International Journal of Anatomy and Applied Physiology (IJAAP)
ISSN: 2572-7451

A Radio-Anatomical Study of Ponticles on Atlas: Clinical point of View

Research Article

Jyothi S.R[1*], Joish Upendra Kumar[2], Vinay S.R[3]

[1] Assistant Professor, Department of Anatomy, India.
[2] Associate Professor, Department of Radiology, India.
[3] Senior ENT Specialist, India.

Abstract

Background: Atlas, an atypical 1st cervical vertebra with anterior and posterior arch supports the globe of the head. The atlas, shows extensive variability in its morphology. Sometimes bony outgrowths known as ponticle (bridge) extend from lateral mass to the posterior arch of atlas or to the posterior root of transverse process, which may be complete or incomplete and, can compress the vertebral artery during its course from foramen transversarium to foramen magnum of skull.
Aims: Observe for different type of ponticles on dry bone, as well as on CT scans of individuals. To aid the clinicians in diagnosing vertebrobasilar insufficiency & surgeons during screw fixation.
Materials & Methods: Cross sectional descriptive study was carried out involving 100 CT scans and 60 dried macerated 1st cervical vertebrae. Individuals found to have fractures, lesions, dislocations of atlas, on CT scan images, were excluded from the study. All dried vertebrae were intact and free from osteophytes.
Sampling method: Convenience non- probability sampling method
Results: Dry bone specimens presented with, complete ponticulus posterior in 5% specimens, and incomplete ring in 30%, complete ponticulus lateralisin 1.6% specimen and incomplete ponticulus lateralis in 3.3% specimens, retrotransverse foramen in 3.3% of specimens. CT scan depicted - Type B variety of posterior ponticle in 6 females & 9 males, Type C in 2 females & 4 males & Type D in 1 male individual. Retrotransverse foramen was seen in 2 male individuals.
Conclusion: The present study is of importance to orthopaedicians, neurosurgeons during spinal surgeries especially during transarticular and transpedicular screw fixation. It also aids otorhinolaryngologist while handling patients with symptoms of vertebrobasilar insufficiency.

Keywords: Atlas Vertebra; Ponticulus Posterior; Ponticulus Lateralis; Retroarticular Canal; Retrotransverse Foramen.

Introduction

The atlas, the first cervical vertebra is named after "ATLAS" who according to Greek mythology supported the Earth on his shoulders.[1] The atlas holds the globe of the head and is unique in that it fails to incorporate a centrum, whose position is occupied by dens of axis. The atlas consists of two lateral masses connected by a short anterior arch and a longer posterior arch. The laminae and pedicles form the posterior arch, which contributes to three-fifths of the circumference of the atlantal ring. The superior surface of posterior arch bears a wide groove for the vertebral artery and venous plexus immediately behind, and, the dorsal ramus of first cervical nerve (suboccipital nerve) intervenes between them. The superior and inferior articular facets lie on the lateral masses, anterior to first and second cervical nerve respectively. The superior articular facets are concave, kidney shaped and is superomedial. They receive the condyles of the occipital bone to form an atlanto-occipital joint which are involved in nodding movements. The inferior is almost circular, slightly concave, and faces downwards and medially. The spine is replaced by posterior tubercle. [2, 3] The superior border of posterior arch gives attachment to the posterior atlanto occipital membrane. The third part of vertebral artery courses from foramen transversarium of the atlas towards the groove on the posterior arch of atlas and then runs upwards into cranial cavity to form basilar artery. The vertebral artery is predisposed to damage by any bony or ligamentous structures during this course. Sometimes a bony outgrowth known as ponticle (bridge) flanges over the groove either in posterior/lateral/

***Corresponding Author:**
Dr. Jyothi S.R,
Assistant Professor, Department of Anatomy, India.
E-mail: jyothisr39@gmail.com
Tel: 9739724658

Received: November 27, 2023
Accepted: January 04, 2024
Published: January 19, 2024

Citation: Jyothi S.R, Joish Upendra Kumar, Vinay S.R. A Radio-Anatomical Study of Ponticles on Atlas: Clinical point of View. *Int J Anat Appl Physiol.* 2024;10(1):223-227.

