

Posterior and lateral ponticles of atlas: An osteological study at Fatima Jinnah Medical University, Lahore

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ABSTRACT

Background: Among the cervical vertebrae, atlas is known to have many variations, posterior ponticle being the commonest. It may completely or incompletely covers the groove of vertebral artery leading to ischemia of posterior circulation. Therefore, vertebral artery is at greater risk of injury during neurological and spinal surgeries. Prevalence of posterior ponticles varies widely among different populations, for instance in Turkish population it was 10.8%, in American 22.1%, Kenyan 14.7%, Brazilian and Indian 16.7%. The prevalence of lateral ponticle in Kenyan population was reported to be 3.9% and in Indians it was 2%. However, the data regarding the prevalence of these ponticles is largely lacking in Pakistan. Therefore, this research was designed to determine the prevalence of posterior and lateral ponticle in atlas vertebrae of Pakistani population.

Materials and methods: A total of 47 human atlas vertebrae of unknown age and gender from bone bank of Department of Anatomy Fatima Jinnah Medical University, Lahore were studied for the presence of complete and incomplete posterior and lateral ponticles. The bones studied were completely intact and did not have any pathology.

Results: Total incidence of ponticles was 38 % in this study, of which 36% were posterior ponticles and 2% were lateral ponticles. Bilateral incomplete posterior ponticles/were found in 8 (17%) atlas vertebrae whereas bilateral complete posterior ponticles/foramen arcuale were found in only 1 (2%) atlas vertebrae. Unilateral incomplete posterior ponticle was identified on right side in 5 (11%) and left side in 2 (4%) atlas vertebrae. Unilateral complete posterior ponticle was found in only 1 (2%) atlas on the left side whereas no such finding was identified on right side in any vertebra. Unilateral complete lateral ponticle was found in only 1 (2%) atlas on the right side but not on left side. No bilateral complete lateral ponticle and incomplete unilateral or bilateral lateral ponticles were identified in this study.

Conclusion: Presence of posterior and lateral ponticles pose a risk of vertebrobasilar vascular insufficiency and may cause variety of symptoms. Vertebral artery may be at risk during neurosurgical procedures when having a foramen arculae and may give a false impression of much wider posterior arch of atlas. Knowing the prevalence of this can help neurosurgeons, general surgeons, radiologists, and chiropractors in management of the patients.

Keywords:

Atlas; Foramen arcuale/posterior ponticle; Vertebral artery

INTRODUCTION

Variations are common in cervical spine, especially the atlas vertebrae which is the first cervical vertebra, it lacks a body, has two lateral masses, bearing concave superior articular facets and circular inferior articular facets, and two transverse processes bearing foramen transversaria. Anterior arch connects both lateral masses, and bears a facet for articulation with dens of axis on inner surface. Superior surface of the larger posterior arch has a groove for third part of vertebral artery, its venous and sympathetic plexus and first cervical nerve. Normally, the vertebral artery exits

foramen transversarium side, passes posteromedially, grooves the posterior arch of atlas and enters the foramen magnum, below the lower border of posterior atlanto-occipital membrane.¹

Bony spurs called ponticle, may arise from ventral or dorsal margins of the groove for vertebral artery converting it to a complete or incomplete foramen and may compress vertebral artery.² Arcuate/arcuale, posterior atlantoid foramen, foramen sagittale/retroarticular/ atlantoideum, Kimmerle variant/ deformity, posterior glenoid process/speculum, and retrocondylar foramen are synonyms of complete posterior ponticle.^{2,3} Literature shows that several studies have been conducted to assess the presence and morphology of these variants of Atlas vertebrae on cadavers, dried vertebrae, lateral cephalograms, and Computerized Tomography (CT) scans. The

