

## Posticulus ponticus and its accent at forensics

V. Shakuntala Soujanya<sup>1,\*</sup>, T. Harsha Vardhan<sup>2</sup>, Aravind Kumbakonam<sup>3</sup>

<sup>1</sup>Assistant Professor, <sup>2</sup>Professor & HOD, Meghna Institute of Dental Sciences, Nizamabad, Telangana, <sup>3</sup>Reader, Dept. of Oral Medicine & Radiology, Malla Reddy Institute of Dental Sciences, Hyderabad, Telangana

**\*Corresponding Author:**

Email: shakuntalasoujanya@gmail.com

### Abstract

**Aim:** The aim of the article is to enlighten the role of posticulus ponticus in forensics for determination of age, sex, race and occupation of an individual, based on radiographs.

**Materials and Method:** A systematic search for the pub med indexed articles till March 2017 was carried out, where 30 published articles and the abstracts were reviewed regarding the prevalence of posticulus ponticus, its anatomical variation in age, sex, racial and occupational discrimination.

**Results:** The incidence of posticulus ponticus has been reported by various studies to be in the range of 9.8 to 25.9% with a male predominance of 5.33% when compared to female prevalence of 3.76%. The average age corresponds to 19.5yrs in patients with a partial bony bridge and 22.8yrs in case with complete formation of the bony bridge. The incidence of partial type (25.9%) was higher when compared to complete type (7.2%). Apart from the age and sex discrimination, posticulus ponticus was found to be showing racial discrimination which is predominant in western population of the world with its prevalence ranging from 5.1% to 37.8%. This anomaly was also found to be showing variation in its prevalence according to occupation.

**Conclusion:** Posticulus ponticus can be used as a potent deterministic anomaly in age, sex, racial and occupational determination; however a huge radiographic studies and review of literature is needed to implement this practically.

**Keywords:** Posticulus ponticus, Atlas vertebrae, Routine radiographic examination, Age, Sex, Racial, Occupational discrimination

### Introduction

In recent years, posticulus ponticus has gained its significance in forensic radiology apart from its role in vertebral basal artery insufficiency and lateral screw fixation in treating atlanto-axial instability, as it is well appreciated in certain lateral skull radiographs, lateral cephalograms and CT scans during routine dental examinations, as an anatomic variation of the atlas vertebrae.<sup>(1)</sup> It is a regressive morphologic alteration seen as an ossified structure forming frequently an incomplete or rarely a complete bridge between the posterior margin of the posterior tubercle of the atlas and superior articular facet showing certain age, sex, racial and occupational discriminating variations morphologically.

The posticulus ponticus has become an important anomaly due to the complications resulting from the damage caused to vertebral artery during lateral mass screw fixation in the treatment of atlanto-axial instability and its side effects due to the pressure on vertebral artery and 1<sup>st</sup> sub occipital nerve passing to arcuate foramen and they may vary from headache, vertigo, diplopia, musculoskeletal problems, cervical pain, shoulder pain due to vertebrobasilar insufficiency. Several authors have also mentioned that this anomaly is formed by ossification of lateral segment of posterior atlanto-occipital membrane intimately attached to atlanto-occipital membrane thus causing migraine type of headache.<sup>(13)</sup>

This anomaly has been known by various names such as sagitale foramen and atlantal posterior foramen

by Loth-Niemiryez (1916); Arcuate foramen or Kimmerle's anomaly by Kimmerle (1930), Upper retroarticular foramen by Brocher (1955), Canalis Vertebralis by Wolff-Heidegger (1961), Retroarticular vertebral artery ring by Lamberty and Zivanovic (1973), Arcuate foramen by Stubbs (1992), Retroarticular canal by Mitchell in (1998) and retrocondylar vertebral artery by Mitchell (1998) and the most accepted Ponticulus posticus by Young et al.in 2005 and Cho in 2009.<sup>(2)</sup> The posticulus ponticus is a bony bridge arising from the posterior portion of the superior articular process of atlas and postero-lateral portion of the superior margin of the posterior arch of the atlas that completely or partially encircles the vertebral artery.<sup>(3,4)</sup> It lies in the same plane as the posterior atlanto-occipital ligament and is often bilateral<sup>(5)</sup> (Fig. 1, 2 and 3).