posterolateral position. The bony spur extending from dorsal side of lateral mass to the posteriormargin of the groove is posterior ponticle, which could be partial or complete. When complete, it describes a foramen known as "Retroarticularcanal" (RAC) or arcuate foramen, if partial then forms ponticulus posticus or Kimmerley anomaly. The bony outgrowth from lateral margin of the lateral mass to the posterior root of transverse process is the lateral ponticle. It may present as partial or complete form. When complete it forms supratransverse foramenor lateral vertebral foramen. The posterolateral ponticle is a bony fragment from the lateral margin of posterior 1/3rd of lateral mass to transverse process and dorsal edge of posterior arch of atlas.[4] Individuals with retroarticular canal may present with vertebrobasilarinsufficiency presenting with dizziness, fainting and transient diplopia during extreme rotation of neck.[5] During flexion and extension of the neck, the bony foramen may limit the normal mobility of the vessels and may cause disturbances of arterial flow and of the periarterial sympathetic plexus giving rise to the symptoms of vertebrobasilar insufficiency syndrome. The vertebral artery can get pinched off during neck rotations leading to thrombosis and embolism, which may lead to cerebellar infarction. Ossification of ligamentous structures is very frequently observed in various parts of the body, which may result in compression of neighboring structures and complications in regional surgeries.[6] The instability of atlantoaxial complex or occipitocervical junction caused by traumatic or nontraumatic conditions are corrected by surgical techniques such as interlaminar clamp, interspinous wiring, plate and screw fixation and very recently, trans articular and transpedicular screw fixation have been used to stabilize the cervical column.Improper insertion of pedicle screw can damage vital structures such as spinal cord, nerve roots,cranial nerves and vertebral arteries.[7] Surgeons operating at craniovertebral junction should be aware of different variations of this three-dimensional structure, the atlas vertebra. Physicians and neurologists should think of bony spur from lateral mass of atlas as predisposing factor for vertebrobasilar insufficiency. The main objective of this study was to look for presence of ponticles, its type both in dry bones and in CT scan.

Materials and Methods

Cross-sectional descriptive study was undertaken in a tertiary care center between January to April 2021, wherein, 100 consecutive CT scans of adults done in study period, in which occipito-cervical regions were included in the scans and 60 dry and fully ossified adult human atlas vertebrae, which were available in the Anatomy Department, were included. Institutional ethical clearance was obtained prior to the study [KVGMC & H/SUL/IEC/39/OCT2020]. A 128 slice Siemens CT scanner was used for obtaining CT images. Images of 1mm thickness were reconstructed from the raw dataset in bone windowing and viewed in all three planes in multi-planar reformatting algorithm. Informed consent of individuals who underwent CT scans was obtained prior to including their imaging dataset into the study. Each type of ponticle was meticulously documented by experienced Radiologist according to classification based on Parita K et al [8]. An Anatomist studied the detailed anatomy of dry atlas vertebrae,its features – arches, surfaces, lateral mass & its transverse process referring to Cunningham's manual [3] and recorded various type of ponticles.

Inclusion criteria: adult subjects who underwent a cervical CT examination in which the C1 vertebra could clearly be seen and who did not present traumatic fractures involving the cervical spine. Please note the clinical indications for the CT examination for each CT scan Sample: cerebral ischemic stroke, for syncope, for headache, for another neurological symptomatology (tinnitus, amaurosis fugax, diplopia, etc.) and for other causes including, but not restricted to, preoperative cardiac surgery, subarachnoid hemorrhage and drop attack. All samples of atlas were inspected to ensure that the vertebrae were intact and free from osteophytes.It was observed carefully for the different ponticuli from the lateral mass. The variations were noted and photographed.

Exclusion criteria: fractures, degenerative diseases of the cervical spine, cervical spine fracture/dislocation, rheumatoid arthritis, previous history of surgery, tumors, or cervical myelopathy with a spinal canal diameter of ≤12 mm.

Sampling method: Convenience non- probability sampling method

Statistical analysis: Data was entered in an Excel sheet & SPSS version 26 was used for statistical analysis. Qualitative data was expressed in the form of frequency & percentage. Chi-square test was used to find out association between the 2 variables. Quantitative data, age of the patient was expressed in the form of mean.

Results

Dry bone specimens were observed for different ponticuli & recorded. Retroarticular canal (Complete ponticulus posterior) in 3 (5%) specimens, and incomplete ring in 18 (30%) specimens was observed. Supratransverse foramen (Complete Ponticulus lateralis) was seen in 1 (1.6%) specimen and incomplete ponticulus lateralis in 2 (3.3%) specimens. Retrotransverse foramen was seen in 2(3.3%) of specimens. (Table 1,2,3 & 4)(Figure 1).