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radiological studies, especially lateral cephalograms (3.4%) report less prevalence of the ponticle than osteological (7.6%) and cadaveric studies (5%) but Cone Beam CT and 3D CT scan studies (6.1%) suggest similar prevalence as osteological studies.⁴⁻⁶ This can be because of the limitation of image superimposition in plain radiographs which is being taken care of by multiple thin slices taken in CT scans.⁵ The data regarding the prevalence of these ponticles is largely lacking in Pakistan. Only one study has been done in 2014 by Maqbool and his associates showing that complete posterior ponticle were present in 8.66% atlas vertebrae, however, authors did not comment on lateral ponticle.⁷ Therefore, this study was designed to ascertain the presence of both complete and incomplete posterior as well as lateral ponticles in Atlas vertebrae at Fatima Jinnah Medical University, Lahore.

MATERIALS AND METHODS

This observational study was carried out from December 2018 to October 2019 in the Department of Anatomy at Fatima Jinnah Medical University, Lahore. Total 47 completely intact atlas vertebrae were taken from the bone bank of Anatomy Department. These were dried bones of unknown age and gender, they were obtained from cadavers and used in anatomy for teaching purpose. Bones were completely intact and did not have any other anatomical variation (fused with axis or occipitalized) /pathology (e.g. osteophytes, pathological fracture, etc.).

These atlas vertebrae were observed on superior surface for having posterior and lateral ponticle on either side of each atlas. Both complete and incomplete posterior and lateral ponticles were observed on either side of each atlas along with them to be unilateral (right/left) or bilateral in this study. Posterior ponticle was defined as an abnormal outgrowth of bone from the posterior/posterolateral aspect of superior articular facet moving towards the superior surface of posterior arch of atlas, posterior to lateral mass. If the bony outgrowth touches the superior surface of posterior arch of atlas and formed a complete ring or canal, it was considered complete posterior ponticle/bridge. If the bony outgrowth did not touch the superior surface of posterior arch of atlas and did not complete a ring, it was considered as incomplete posterior ponticle/bridge.²

A lateral bony growth from the superior articular facet or lateral mass towards transverse process of the atlas was called lateral ponticle. If it completes the ring and touches the posterior root of transverse process, it

was called complete lateral ponticle or supratransverse foramen. Whereas, if it did not touch the posterior root of transverse process of atlas, it was named as incomplete lateral ponticle.⁸

Classification devised by Hasan and his associates was used to evaluate the atlas vertebrae in this study.⁹

Class I - only the impression of vertebral artery on posterior arch of atlas

Class II - the impression is deeper and becomes groove

Class III - partial posterior ponticulus as a bony spicule extending from superior articular facet overhanging the dorsal arch

Class IV- complete posterior ponticulus

Class V- lateral bridge extending from lateral mass to the transverse process

Class VI - relatively more extensive posterolateral tunnel

RESULTS

Out of 47 atlas vertebrae, total 18 (38%) atlas vertebrae were found to have ponticles, of which 17 were posterior ponticle while 1 was lateral ponticle. Prevalence of posterior ponticle in our study was 36% and lateral ponticle was 2%. Bilateral incomplete posterior ponticles (class III) were found in 8 (17%) atlas vertebrae (Figure 1A and B). Bilateral complete posterior ponticle (class IV) was found in only 1 (2%) atlas vertebrae (Figure 1C and D). Only 1 (2%) left sided unilateral complete posterior ponticle was present (Figure 1E), whereas right sided unilateral complete posterior ponticle was not observed. However, right sided unilateral incomplete posterior ponticles were observed in 05 (11%) atlas vertebrae. Two (4%) atlas vertebrae had left sided unilateral incomplete posterior ponticles (Figure 1F and G). No atlas vertebrae were having complete posterior ponticle on one side and incomplete on the other side. Regardless of laterality, the prevalence of complete posterior ponticle is 4.2% whereas incomplete is 31.9%. Unilateral complete lateral ponticle (class V) was found in only 1 (2%) atlas on the right side (Figure 1B and 2). Bilateral complete lateral ponticle or unilateral or bilateral incomplete lateral ponticle were not found in this study.

