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RESEARCH ARTICLE

A STUDY OF ARCUATE FORAMEN IN HUMAN ATLAS VERTEBRAE: INCIDENCE AND CLINICAL CORRELATIONS

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ABSTRACT

Background: Atlas is the first cervical vertebra. Arcuate foramen transmits vertebral vessels and sympathetic plexus. Any additional foramen on atlas other than foramen transversaria is termed as arcuate foramen. Presence of arcuate foramen in various countries giving an incidence from 8 to 24 % by various authors. Embryological variations in the presence and passage of the vertebral vessels will manifest as variant foramen. **Objectives**: To find the incidence of arcuate foramen in the first cervical vertebrae. Knowledge of this foramen is important in clinical diagnosis and surgical procedure for neurophysician and neurosurgeon. **Material and Methods**: The study was conducted in adult 45 dried atlas vertebrae of unknown sex in the Department of Anatomy, AIIMS Patna. **Result:** The incidence of as arcuate foramen was 17.77% and was bilateral in 11.11% whereas unilateral in 6.66%. **Conclusion**: Awareness of this type of variation is essential for orthopaedic surgeons, neurosurgeons and radiologists to avoid misdiagnosis in their clinical practice.

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INTRODUCTION

Atlas is the first cervical vertebra which supports the head. Atlas is ring shaped and does not have a body and spine. The absence of spine is responsible for the free nodding movement of the head. It is consisting of anterior, posterior arches and two lateral masses along with the transverse processes. Normally a single foramen transversarium bilaterally on the transverse process is present. Which transmits vertebral artery, vertebral vein and sympathetic plexus. The posterior arch of atlas bears a groove called sulcus arteriae vertebralis. The groove transmits third part of vertebral artery surrounded by venous plexus and dorsal ramus of first cervical nerve (Richard, 2008). Normally, the upper border of the posterior arch of first cervical vertebra provides an attachment to the posterior atlanto occipital membrane. Occasionally, when the lateral margin of this membrane get ossified, then sulcus arteriae vertebralis may get converted into a foramen, named as arcuate foramen. This foramen has been named by various authors as canal is arteriae vertebralis foramen atlanto ideumposterius, ponticulus posticus, pons posticus, retroarticular foramen, Kimmerle anomaly, foramen sagitale, retrocondylar bony foramen, retroarticular VA ring, foramen of the atlas.These foramen may be complete or incomplete (Last, 1966; Tubbs *et al*., 2007). The causing mechanism of this bony foramen is still unknown but different authors proposed that it may be due to ossification of connective tissue surrounding the vertebral artery, degenerative calcification, ossification due to ageing process of atlanto-occipital membrane (Krishnan *et al*., 2002). The ossification of membrane may be due external mechanical factors such as carrying heavy loads on head or induced by pulsation of vertebral artery. These anatomical anomalies may lead to common symptoms like neck pain, vertigo, migration, diplopia, shoulder pain etc (Krishnamurthy *et al*., 2007). Embryological variations in the presence and passage of the vertebral vessels will manifest as variant foramen. The presence of arcuate foramen was also seen in young aged persons. Sometimes, a bony spurs may arise from the margins of the sulcus arteriae vertebralis referred to as ponticles and they occasionally convert the groove into foramen (Richard, 2008; Last, 1966). The posterior ponticles may be a remnants of the proatlas (occipital vertebra) (Cushing *et al*., 2001; Taitz,

1986). Similar to arcuate foramen a bony ring of the vertebral artery is a commonly found in other vertebrates. A very limited data were available about these variation in Bihar region therefore, the necessity of this study arose. Presence of arcuate foramen in various countries giving an incidence from 8 to 24% by various authors (Brown, 2009; Mitchel, 1998; Gopal *et al*., 2013). The main objective of the present study is to investigate the incidence of arcuate foramen in the Atlas vertebrae and to discuss its clinical importance.