The mean age of participants underwent CT scans was 31.4 years and included 43 females and 57 males. Type B variety of posterior ponticle was seen in 6 females & 9 males(chi square = 0.277, p value = 0.87), Type C was seen in 2 females & 4 males(chi square =1.5, p value= 0.47). Type D (complete posterior ponticle – Retroarticular canal) in 1 male individual (chi square not applicable), (Figure2) & (Table 5). Retrotransverse foramen was seen in 2 male

Table 1. Distribution of Posterior ponticulus.

Side of the Atlas (Dry bone)	Complete ponticulus posterior	Incomplete ponticulus posterior
Right	2	7
Left	1	9
Bilateral	0	2
Total	3(5%)	18 (30%)

Table 2: Distribution of Ponticulus lateralis in Dry Bone.

Complete Ponticulus lateralis (SUPRATRANSVERSE FORAMEN)				Incomplete Ponticulus lateralis			
Unilateral		Bilateral	Total	Unilateral		Bilateral	Total
Right side	Left side	-	1	Right side	Left side	-	2
-	1	-		1	-	1	

Table 3: Comparative Incidence of Various Atlas Ponticulus.

Sl. No	Researchers	Incidence of different ponticulus in dry bone			
		Number of specimens	Complete posterior ponticulus	Incomplete posterior ponticulus	Lateral ponticulus
1	Mitchell J [10]	1354	9.80%	29.60%	12.24%
2	Lamberty & Zivanovic [17]	60	15%	21.66%	-
3	Paraskevas & Papaziogas [18]	176	10.23%	24.43%	11.36%
4	Hassan et al [22]	350	6.57%	-	2%
5	Present study	60	5%	30%	5%

Table 4: Retro transverse foramen in Dry Bone.

Retro transverse foramen		AP	Transverse diameter
Unilateral	Left side	1mm	1mm
Bilateral	Right side	1mm	1mm
	Left side	1mm	1mm

Table 5: Radiological types of Ponticulus posterior.

TYPE	SIDE	SEX	
		Female	Male
Type B	Bilateral	2	2
	Left	2	3
	Right	2	4
Total		6	9
Type C	Bilateral	1	1
	Left	-	2
	Right	1	1
Total		2	4
Type D	Bilateral	-	-
	Left	-	
	Right	-	-
Total		-	1

individuals. The comparison b/w sex & sides were not statistically significant.

Discussion

Recently various surgical techniques and instrumentation have been employed to stabilize the unsteady cervical spine. The management of various traumatic, congenital or neoplastic conditions associated with atlas and its joints require more information about the bone and its adjacent anatomy. The knowledge on different ponticles of atlas vertebra may be helpful to overcome complications such as vertebral artery injury, spinal cord injury and cranial nerve damage during C1 stabilizing operation and in diagnosis of vertebrobasilar insufficiency syndrome. [9, 10]

Among all cervical vertebrae the atlas is known for its variations. The atlas ponticle are shared structure between human and non-human primates. [11, 12]

Figure 1: A to F, shows dry atlas vetebrae presenting different ponticles – Ponticulus posterior & Ponticulus lateralis, both complete & incomplete variety.

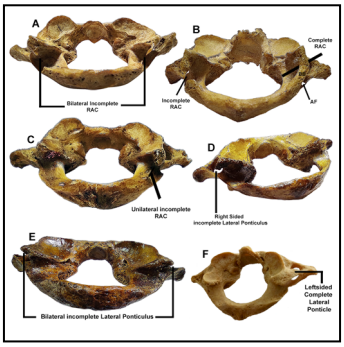
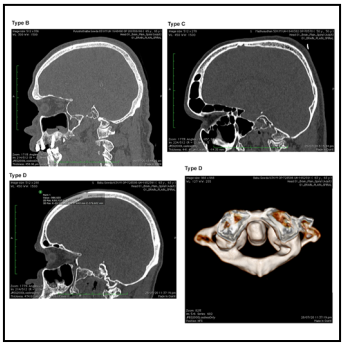


Figure 2: CT scan of individuals presenting Type B, C & D variety of ponticulus posterior.



Parita K et al [8] describes radiological classification of posterior ponticle in detail as below and the results obtained in our study is depicted in (Table 5).