DISCUSSION

Current study showed that 38% atlas vertebrae were having ponticles, of which posterior ponticles (total 36%, complete 4.2% whereas incomplete is 31.9%) were much more prevalent than lateral ponticles (2%). These findings are consistent with findings of other researchers.^{8,10-12} Incomplete variant is much more

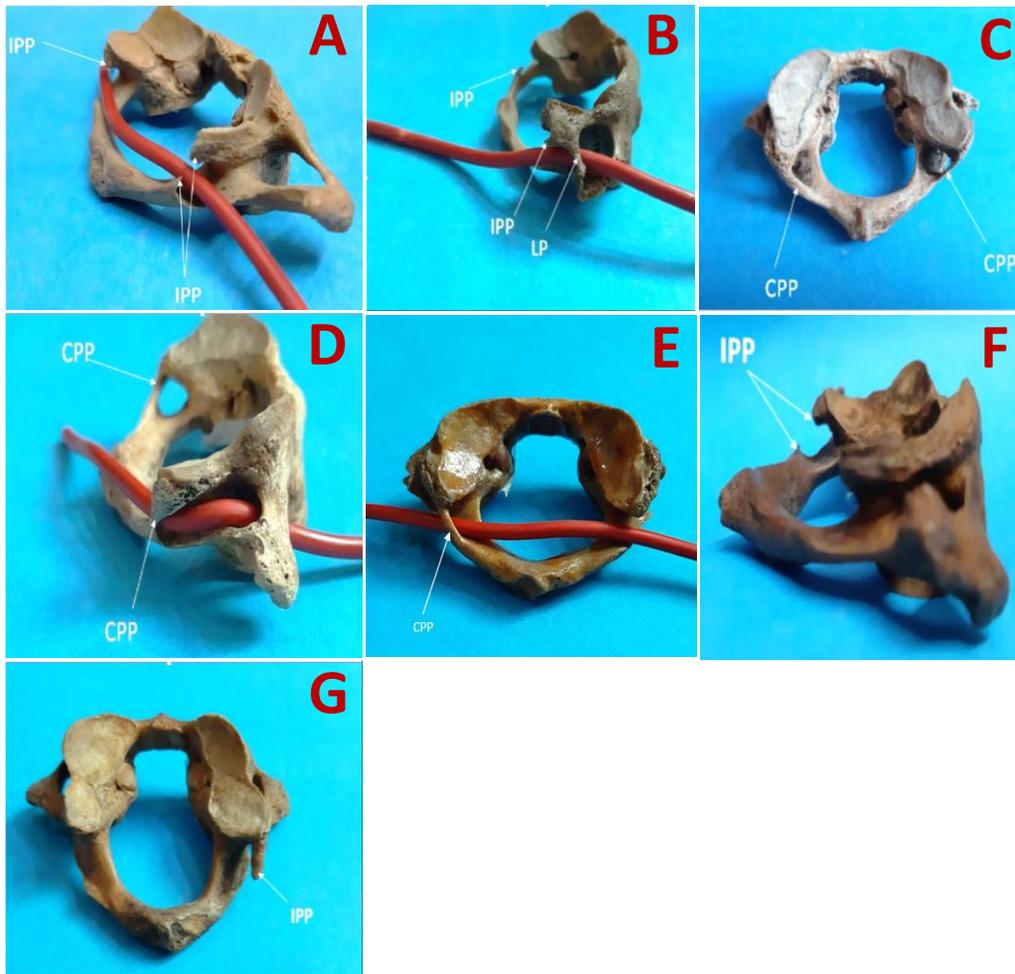


Figure 1. **A)** Atlas vertebrae showing bilateral incomplete posterior ponticle (IPP), the red wire is placed to enhance the contrast and make visibility better. **B)** Atlas vertebrae showing bilateral incomplete posterior ponticle (IPP), and lateral complete ponticle (LP), the red wire is placed to show the course vertebral artery takes emerging from foramen transversarium to pass through supratransverse foramen before entering to foramen magnum. **C)** Atlas vertebrae showing bilateral complete posterior ponticle (CPP). **D)** Atlas vertebrae showing bilateral complete posterior ponticle (CPP), the red wire is placed to show the course vertebral artery takes emerging from foramen transversarium to pass through foramen arcuate before entering to foramen magnum on either side. **E).** Atlas vertebrae showing unilateral complete posterior ponticle (CPP), the red wire is placed to enhance the contrast and make visibility better. **F & G).** Atlas vertebrae showing unilateral incomplete posterior ponticle (IPP).