MATERIALS AND METHODS

The present study carried out on 45 dried fully ossified human atlas which were obtained from the Department of Anatomy, All India Institute of Medical Sciences, Patna. The vertebrae with absence of foramen Transversarium, incomplete foramen Transversarium, hemi-vertebrae, fused vertebrae, ossified atlanto-occipital joints, broken or fractured vertebrae were excluded from this study. The atlas vertebrae having arcurate foramen were macroscopically observed and classified according to Mitchell J classification (Mitchel, 1998).

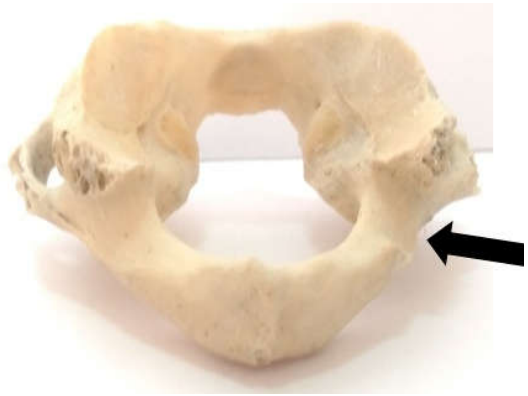

Fig. 1. Atlas vertebra showing Type I right side arcuate foramen.