Type A: Normal - No degree of this anomaly can be detected; including exaggerated grooving of the fossa arterialis with no distinct spicule.

Type B: Trivial - Partly developed foramen ranging from a minute but distinct spicule to a developing bridge that encases less than 50% of the circumference of the vertebral artery.

Type C: Partial, well-developed -Well-developed foramen encases at least the majority (greater than 50%) of the vertebral artery's circumference.

Type D: Complete - The vertebral artery is completely encased by bone

Bipedalism and acquisition of erect posture might have led to the regressive and disappearing phenomenon in atlas leading to formation ofponticles. [13] Macalister was the first to report the posterior and lateral ponticles. Number of theories has been postulated to explain the ponticles.One theory explains that it is due to persistence of superior oblique process of other mammals.[14] According to some authors it develops from dorsal arch of proatlas and belongs to occipital vertebra.[15] Le Double described that ponticles could be due to ossification of the lateral fibers of posterior atlanto-occipital membrane or acquired ossification of oblique ligament, due to pulsation of vertebral artery [13] or by external mechanical factor like carrying heavy objects on the head.[16] Some authors have postulated that the lateral extension of proatlas may lead to the formation of lateral ponticles. [17]

Lamberty and Zivanovic observed the bony ring in atlas of two children's skeleton aged 2 and 4 years and also in the cervical spine x-ray of a 13-year-old boy. From this observation they inferred that ossification of a ligament does not occur normally in such young persons.[18] Paraskevas G et alexplained that incomplete bony ponticuli are precursor of the complete bony ponticuli. [19] The same was also observed by Kendrick GA and Biggs NL where in, they found in two females unilateral incomplete posterior ponticle changed to complete ring over duration of 1to 2 years.[20]

The procedures like atlas screw fixation have gained popularity to such an extent that it has increased the need for thorough evaluation of the anatomy of C1 vertebra and the vertebral artery. During the above procedures if any injury to vertebral artery may lead to severe intraoperative bleeding and may cause unpredictable neurological deficits, depending on the adequacy of blood flow from the contralateral vertebral artery.[21] When patients present with symptoms like pain in temporal region, pain in back of eye, vertigo and paresthesia of hand radiography of cervical spine is the simplest and useful aid to detect the presence of ponticles. [22] Hassan M et al classified posterior bridges into 6 classes [23].

Class 1 - included those having only the impression of vertebral artery on the posterior arch of atlas

Class 2 - included those having deeper impression like groove or sulcus for the vertebral artery

Class 3 – included those in which partial ponticulus posterior was present as a bony spicule.

Class 4- included those having complete ponticulus posterior

Class 5 – included those having ponticulus lateralis which extended from the lateral mass to the transverse process

Class 6 – included those having postero- lateral tunnel i.e., combination of complete ponticulus posterior and ponticulus lateralis.

In the present study, type class 2 was seen in 14(23.3%) of specimens, type class 3 was seen in 18(30%) of specimens, type class 4 was observed in 3(5%) of specimens and type class 5 was seen in 3(5%) of specimens.

Satheesha Nayak reported retro transverse foramen in one specimen and right being larger than left.[24] In the present study, we observed in one specimen on left side among the dry bone of atlas. CT scan of atlas showed such retrotransverse foramen in two cases.

Conclusion

Extreme rotation of head and neck may compress vertebral artery.This may get aggravated by presence of retroarticular canal for vertebral artery, resulting in stenosis and compromised blood flow.Hence the present anatomical study was undertaken to study the differentponticles of atlas vertebra. The awareness may be helpful to neurosurgeons and orthopaedicians while approaching craniocervical junction through posterior route. The detail knowledge, also aids neurophysicians and otolaryngologists to treat patients presenting with symptoms of vertebrobasilar insufficiency. To achieve optimal therapeutic results, a complete understanding of the morphology is indispensable.