The vertebral artery and the first cervical nerve passes through the groove of the vertebral artery which is located behind the lateral mass of the atlas.<sup>(4,6)</sup> The vertebral artery travels above the posterior arch of atlas, lateral to the C1 lateral mass and it bends approximately at 90° in the posterior direction after exiting the transverse process foramen of C1 and turns medially to engage with the groove on the superior surface of the posterior arch of atlas where it turns around the superior facet and blends anteriorly to enter the spinal canal. This groove can be converted into a foramen by anomalous ossifications known as ponticulus posticus.<sup>(4-11)</sup> However, this anomaly is known to be having variation in its form with the age,

sex, race and occupation, thus the aim of this article is to enlighten the role of posterior ponticulus in age, sex, race and occupational determination.

### Materials and Method

**Search strategy:** All the pubmed indexed articles till March 2017 were searched, among them around 30 articles were selected and reviewed systematically for the literature regarding the radiographic prevalence of posticulus ponticus, their morphological variations, types and its occurrence in different age groups, sex, races and occupations and for the articles for which full article is not accessed at least abstracts were reviewed.

**Selection of reviews:** Review articles were included in the analysis if they met any of the four following inclusion criteria and remaining were excluded:

- Showing discrimination among various age groups
- Showing discrimination between the sex i.e. males and females
- Showing discrimination among the various races
- Showing discrimination based on occupation i.e. labourers and non-labourers.

Finally, a standard protocol was designed and followed for all the review steps using widely recommended methods and reported according to PRISMA guidelines.

### Results of the systematic review showing age, sex, racial and occupational discrimination of posticulus ponticus

Author	Material	Age	Types		Sex		Race
			Complete	Partial	Males	Females	
Kimm et al.,	225, 3D CT scan images	Average age 28 yrs			5.3%	37.6%	Koreans
Takaaki	Radiographs		4.89%	2.93%	12.5%	5.1%	Japanese (9.1%)
Kedrick and biggs	353 lateral cephalograms	6.17yrs			14.6%	16.95%	Caucasian
Mitchell et al.,	1354 atlas vertebrae	Adults 20-80 yrs			Lower	Higher	Blacks> Whites
Simsek and Yigitkanli	158 atlas vertebrae						Turkish
Cakmak O et al.,	60 dry vertebrae						Turkish (3.6 -25%)
Cakmak O et al.,	416 lateral cervical spine radiographs		7.2%	6.25%	4.55%	8.45%	Turkish
Parakevas et al.,	176 dry vertebrae (Labourer)	Partial (5-44yrs), Complete (45-70yrs)			11.11%	9.3%	Europe
Schilling and Suazo	436 digital teleradiographs	Common age group of 11-20 yrs >21-30yrs	9.2%	10.1%			
Lamberg and Zivanoic	60 atlas vertebrae						Europe (36.66%)
Taitz and nehan	672 atlas vertebrae		7.9%	25.9%			
V. Sharma et a.,	858 lateral cephalograms				5.33%	3.76%	Western India (5.1% - 37.8%)

### Results

A Meta analysis of all the data collected from reviewed articles was done and the results were interpreted (Table 1) where partial type (25.9%) of posticulus ponticus was highly prevalent than complete type (7.2%). In the age discrimination it was common in age group of 11- 20yrs followed by 21-30yrs and 30-80yrs respectively. It was also reviewed that partial type was more common in younger age group (5.5%) than complete type as seen in older age group (4.6%) and there was a decreased prevalence of partial type as the age increases.

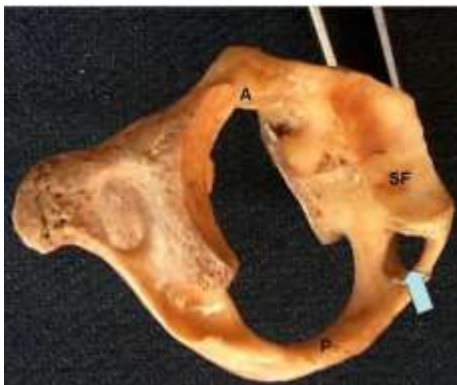
Now coming to its role in sex determination, a female predominance of 3.76% to 16.9% was found than males (4.55% to 14.6%) with partial type commonly seen in females (25.9%) and complete type (8.33%) seen in males.

Similarly, a racial predominance in Europeans (36.66%) was found compared to Asians, Caucasians and Africans (9.8-25.9%) and among the Asians it was predominant in Japanese (9.1%) population followed by Koreans and Turkes (3.6% - 25%). Among the Indians it was predominant in Western Indians (5.1% - 37.8%) than South Indians (9.8 - 25.9%) and North Indians.

