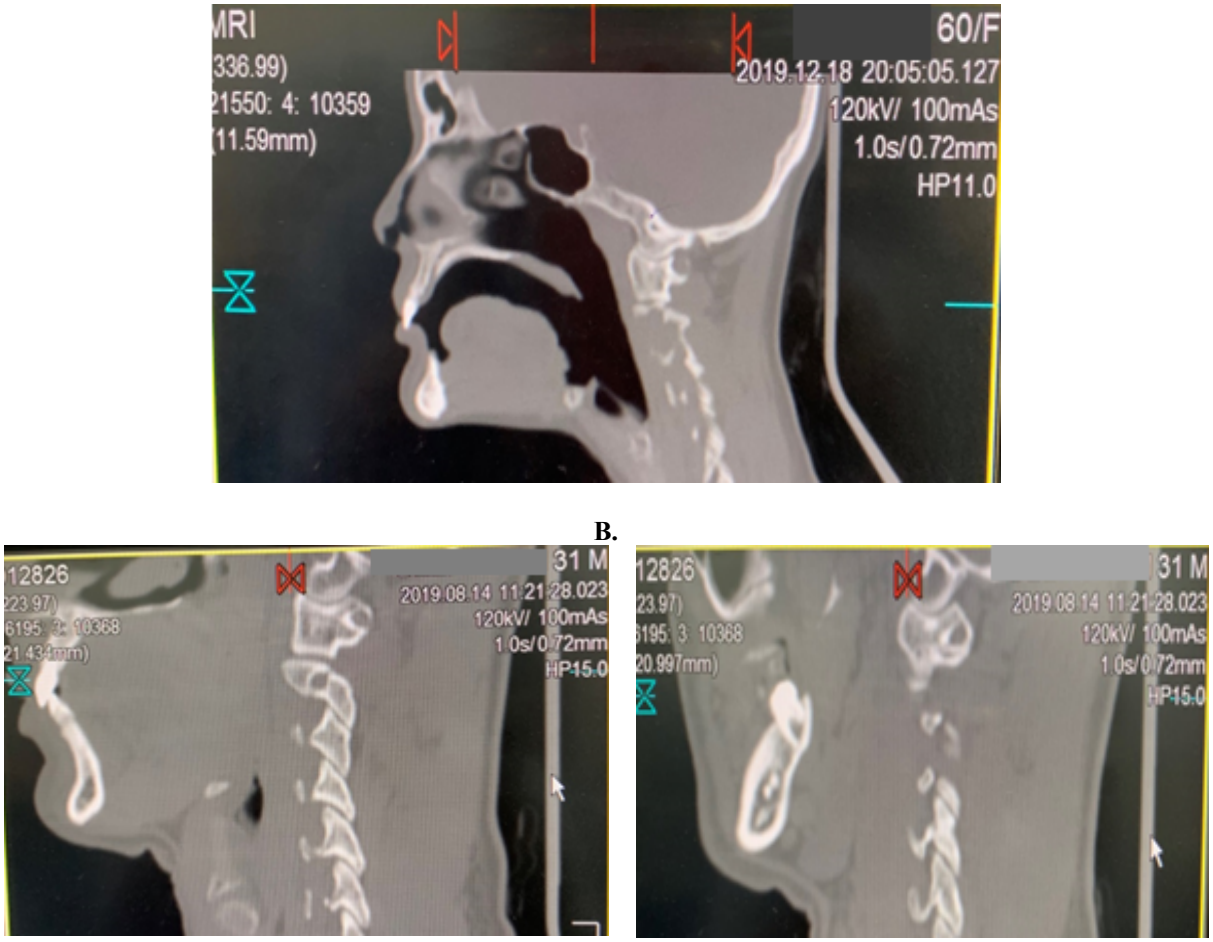

Figure 2: A, Partial arcuate foramen; B, Bilateral arcuate foramen

Discussion

The findings of the study on the prevalence and demographic distribution of C1 ponticulus posticus (arcuate foramen) provide valuable insights into the occurrence of this anatomical variant among patients undergoing CT evaluation of the neck and upper cervical spine. The study revealed an overall prevalence of 5.8% for C1 ponticulus posticus among the 120 patients included in the analysis. This prevalence aligns with previous studies, which have reported a wide range of prevalence rates depending on the population studied and the imaging modality used.[16] Elliot et al.[16] Studied the prevalence of ponticulus posticus and its importance in Goel-Harms procedure by using CT scan, plain radiograph, and cadaver.