Conflicts of Interests: None

Acknowledgements

The authors sincerely thank those who donated their bodies to science so that anatomical research could be performed. Results from such research can potentially increase mankind's overall knowledge which can then improve patient care. Therefore, these donors & their families deserve our highest gratitude.[25]

References

[1]. MooreKL. Clinical Oriented Anatomy.The back.3rd ed.Baltimore:Williams and Wilkins; 1992:331
[2]. Standring S. Gray's Anatomy.The anatomical basis of clinical practice. The back. 40thed.Philadelphia: New Elsevier Churchill Livingstone; 2008 :719
[3]. Romanes G J. Cunningham's manual of practical anatomy. The head and neck. 15th ed. Oxford: Oxford Medical Publications;2006;3:2
[4]. Patel NP, Gupta DS, Parmar ND. Incidence of ponticles in human atlas vertebrae: a study from South Gujarat population. Indian J Clin Anat Physiol. 2015;2(3):135-9.
[5]. Sylvia S, Kulkarni S, Hatti A. Bilateral retro articular ring in atlas vertebra a case report. Anatomica Karnataka. 2011;5(1):81-6.
[6]. Cakmak O, Gurdal E, Ekinci G, Yildiz E, Cavdar S. Arcuate foramen and its clinical significance. Saudi Med J. 2005 Sep 1;26(9): 447-451.
[7]. ŞENGÜL G, KADIOĞLU HH. Morphometric anatomy of the atlas and axis vertebrae. Turk. Neurosurg. 2006;16(2):69-76. https://scholar.google.com/scholar?hl=en&as_sdt=0%2C5&q=Morphometric+anatomy+of+the+atlas+and+axis+vertebrae&btnG=
[8]. 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 Dec;7(12):3044-7.Pubmed PMID: 24551723.
[9]. Gupta C,Radhakrishnan P, Palimar V, D'Souza AS, Kiruba NL. A quantitative analysis of atlasvertebrae and its abnormalities. J. Morphol. Sci 2013;30(2):77-81
[10]. Lalit M, Piplani S, Kullar JS, Arora AK, Mannan R. The morphological analysis of the superior articular facet of the adult human atlas vertebra. J Clin Diagn Res. 2011 Apr;5(2):274-77.
[11]. Mitchell J. The incidence and dimensions of the retroarticular canal of the atlas vertebra. Acta Anat (Basel). 1998;163(2):113-20. Pubmed PMID: 9873140.
[12]. MITCHELL J. The incidence of the lateral bridge of the atlas vertebra. J Anat. 1998 Aug;193(2):283-5.
[13]. 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
[14]. Macalister A. Notes on the homologics and comparative anatomy of the atlas and axis. J Anat and Physiol 1869;3:54-64
[15]. Von Torklus D, Gele W. The upper cervical spine. New York: Grunne and Stratton;1972:28-30
[16]. Taitz C, Nathan H. Some observations on the posterior and lateral bridge of the atlas. Acta Anat(Basel). 1986 Jul 15;127(3):212-7.
[17]. Allen W. The Varieties of the Atlas in the Human Subject, and the Homologies of its Transverse Processes. J Anat Physiol. 1879 Oct;14(Pt 1):18-28. Pubmed PMID: 17231305.
[18]. Lamberty BG, Zivanović S. The retro-articular vertebral artery ring of the atlas and its significance. Acta Anat (Basel). 1973;85(1):113-22.Pubmed PMID: 4197316.
[19]. Paraskevas G, Papaziogas B, Tsonidis C, Kapetanos G. Gross morphology of the bridges over the vertebral artery groove on the atlas. Surg Radiol Anat. 2005 Apr;27(2):129-36.Pubmed PMID: 15800734.
[20]. KENDRICK GS, BIGGS NL. Incidence of the ponticulus posticus of the first cervical vertebra between ages six to seventeen. Anat Rec. 1963 Mar;145:449-51.Pubmed PMID: 14031912.
[21]. Simsek S, Yigitkanli K, Comert A, Acar HI, Seckin H, Er U, et al. Posterior osseous bridging of C1. J. Clin. Neurosci. 2008 Jun 1;15(6):686-8.
[22]. Parkin PJ, Wallis WE, Wilson JL. Vertebral artery occlusion following manipulation of the neck. N Z Med. 1978 Dec 1;88(625):441-3.
[23]. Hassan M, Sulka S, Siddiqui MS, Singh D.Posterolateral tunnels and ponticuli in human atlas vertebrae. J Anat2001;199:339-343
[24]. N Satheesha, V Venkata Ramana and R Deepthinath. Neuroanatomy 2005; 4:39
[25]. Iwanaga J, Singh V, Ohtsuka A, Hwang Y, Kim HJ, Moryś J, et al. Acknowledging the use of human cadaveric tissues in research papers: Recommendations from anatomical journal editors. Clin Anat. 2021 Jan;34(1):2-4. Pubmed PMID: 32808702.