Hasan et al.,	350 dried vertebrae		3.8%	5.6			North India
A.Krishnamurthy et al.,	1044 atlas vertebrae		8.33%	5.5%	Commonly seen		South India (9.8 – 25.9%)



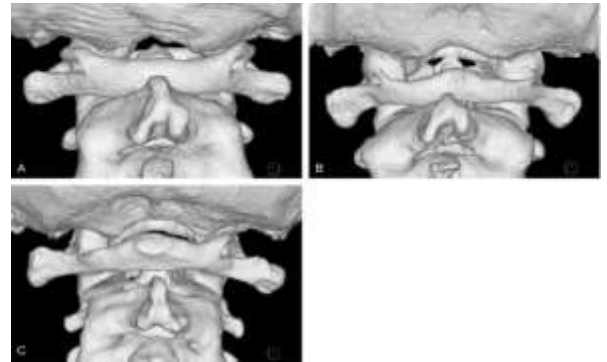
**Fig. 1:** Left supero-lateral view of the atlas vertebra showing the presence of complete arcuate foramen. On the right side: A – Anterior arch, P – Posterior arch, SF – Superior articulating facet, Block arrow – Right sided complete arcuate foramen



**Fig. 2:** Right supero-lateral view of the atlas vertebra showing the presence of complete arcuate foramen on the left side: SF – Superior articulating facet, Block arrow – Left sided complete arcuate foramen



**Fig. 3:** Bilateral ponticuli lateralis seen on the three-dimensional CT scan



**Fig. 4:** Various types of ponticuli posticus seen on three-dimensional CT images. (A) Bilateral complete. (B) Complete on the left side and partial on the right side. (C) Unilateral



**Fig. 5:** In the left image observed a complete bony bridge while the right image shown a partial ossification

**Discussion**

The incidence of posticulus ponticus has been reported by various studies to be in the range of 9.8 to 25.9%.<sup>(12)</sup> The posticulus ponticus has been classified radiographically by Miki et al. into 3 types:

1. Full type: it forms a complete bony ring,
2. Incomplete type: some portion of the bony ring is defective and
3. Calcified type: there is a linear or amorphous calcification<sup>(2)</sup> (Fig. 4, 5).

A male predominance has been found out in the occurrence of posticulus ponticus,<sup>(13)</sup> as in a study by V. Sharma et al. in the analysis of 858 lateral cephalograms which revealed posticulus ponticus in 37 patients with a prevalence rate of 9.09%, with male predominance of 5.33% when compared to female prevalence of 3.76%.<sup>(13)</sup> The average age corresponds to 19.5yrs in patients with a partial bony bridge and 22.8yrs in case with complete formation of the bony bridge.<sup>(2)</sup> The incidence of partial type is higher when compared to complete type<sup>(2,9,14)</sup> and Parakevus. G

found in his study the higher incidence of incomplete canal for vertebral artery in the age group 5-44yrs and complete in 45-75yrs age group.<sup>(12)</sup>

Apart from the age and sex discrimination, posticulus ponticus was found to be showing racial discrimination which was predominant in western population of the world with its prevalence ranging from 5.1% to 37.8%.<sup>(13,14)</sup> The study on lateral cephalograms of Caucasian orthodontic patients by Kedrick and Biggs found posticulus ponticus at prevalence of 15.8%.<sup>(7,13,15)</sup> The Caucasian racial group includes people of Europe, North Africa, Horn of Africa, Western Asia, Central Asia, and South Asia of world's population. The study by Schilling and Suazo on asymptomatic European population and Lamberg and Ziranovic on 60 atlas vertebrae of European individuals shows the higher prevalence (15% complete, 21.66% partial type) of posticulus ponticus in Europe.<sup>(2,4,16)</sup> Similarly higher incidence was found in South Africans according to Mitchell et al. Then another study by V. Sharma et al. on 858 lateral cephalograms of western-Indian orthodontic patients revealed posticulus ponticus in 37 patients and similarly the study of Hasen et al. on 350 dried macerated atlas vertebrae in north Indian population has shown its prevalence.<sup>(17)</sup> Then apart from these races, the studies by Kim et al. in Korean population, Takaki et al. in Japanese population and Simsek and Yigitkali in Turkish population has showed its prevalence in their respective racial groups. Thus from the above studies it is concluded that posticulus ponticus is prevalent in Koreans, Japanese, Caucasians, Turkish and European populations and in western India.<sup>(13,18)</sup>

This anomaly was also found to be showing variation in its prevalence according to occupation by Parakevus. G in his study with its higher incidence in laborers than non-laborers.<sup>(12)</sup>

## Conclusion

Thus, posticulus ponticus due to its uniqueness in its morphology and prevalence, it can be definitely used as a potent tool in forensics radiology, in nearby future for age, sex, racial and occupational discrimination.