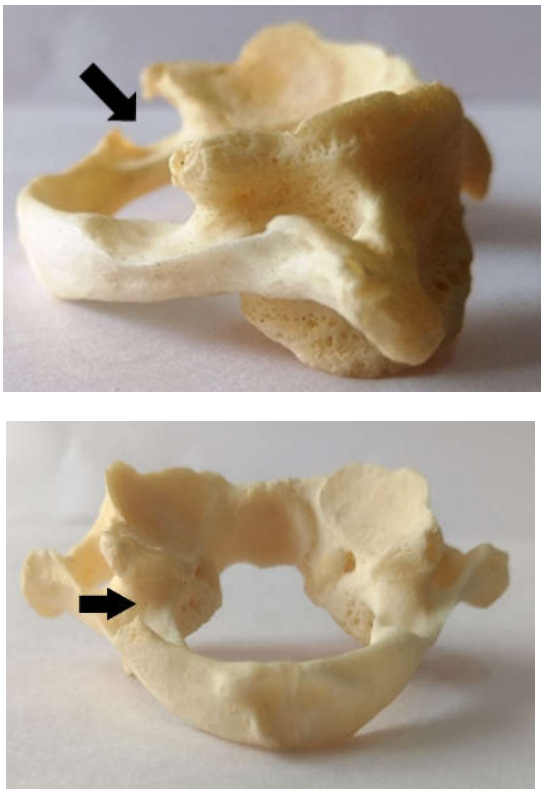

Fig. 2. Atlas vertebra showing Type II left side arcuate foramen

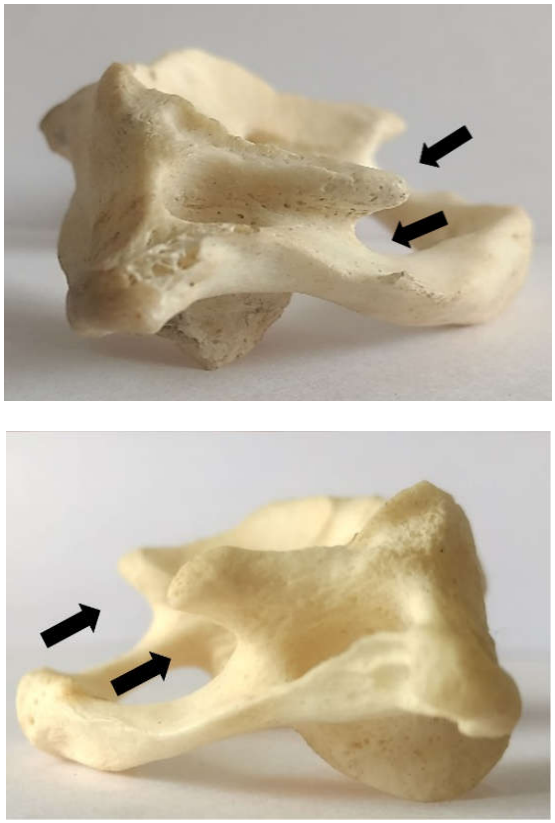

Fig. 3. Atlas vertebra showing Type II bilateral arcuate foramen

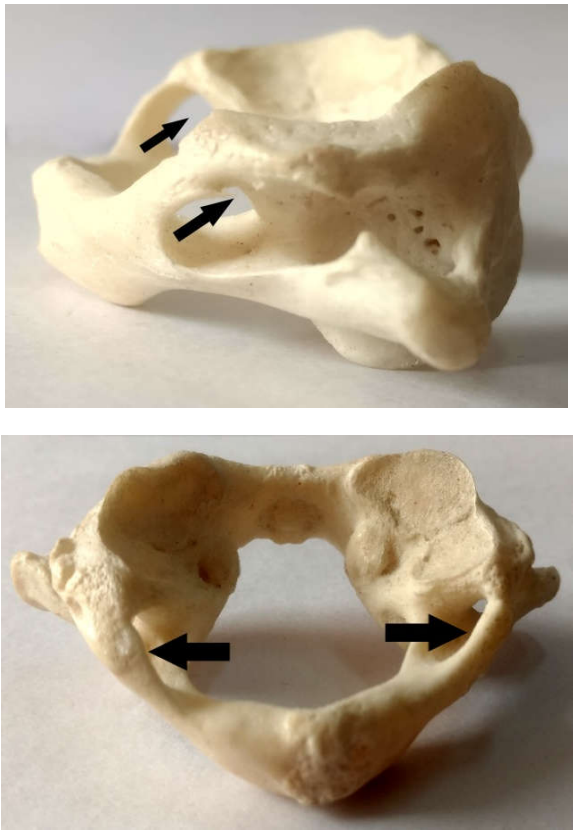

Fig. 4. Atlas vertebra showing Type III bilateral arcuate foramen.

RESULTS

The macroscopic examination for the presence of arcuate foramen was done among the 45 dry atlases. It is found that in 3 (6.66%) vertebrae had unilateral and 5 (11.11%) vertebrae had bilateral bony bridge formation.

Table 1. The occurrence rate of arcuate foramen

Type	Unilateral		Bilateral (%)	Total (%)
	Right side (%)	Left side (%)		
Type I	1 (2.22)	-	3 (6.66)	4 (8.88)
Type II	1 (2.22)	1 (2.22)	1 (2.22)	3 (6.66)
Type III	-	-	1 (2.22)	1 (2.22)

Sl. No.	Authors	Year	Method of study	Incidence of arcuate foramen (%)
1	Malhotra et al. (1979)	1979	Dry bone specimens	5.14
2	Kavakli et al. (2004)	2002	Dry bone specimens	22.10
3	Cakmak et al. (2005)	2005	Dry bone specimens	15
4	Young et al. (2005)	2005	Plain radiographs	15.50
5	Krishnamurthy et al. (2007)	2007	Dry bone specimens	13.80
6	Dahiphale (2009)	2009	Dry bone specimens	20
7	Zambare & Reddy (2011)	2011	Dry bone specimens	16
8	Gopal et al. (2013)	2013	Dry bone specimens	17.33
9	Lalit et al. (2014)	2014	Dry bone specimens	23.33
10	Akhtar et al. (2015)	2015	Dry bone specimens	21.17
11	Santhi et al. (2017)	2017	Dry bone specimens	12.06
12	Present study	2018	Dry bone specimens	17.77

The bony bridge formation was seen bilaterally in 3vertebrae (6.66%) of Type I whereas single vertebra of Type II and Type III respectively (Figure 1, 3 and 4). The bony bridge formation was seen unilaterally in one (2.22%) vertebra of Type I (right side) and two (4.44%) were Type II (left and right side) (Fig. 2). The occurrence rate of arcuate foramen were stated in Table 1. Of the 45 dry atlases, 4 (8.88%) were type I, 3 (6.66%) were Type II and 1 (2.22%) was Type III. The incidence of arcuate foramen was 17.77%.

