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An observational study to assess the various dimensions of the C1 in relation to the vertebral artery groove.

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KEYWORDS
Atlas vertebra, Foramen transversarium, Vertebral Artery

ABSTRACT

Aim: The aim of the present study was to assess the various dimensions of the C1 in relation to the vertebral artery groove.

Material & methods: 100 atlas vertebrae, available in the Dept of anatomy, autonomous state medical college, Kanpur Dehat, Uttar Pradesh, India were studied. The specimens selected were dry, complete, of human cadaveric vertebrae of Indian origin. Vertebrae with gross vertebral pathology were excluded.

Results: Test of significance (paired t-test) was carried out for comparison of right and left sides. The p value < 0.05 was considered to be significant and > 0.05 was considered to be insignificant. For all parameters, this was insignificant showing bilateral symmetry.

Conclusion: The overall goal of this study was to generate information that would be useful for geometric modelling of vertebrae and give necessary morphometric data on human atlas vertebra in of Indian population.

INTRODUCTION

The atlas is the first cervical vertebra which supports the globe of the head.[1] It has undergone many structural modifications. It is critically located and close to the 'life centres'. The atlas vertebra has many unique features. It is located at a critical point close to the vital centres of the medulla oblongata, which can get compressed by a dislocation of the atlanto-axial complex or instability of atlanto-occipital joint.[2] It shaped like an irregular ring. Because it's a ring fracture results in disruption of this ring and more than one location is affected. Fractures of atlas account for approximately 5% of the cervical spine injuries.[3]While the Jefferson fracture (a four part ring fracture) is the most frequent fracture pattern, there are many other variants like posterior arch, lateral mass, transverse process fractures. [4] Craniovertebral junction (CVJ) surgery is one of the essential parts of spinal surgery. The CVJ is an anatomical transition zone between the skull and the cervical spine. It contains the caudal part of the occipital bone, atlas and axis vertebrae, ligaments, many cranial nerves, blood vessels, and lymphatics.[5,6] Atlas vertebrae within the CVJ have anatomical properties that differ from other cervical vertebrae.[7] Atlantoaxial and craniovertebral instability present unique challenges in spinal surgeries.[8] Instability at the atlas and axis requires internal fixation not only for immediate stability, but also to provide long-term immobility so as to attain a solid fusion. [9]

Atlas consists of two symmetrical lateral masses that are united by the anterior and posterior arches. These lateral

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masses are thick, supportive elements composed of both a superior and inferior articular surfaces.[10] This large size of lateral masses enables screw placement feasibility in almost all patients.[11] The sulcus arteriae vertebral is (groove for the vertebral artery) is situated on the cranial surface of the posterior arch at its junction with the lateral mass.[10] This smooth groove is for the lodgement of the vertebral artery with the venous plexus around it and the suboccipital nerve. There can be compression of these structures while passing through the vertebral ring and can lead to pain in temporal region, occipital headache, periodic photophobia, paraesthaesia of hands, leading to psychogenic tension, functional headache, cervical pain and stress.[1] The superior oval articular surface articulates with the occipital condyles. The inferior circular articular facet articulates with the superior articular surface of axis, both these surfaces differ from other cervical articular surfaces by being situated ventral to the exit sites of the spinal nerves. The transverse process, which extends more laterally than the other cervical processes serves as a good surgical landmark.[10]

Knowledge of the variability of atlas is important for neurosurgeons, orthopaedicians, otorhynologists and other physicians who in everyday practice are in contact with disorders of the spine and their consequences.[12] This will help in avoiding vascular complications as a result of vertibrobasilar insufficiency which may manifest as a variety of symptoms from dizziness to unconsciousness and death. [1] Keeping this in mind, the present study was taken on the Morphometry of atlas vertebra in relation to sulcus arteriae vertebralis in Indian population.

MATERIAL & METHODS

100 atlas vertebrae, available in the Dept of anatomy, autonomous state medical college, Kanpur Dehat, Uttar Pradesh, India were studied. The specimens selected were dry, complete, of human cadaveric vertebrae of Indian origin. Vertebrae with gross vertebral pathology were excluded.

ANATOMICAL MEASUREMENTS ON ALTAS

Antero-Posterior Diameter (APD) of Foramen Transversarium (FT) – the maximum distance between two points, one on the anterior and another on the posterior margin of FT along its principal axis.

Transverse Diameter (TD) of FT – It is the maximum distance between two points on the lateral and medial margin of FT perpendicular to the principal axis.

APD of Superior Articular Facet (SAF)– maximum antero-posterior dimension of superior articular surface along its principal axis directed anteromedially. TD of SAF– the maximum transverse dimension of superior articular surface perpendicular to the antero-posterior dimension.

APD of Inferior Articular Facet (IAF)– the maximum antero-posterior dimension of inferior articular surface along its principal axis directed anteromedially.

TD of IAF – maximum transverse dimension of inferior articular surface perpendicular to the antero-posterior dimension.

Outer Distance of Vertebral Artery Groove (VAG) – the distance from posterior midline to the lateral most edge of vertebral artery groove on the outer cortex.

Maximum Transverse Diameter of Atlas (MTD) – distance between both the tips of transverse processes.

Distance between Lateral Most Edge of both Foramen Transversaria (distance between both lateral-most edge of FT) – it was measured as the distance between lateral borders of upper rims of two transverse foramina.

Distance between Medial Most Edge of both Foramen Transversaria (distance between both medial-most edge of FT) – it was measured as the distance between medial borders of upper rims of two transverse foramina.