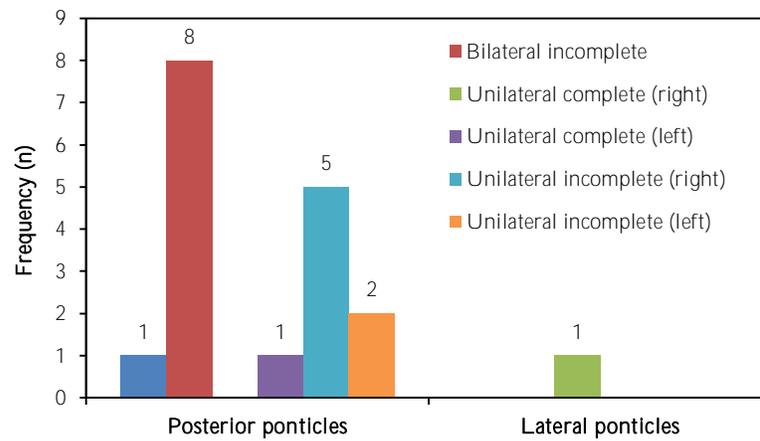


Figure 2. Number of ponticle of different categories.

Table 1. Prevalence of complete and incomplete posterior ponticle in various osteological studies

Researcher	Year	Population	Prevalence of complete posterior ponticle (%)	Prevalence of incomplete posterior ponticle (%)
Wysocki et al ¹³	2003	ORP (Poland)	13.7	17.9
Senoglu et al ¹⁴	2006	Turkish	10.8	4.8
Lee et al ¹⁵	2006	American	22.1	4.83
Bundi et al ¹²	2010	Kenyan	14.7	39.2
De Carvalho et al ¹⁶	2012	Brazilian	16.7	23.3
Lalit et al ¹⁰	2014	Indian	16.7	16.7
Maqbool et al ⁷	2014	Pakistani	8.7	Not reported
Khanfour and El Sekily ¹⁷	2015	Egyptian	8.0	12
Travan et al ⁵	2015	Italian	7.4	Not reported
Present study	2020	Pakistan	4.2	31.9

Table 2. Prevalence of lateral ponticle in various osteological studies

Researcher	Year	Population	Prevalence of lateral ponticle (%)
Hassan et al ⁹	2001	Indian	0.57
Bundi et al ¹²	2010	Kenyan	3.9
Patel et al ²¹	2015	Indian	02
Lalit et al ⁸	2019	Indian	1.25
Present study	2020	Pakistan	02

common than complete posterior ponticle/foramen arcuate either bilaterally or unilaterally in this study. This is supported by other studies as well.^{11,13} However, a few researchers reported higher prevalence of complete posterior ponticle than incomplete ponticles.^{14,15} The difference could be ethnic as the study population of each researcher was different. Table 1 shows the comparison of various osteological studies showing prevalence of posterior ponticle.