The results showed the total prevalence to be 16.7%. Cadaveric studies showed 18.8%, CT scans revealed 17.2% and other radiographic studies showed 16.6% prevalence. Complete foramen was seen in 9.3% and partial foramen was seen in 8.7%.There is no significant sex difference. Arcuate foramen was present bilaterally in 5.4% and unilaterally in 7.6%. The study concluded that the presence of arcuate foramen gives the false sense that the posterior arch of atlas is of adequate size which may lead to inadvertent vertebral artery injury.[16]

The presence of C1 ponticulus posticus can have clinical implications, including potential complications during surgical procedures involving the atlanto-occipital region, such as transarticular screw fixation or posterior atlantoaxial fusion.[17] Elgafy et al.[18] Studied the association of ipsilateral arcuate foramen and high riding vertebral artery and its implication on C1C2 instrumentation by using CT scan.

High riding vertebral artery was considered, if isthmus thickness of C2 is less than 5mm or internal height of lateral mass is less than 2mm. The results showed that 14% had complete arcuate foramen; of that, six were left sided, three were right sided, and five were bilateral. The distribution of partial arcuate foramen was 24%. Importantly, 32% patients had high riding vertebral artery, 13 were left sided, 9 were right sided and 10 were bilateral. Association of high riding vertebral artery and arcuate foramen was seen in 5% of patients.[18] In the present study, the association of arcuate foramen and high riding vertebral artery was seen in 1.7% (two patients).

Association of arcuate foramen and narrow pedicle width was seen in 2.5% (three patients). One patient (0.8%) had association of arcuate foramen with both narrow pedicle width and high riding vertebral artery. The present study identified a significant association between age and the presence of C1 ponticulus posticus, with the majority of cases (85.7%) occurring in patients aged 60 years or older.

This finding is consistent with previous research indicating an increased prevalence of C1 ponticulus posticus with advancing age. [4,19] However, no statistically significant association was found between gender and the presence of C1 ponticulus posticus, although there was a higher proportion of males among cases with this variant. Understanding the prevalence and demographic distribution of C1 ponticulus posticus is crucial for clinicians, particularly those involved in procedures or surgeries in the upper cervical spine region.

Awareness of this anatomical variant can help prevent potential iatrogenic injuries and improve surgical outcomes by guiding preoperative planning and intraoperative decision-making.[20] It's essential to acknowledge the limitations of our study, including its single-center, hospital-based design, and relatively small sample size.

Further research with larger and more diverse patient populations is warranted to validate our findings and provide additional insights into the clinical significance of C1 ponticulus posticus.

Conclusion

The present study documents the prevalence and demographic distribution of C1 ponticulus posticus (arcuate foramen) among patients undergoing CT evaluation of the neck and upper cervical spine. With an overall prevalence of 5.8%, we observed both unilateral and bilateral presentations of this anatomical variant. Importantly, our findings revealed a significant association between age and the presence of C1 ponticulus posticus, with the majority of cases occurring in patients aged 60 years or older. While no statistically significant association was found between gender and the presence of C1 ponticulus posticus, our study underscores the clinical relevance of this anatomical variant, particularly in the context of surgical interventions involving the upper cervical spine. Awareness of the prevalence and demographic distribution of C1 ponticulus posticus can help guide preoperative planning and intraoperative decision-making, potentially reducing the risk of iatrogenic injuries and improving surgical outcomes. Overall, our study contributes to the existing body of literature on this topic and highlights the importance of considering anatomical variants like C1 ponticulus posticus in clinical practice, particularly in the management of conditions affecting the upper cervical spine.