STATISTICAL ANALYSIS

Various dimensions were taken with the help of Vernier calipers, metric scale and graph paper. All the measurements were recorded in millimetres (mm) and bilaterally wherever applicable. The measured data was statistically analysed including test of significance (paired t-test). Comparison was done with existing studies. The p value < 0.05 was considered to be significant and > 0.05 was considered to be insignificant.

RESULTS

Table 1: The recorded observations with range, mean and standard deviation (SD)

Parameter		**Range(mm)**	**Mean± S.D. (in mm)**	
	Right	Left	Right	Left
TD of FT	4.78 – 9.42	4.16 – 8.12	6.14 ± 0.96	6.03 ± 0.96
APD of FT	5.35 – 9.95	5.85 – 9.75	7.73 ± 1.05	7.63 ± 0.92

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Outer Distance of VAG	22.36 – 31.16	22.68 – 29.66	26.22 ± 2.32	25.84 ± 1.85
Inner Distance of VAG	8.72 – 18.12	9.79 – 17.13	13.12 ± 1.68	13.18 ± 1.56
APD of SAF	17.00 – 27.00	17.73 – 25.45	22.54 ± 2.38	22.52 ± 2.08
TD of SAF	8.46 – 15.12	9.21 – 16.48	11.22 ± 1.48	11.33 ± 1.54
APD of IAF	14.26 – 21.26	12.28 – 21.32	17.53 ± 1.52	17.72 ± 1.62
TD of IAF	12.74 – 18.82	12.84 – 19.91	15.95 ± 1.68	14.96 ± 1.52
MTD of Atlas	62.48 – 84.82		73.07 ± 5.55	
Distance between Lateral- Most Edge of both Foramen Transversaria	48.00 – 68.62		57.38 ± 4.16	
Distance between Medial- Most Edge of both Foramen Transversaria	38.82 – 52.12		45.75 ± 3.68	

Test of significance (paired t-test) was carried out for comparison of right and left sides. The p value < 0.05 was considered to be significant and > 0.05 was considered to be insignificant. For all parameters, this was insignificant showing bilateral symmetry.

DISCUSSION

Craniovertebral junction (CVJ) surgery is one of the essential parts of spinal surgery.[13] Atlas vertebrae within the CVJ have anatomical properties that differ from other cervical vertebrae.[14] In CVJ surgery, it is necessary to have knowledge about the anatomy of this region, particularly the atlas vertebrae.[13] Cacciola et al[15] stated that the anatomy of the vertebral artery at the level of atlas and axis vertebrae is significantly different from the relatively straightforward course of the C3 to C6 vertebrae. Due to these anatomical differences and the location of the vertebral artery groove in a vital place, surgical procedures in this region are very difficult.[13] However, the number, size, and shape of the foramen transversarium can affect the morphology of the vertebral artery. Besides, conditions such as vertebrobasilar insufficiency, headache, migraine, and fainting attacks may occur as a result of pressure on the vertebral artery due to these variations.[16]

Test of significance (paired t-test) was carried out for comparison of right and left sides. The p value < 0.05 was considered to be significant and > 0.05 was considered to be insignificant. For all parameters, this was insignificant showing bilateral symmetry. Any deformation of the foramen can cause derangements of these structures in their course. Moreover the transverse and antero-posterior diameters of FT reflect the differences in size and anatomy of vertebral artery.[17] In addition, the relationship between the vertebral artery and the groove for the vertebral artery of the atlas vertebrae has an essential role in the operative approaches to be applied to this region.4 Screw fixation can be used in atlas instabilities.[14] Although pedicle screw fixation provides the strongest stability for cervical reconstruction, there is a risk of neurovascular injury during this procedure. Moreover, various complications such as the vertebral artery, nerve root, and spinal cord injuries and infections may also occur due to this procedure.[18,19] More dramatically, even very serious problems such as cerebral infarction or death can occur due to injury to the bilateral vertebral arteries.[20] When all these complications are considered, it is extremely important to know the morphology, morphometry, and variation of the all-anatomic structures on the atlas.

In a study by Tan et al[21] on Asians this parameter was measured as 24.28 ± 2.27mm on right side and 24.61 ± 1.25 on left side, also by Jian et al[22] on Chinese as 27.0 ± 3.2mm on right and 26.0 ± 3.6mm on left. Our values are closer to these studies; hence there are some ethnic similarities. The mean distance between lateral-most edge of both foramen transversaria and the mean distance between medial-most edge of both foramen transversaria, the values observed in the Indian studies are similar. The trajectory and angulation while screw placements is crucial because of the surrounding neurovascular structures, i.e. vertebral artery on the lateral and spinal cord on the medial aspect of superior articular facets of atlas. The knowledge of the APD and TD dimensions of SAF can help in the safe planning of these screw placements. There is a dimensional

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equivalence amongst most of the Indian studies and the present study while comparing the diameters of the SAF and the IAF. Sengul et al[14] have observed lower value in the Turkish population.

The number, size, and shape of the foramen transversarium may affect the morphology of the vertebral artery, causing vertebrobasilar insufficiency. Depending on the morphology and morphometry of the foramen transversarium, vertebral artery compression may occur. This situation may cause clinical symptoms such as chronic headaches, migraines, and fainting attacks.[16] Moreover, Taitz et al[23] stated that foramen transversarium and vertebral vessels are interrelated, and it can be assumed that variations of the vertebral vessels may manifest as variations of the foramen transversarium. Therefore, it is essential to know the transverse (P11) and anteroposterior (P12) diameters, area (P13), and shape (P15) of the foramen transversarium.

CONCLUSION

The overall goal of this study was to generate information that would be useful for geometric modelling of vertebrae and give necessary morphometric data on human atlas vertebra in Indian population.

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