Bilateral incomplete posterior ponticle was found to be more common than unilateral incomplete posterior ponticle in this study which was in accordance with the study of Giest and coworkers.⁶ Complete posterior ponticle is more common on left side, consistent with findings of Santhi and coauthors.¹¹ However, incomplete variant is more prevalent on right side in current study contrary to the report of Santhi and colleagues but consistent with findings of Vyas and group.¹⁸ Right vertebral artery has a slight lesser diameter than left and in addition presence of more ponticles on right side warns more risk to right vertebral artery for compression as reported by Bundi and coauthors suggesting right vertebral artery is prone to compression due to these ponticles.¹²

Previous studies reported a decrease in diameter of the part of vertebral artery that has to pass through foramen arcuate being formed by complete posterior ponticle and the artery resumes its diameter as it exits from the foramen.^{2,12} In these cases, excessive cervical spine motion during exercise, physiotherapy or surgery may alter blood flow leading to ischemia of posterior circulation and may also be responsible for tethering and dissection of vertebral artery.²⁶ Vertigo, headaches, migraine, difficulty in swallowing, phonation, diplopia,

craniocervical pain and Barre-Lieou syndrome have been reported associated with complete variety of posterior ponticle when present.^{11,20} Limousin reported that surgical intervention led to clinical improvement in symptomatic patients having foramen arcuate. This also indicates that patients were symptomatic when the bone was pressing the artery and later decompression alleviated the symptoms.²⁰

Unilateral complete lateral ponticle was found in Atlas on the right side in present study. Right predisposition of complete lateral ponticle was also reported by Bundi and coworkers.¹² Bilateral complete lateral ponticle or unilateral or bilateral incomplete lateral ponticles were not found in this study which was consistent with findings of Lalit and associates.¹⁰ Table 2 compares the prevalence of lateral ponticle in various osteological studies.

Ossification of posterior atlantooccipital membrane was held responsible for the formation of these ponticle by some researchers.²² They propose that following accidents and injuries in cervical spinal region there may be formation of hematoma which later calcified and ensued into bony ponticle.²³ Pulsating vertebral artery has been held responsible for induction of ossification of ligaments leading to formation of these ponticle and foramina with age.²⁴ Kendrick and Biggs observed conversion of incomplete ponticle unilaterally to a complete radio opaque ponticle (foramen) in a female in around 2 years.²⁵ Some researchers proposed regression of middle part of complete posterior ponticle and may lead to development of incomplete posterior ponticle.^{4,24} Finding cartilaginous stage of these bony ponticle make others believe their genetic or congenital origin.⁴

According to von Torklus and Gele, ponticle develops from proatlas representing occipital vertebrae.²⁶ Taitz and Nathan related this anatomic variant of Atlas to occupations which involved carrying heavy weight on head and neck region.²⁷ Similarly Paraskevas and colleagues reported higher prevalence of ponticle in laborers.²⁴ These bony ponticle are more prevalent in Quadrupedal mammals, and are present in the form of complete bony ring supporting and maintaining their posture by use of cervical extensors and ligaments but as bipedal evolved superior articular facet took the responsibility of bearing weight of skull, natural selection may be held responsible for decreased prevalence of these ponticle in humans.²⁸ Friedrich found out that half the cases of nevoid basal cell carcinoma syndrome (Gorlin-Goltz syndrome) were having Posterior ponticle on their lateral cervical radiographs and presence of this radiological finding may point to the diagnosis. Many odontologist and dentist also report these ponticles as incidental finding on cephalograms.²⁹

CONCLUSIONS

Posterior ponticle/foramen arcuate of atlas is more commonly observed than lateral ponticle/supra transverse foramen which is much rarer. The structures passing through foramen transversarium need to pass through foramina formed by posterior and lateral ponticle on their way to foramen magnum and may lead to compression of third part of vertebral artery, therefore leading to vertebrobasilar vascular insufficiency causing neurological deficit. Thus, neurosurgeons, orthopaedic and cervical spine surgeons must keep these variants in mind while operating in head and neck region especially lateral mass screwing in atlas because presence of posterior ponticle may give false impression of much wider posterior arch of atlas. Chiropractors and radiologists must also have knowledge of these ponticle for better diagnosis & treatment of their patients and odontologist should report these if found incidentally. One of the limitation of this study was that age, gender, ethnicity and symptomatic correlation were not taken in account of this study as this was an osteological study.

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