DISCUSSION

The Atlas consist of two bulky lateral masses, short anterior arch, and a long curved posterior arch with no body and spine. The superior surface of posterior arch bears a wide groove for the vertebral artery, venous plexus and the C1 nerve immediately behind the lateral mass. The flange-like superior border gives attachment to the posterior atlanto-occipital membrane, and the flatter inferior border to the highest pair of ligament flava (Richard, 2008). The dorsal bony bridge found posterior to lateral mass on the posterior arch of the first cervical vertebra was named in 1972 as arcuate foramen by Von Torklus and Gele (Torklus, 1972). In the present study we observed 17.77% cases of arcuate foramen in Atlas Vertebra which is near to study of Gopal K *et al*. 2013 who reported 17.33% cases of ponticulus posteriorin their study. Incidence of arcuate foramen in various countries giving from 8-24% by various authors (Table 2) (Malhotra, 1979; Lalit *et al*., 2014). According to Unur *et al*. the complete posterior ponticuli is a normal structure in the adult Japanese macaques (Unur et al., 2004).

Lamberty and Zivanovic found in a study done on non human primates atlases that the presence of ponticles are characteristic of primates where as in humans it represents its persistence of the progressive disappearance of the atlantalponticles particularly during hominoid evolution (Lamberty, 1973). The 3rd part of vertebral artery is prone to compression during extreme rotation movement of head and neck. Last observed that the free border of the posterior atlanto-occipital membrane, arching over the artery and nerve is sometimes ossified and converted the groove for the vertebral artery into a foramen (Last, 1966). According to Shimizu *et al*, repeated rotational neck movements were the most likely mechanism underlying the ossification.

These foramina may be complete or incomplete, which is commonly known as ponticulus posterior (ponticulusposticus) or arcuate foramen of the atlas (Shimizu et al., 1998).The presence of arcuate foramen may restrict the mobility of the vessels during flexion and extension of the neck and compression of the vessels and periarterial sympathetic plexus may cause disturbances of arterial flow and give rise to the symptoms as found in the Barre-Lieou syndrome and photophobia. Schilling *et al*., reported about the functional significance of bony bridge of arcuate foramen in protecting the tortuous vertebral artery in an area of high mobility (Schilling *et al*., 2010). Le Double described that pulsation of vertebral artery induced the ossification of the oblique ligament (Limosin, 1980). Otolaryngologists regularly attends the patients complaining about the symptoms of vertebrobasilar insufficiency like headache, vertigo, pain in temporal region as well as back of eye, periodic photophobia, shoulder and arm pain. Li and Li reported that patients with repeatedly history of occurrence of ischemic attacks following voluntary neck rotation, on radiological evaluations showed a complete arcuate foramen (Li, 1995). Orthopaedician during lateral dissection and C1 laminectomy through the posterior approach for craniovertebral junction, should know about the presence of foramen in advance. The knowledge of presence of arcuate foramen is also helpful during stabilization procedures such as screwing of the lateral mass of the atlas as it will reduce the risk of vertebral artery injury during operative procedures (Young *et al*., 2005; Gupta, 2008; Stauffer, 1994).

Conclusion

Out of 45 atlas vertebrae observed, 8 atlas vertebrae (17.77%) showed arcuate foramen. This type of observations is useful in lateral mass screws for the fixation of the atlas. The formation of the incomplete and complete arcuate foramen may be damaged during neck injuries and Surgeries. Hence the knowledge of atlases variations is important for neurologist, radiologist, physicians, otorhinolaryngologists, and orthopaedicians. They should have detail knowledge about these variation and try to look for it when dealing with the patients complaining of symptoms of headache, vertigo, shoulder and arm pain.

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