## References

1. Buna. M, Coghlan W, deGrunchy M, Williams D, Zmiywsy O. Ponticles of the atlas: a review and clinical perspective. *J Manipulative Physiol Ther* 1984;7:261-6.
2. Juan Schilling; Alejandro Schilling and Ivan Suazo Galdames. Ponticulus posticus in the Posterior Arch of Atlas, Prevalence Analysis in Asymptomatic patients. *Int. J. Morphol.*,28(1):317-322, 2010.
3. SK Buyuk, AE Sekerci, YA Benkli, A Ekizer. A Survey of Posticulus ponticus: Radiological analysis of atlas in orthodontic population based on CBCT. *Niger J Clin Pract* 2017;20:106-10.
4. Lamberty BHG, Zivanovic S. The retro-articular vertebral artery ring of the atlas and its significance. *Acta Anat* 1973;85:113-22.
5. Stuart Wight, Neil Osborne, Alan C. Breen. Incidence of ponticulus posterior of the atlas in migraine and cervicogenic headache. *Journal of manipulative physiological therapeutics.* 22(1):15-20,1999.
6. M. Hasan, S. Shukla, S. Siddiqui et al. Posterolateral tunnels and ponticuli in human atlas vertebrae. *J Anat*, 199 (2001),pp. 339-433.
7. G. Kendrick, N. Biggs. Incidence of the ponticulus posticus of the first cervical vertebrae between ages 6 to 17. *Anat Rec*, 145(1963), pp. 449-451.
8. Mitchell. The incidence and dimensions of the retroarticular canal of the atlas vertebra. *Acta Anat (Basel)*, 163 (1998), pp. 113-120
9. C. Taitz, H. Nathan. Some observations on the posterior and lateral bridge of the atlas. *Acta Anat (Basel)*, 127 (1986), pp. 212-217.
10. J. Pyo, R.M. Lowman. The "ponticulus posticus" of the first cervical vertebrae. *Radiology*, 72(1959), pp. 850-854.
11. T. Romanus, A. Tovi. A variation of the atlas. *Acta Radiol Diagn*, 2(1964), pp. 289-297.
12. A. Krishnamurthy, S.R. Nayak, S. Khan, Latha V. Prabhu, Lakshmi A. Ramanathan, C. Ganesh Kumar, ABHISHEK PRASAD Sinha. Arcuate foramen of atlas: incidence, phylogenetic and clinical significance. *Romanian Journal of Morphology and Embryology* 2007, 48(3):263-266.
13. V Sharma, D Chaudhary and R Mitra. Prevalence of ponticulus posticus in Indian orthodontic patients. *Dentomaxillofacial Radiology* (2010) 39, 277-283.
14. Kyeong Hwan Kim, Kun Woo Park, Tran Hoang Manh, Jin Sup Yeom, Bong-Soon Chang, Choon-Ki Lee. Prevalence and Morphologic Features of Ponticulus Posticus in Koreans: Analysis of 312 Radiographs and 225 Three-dimensional CT scans. *Asian spine Journal* Vol. 1. No. 1, pp 27-31, 2007.
15. Posticulus ponticus on the posterior arch of atlas, Prevalence analysis in symptomatic patients of Gulbarga population. *Journal of Clinical and Diagnostic research* 2013 Dec; 7(12): 3044-3047.
16. Malukar Ojaswini, Prajapati P. Vipul, Nagar S.K. Ponticulus posticus of the atlas vertebra. *National Journal of Medical Research.* 2011;1(2):51-53.
17. Patel Zarna, Zalawadia Ankur, Pensi CA. Study of Arcuate Foramen In Atlas Vertebrae In Gujarat Region. *NJIRM.* 2012;3(2):73-75.
18. Frequency of posticulus ponticus in lateral cephalometric radiographs of Prussian patients. *Int J Morphol* 32(1):54;60, 2014.