References

1. Wysocki J, Bubrowski M, Reymond J, Kwiatkowski J. Anatomical variants of the cervical vertebrae and the first thoracic vertebra in man. Folia Morphol (Warsz). 2003; 62(4):357-63.
2. Buyuk SK, Sekerci AE, Benkli YA, Ekizer A. A survey of ponticulus posticus: Radiological analysis of atlas in an orthodontic population based on cone-beam computed tomography. Nigerian Journal of Clinical Practice. 2017; 20(1).
3. Huang DG, Hao DJ, Fang XY, Zhang XL, He BR, Liu TJ. Ponticulus posticus. Spine J. 2015; 15(11):e17-9.
4. Kim KH, Park KW, Manh TH, Yeom JS, Chang BS, Lee CK. Prevalence and Morphologic Features of Ponticulus Posticus in Koreans: Analysis of 312 Radiographs and 225 Three-dimensional CT Scans. Asian Spine J. 2007; 1(1):27-31.
5. Nedelcu A, Tepordei R, and Augustin I, Partene Vicoleanu S, Mitrea M, Taranu T, et al. Uncommon Osseous Bridge of the atlas identified on cervical spine radiography: Ponticulus Posticus—Case series. Rom J Funct Clin Macro Microsc Anat Anthropol. 2016; 15:387-92.
6. Stubbs DM. The arcuate foramen. Variability in distribution related to race and sex. Spine (Phila Pa 1976). 1992; 17(12):1502-4.
7. Chitroda PK, Katti G, Baba IA, Najmudin M, Ghali SR, Kalmath B, et al. Ponticulus posticus on the posterior arch of atlas, prevalence analysis in symptomatic and asymptomatic patients of gulbarga population. J Clin Diagn Res. 2013; 7(12):3044-7.
8. Tambawala SS, Karjodkar FR, Sansare K, Motghare D, Mishra I, Gaikwad S, et al. Prevalence of Ponticulus Posticus on Lateral Cephalometric Radiographs, its Association with Cervicogenic Headache and a Review of Literature. World Neurosurg. 2017; 103:566-75.
9. Nedelcu AH, Hutanu A, Nedelcu I, Partene Vicoleanu S, Statescu G, Gavril L, et al. The Prevalence and Morphology-Wise Demographic Distribution of Ponticulus Posticus on CT Scans—A Retrospective Observational Study. Medicina [Internet]. 2023; 59(4).
10. Tambawala S, Karjodkar F, Sansare K, Motghare D, Mishra I, Gaikwad S, et al. Prevalence of Ponticulus Posticus on Lateral Cephalometric Radiographs, its Association with Cervicogenic Headache and a Review of Literature. World Neurosurgery. 2017; 103.

11. Geist JR, Geist SM, Lin LM. A cone beam CT investigation of ponticulus posticus and lateralis in children and adolescents. Dentomaxillofac Radiol. 2014; 43(5):20130451.
12. Olszewski R, Issa J, Odri GA. A New Classification of the Morphology of Complete Ponticulus Posticus on Cone Beam Computed Tomography. Diagnostics (Basel). 2023; 13(18).
13. Arslan D, Ozer MA, Govsa F, Kıtıs O. The Ponticulus Posticus as Risk Factor for Screw Insertion into the First Cervical Lateral Mass. World Neurosurg. 2018; 113:e579-e85.
14. Kuhta P, Hart J, Greene-Orndorff L, McDowell-Reizer B, Rush P. The prevalence of posticus ponticus: retrospective analysis of radiographs from a chiropractic health center. J Chiropr Med. 2010; 9(4):162-5.
15. Lo Giudice A, Caccianiga G, Crimi S, Cavallini C, Leonardi R. Frequency and type of ponticulus posticus in a longitudinal sample of nonorthodontically treated patients: relationship with gender, age, skeletal maturity, and skeletal malocclusion. Oral Surg Oral Med Oral Pathol Oral Radiol. 2018; 126(3):291-7.
16. Elliott R, Tanweer O. The Prevalence of the Ponticulus Posticus (Arcuate Foramen) and Its Importance in the Goel-Harms Procedure: Meta-Analysis and Review of the Literature. World neurosurgery. 2013; 82.
17. Goel A, Pareikh S, Sharma P. Atlantoaxial joint distraction for treatment of basilar invagination secondary to rheumatoid arthritis. Neurol India. 2005; 53(2):238-40.
18. Elgafy H, Pompo F, Vela R, Elsamaloty HM. Ipsilateral arcuate foramen and high-riding vertebral artery: implication on C1-C2 instrumentation. Spine J. 2014; 14(7):1351-5.
19. Xu X, Zhu Y, Ding X, Yin M, Mo W, Ma J. Research Progress of Ponticulus Posticus: A Narrative Literature Review. Frontiers in Surgery. 2022; 9.
20. Donald PM, Nagraj SK, Pallivathukkal RG, Ismail ARB. Ponticulus posticus of atlas vertebrae: an incidental finding in Malaysian orthodontic patients. BMJ Case Rep. 2017; 2017.