

A MORPHOMETRIC STUDY OF ATLAS & AXIS VERTEBRAE IN RAJASTHAN POPULATIONRekha Parashar¹, Sangita Chauhan², Dhiraj Saxena³, Saroj Lata Meena⁴**HOW TO CITE THIS ARTICLE:**

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ABSTRACT: Knowing the dimensions of the vertebral elements is very important for the development of instrumentation related to cervical spine. Ethnic variations have been reported in these dimensions. Aim of the present study was to evaluate the metrical details of first and second cervical vertebrae to correct the instability of atlantoaxial joint, and to analyze the morphological features to understand the ergonomics of the craniovertebral joints. This study was conducted in the Department of Anatomy S. M. S. Medical college jaipur. Total 150 (75 atlas and 75 axis) cervical vertebrae were evaluated. All the measurements were taken in bilateral manner using Digital Vernier Calipers with .01 precision. Calculated mean value for width of atlas in our study was 69.03 mm. In present study the observed mean value for anteroposterior diameter of vertebral canal of atlas was 25.52 mm. and transverse diameter was observed as 21.98 mm. Mean value for height of anterior arch of atlas was 7.42 mm and for posterior arch height was calculated 5.3 mm. The mean value of Anteroposterior diameter of Rt. and Lt. Superior articular facet was calculated 17.99 and 18.29 mm and transverse diameter was observed as 7.81±1.28 and 8.33±1.54 mm. In our present study anteroposterior diameter of inferior articular facet of atlas was calculated as 13.35±1.50mm and 13.38±1.65 respectively for right and left side and transverse diameter was observed as 6.86±1.32 mm and 6.92±1.44 mm for right and left side. Calculated mean value for width of dens was observed 6.64±0.992mm and mean value of dens length was 12.95 mm. Calculated mean value for A-P diameter of vertebral canal was observed 16.48±1.12 mm and transverse diameter of vertebral canal was calculated as 19.81±1.18 mm. Calculated A-P diameter of Rt. Superior articular facet of axis was 14.65±1.44 mm and for Lt. It was calculated 14.65±1.44 mm and transverse diameter was calculated as 13.38 ±1.65. For inferior articular facet mean value of anteroposterior diameter were observed as 13.35±1.50 and 13.38 ±1.65 mm for right and left side respectively and transverse diameter was evaluated as 6.86 and 6.92 mm for right and left side. Morphometric data's can provide more accurate measurements of anatomical elements of cervical spine that could facilitate diagnosis and preoperative planning and will allow for more accurate modeling of this region.

KEYWORDS: vertebral foramina, articular facets, anterior arch, posterior arch, width of atlas, dens.

INTRODUCTION: The cervical spine provides higher level of flexibility and motion as compared to the lumbar and thoracic spine regions. These characteristics can be attributed to the anatomy of the specific cervical vertebrae. Knowing the dimensions of the vertebral elements is very important for the development of instrumentation related to cervical spine. Ethnic variations have been reported in these dimensions. Instrumentation of the vertebral column is used for the treatment of cervical instability as well as for the decompression of neural structures. These studies have used diverse techniques to obtain vertebral column measurements and these parameters can be used as reference values for evaluating various clinical conditions in the cervical spine. The insertion of such

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instrumentation must respect the anatomic limits of the region. There are seven cervical vertebrae out of which the first, second and seventh are atypical. First and second cervical vertebrae is called atlas and axis respectively. Aim of the present study was to evaluate the metrical details of first and second cervical vertebrae to correct the instability of atlantoaxial joint, and to analyze the morphological features to understand the ergonomics of the craniovertebral joints.

MATERIAL AND METHODS: This study was conducted in the Department of Anatomy S. M. S. Medical college jaipur. Total 150 (75 atlas and 75 axis) cervical vertebrae were evaluated. All of the vertebrae which were included in the study were in good condition, without trauma or infection or neoplastic disease and without apparent disease or deformities. All the measurements have taken in bilateral manner using Digital Vernier Calipers with .01 precision.

Following parameters of atlas were Measured:

- A. Width of Atlas- it is measured as the distance between the tips of two transverse process of first cervical vertebrae
- B. Vertebral Foramina Diameter- Transverse diameter and Anteroposterior (A-P) Diameter.
 - a. Transverse Diameter of vertebral canal - it is measured along frontal plane passing through the canals midpoint.
 - b. Anteroposterior Diameter of vertebral canal - it is measured along midsagittal plane passing through canals widest point.
 - c. Height of anterior arch- it is measured in the midline from its superior border to inferior border.
- C. Height of posterior arch- it is measured in the midline posterior part as distance between superior and inferior border.
- D. Superior articular facet- Transverse and anteroposterio (A-P) diameter of right and left side of superior articular facets are measured.
- E. Length /A-P Diameter- it is measured from inferior border to superior vertex of process.
- F. Width /Transverse Diameter- it is marked as length of transverse Diameter of the process.
- G. Inferior articular facet- Transverse and Anteroposterior (A-P) Diameter of right and left side of inferior articular facet are measured.
 - a. Length/A-P Diameter- it is measured from inferior border to superior vertex of the process.
 - b. Width - it is marked as length of transverse Diameter of the process.

Measurements of Second cervical vertebra (Axis):

- A. Width of dens axis- it is measured as the widest diameter of dens axis on coronal plane.
- B. Height of dens- measured as distance from the tip of dens axis to horizontal line which arbitrarily passed superior to superior articular facet of axis.
- C. Length of inferior articular process- it is measured as the anteroposterior diameter of inferior articular facet.
- D. Width of inferior articular process- it is measured as the transverse diameter of facet.
- E. Length of superior articular facet- it is measured as the anteroposterior Diameter of superior articular facet.

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- F. Width of superior articular process- it is marked as the transverse diameter of superior articular facet.
- G. Anteroposterior diameter of vertebral foramina- Measured along midsagittal plane passing through the canals widest point.
- H. Transverse Diameter of vertebral foramina- it is measured along frontal plane passing through the canals midpoint.

OBSERVATION TABLES:

Descriptive Statistics of first cervical vertebrae (Atlas)				
Observed parameters	N	Mean	Std. Deviation	Range
WIDTH OF ATLAS	75	69.028667	3.3986501	74.75-60.6
A-P DIAMETER OF VERTEBRAL CANAL	75	25.5230666	1.882662236	32.1-20.5
TRANSVERSE DIAMETER OF VERTEBRAL CANAL	75	21.9852	1.839694	27.5-18.25
HEIGHT OF ANTERIOR ARCH	75	7.4206667	1.1504727	10.85-5.3
HEIGHT OF POSTERIOR ARCH	75	5.3452	0.833724	8.85-3.25
A-P DIAMETER OF Rt. SUP. ARTICULAR FACET	75	17.7999	2.03045	21.75-12.75
A-P DIAMETER OF Lt. SUP. ARTICULAR FACET	75	18.2901	2.50672	25-11.75
TRANSVERSE DIAMETER OF Rt. Sup. ARTICULAR FACET	75	7.80747	1.2847	11.5-5.5
TRANSVERSE DIAMETER OF Lt. SUP. ARTICULAR FACET	75	8.3284	1.5433	11.6-4.15
A-P DIAMETER OF Lt. INF. ARTICULAR FACET	75	14.2653	1.77378	20.85-11.75
A-P DIAMETER OF Lt. INF. ARTICULAR FACET	75	14.8344	2.16713	20.2-10.5
TRANSVERSE DIAMETER OF Rt. INF. ARTICULAR FACET	75	10.416	1.411362	13.85-6.8
TRANSVERSE DIAMETER OF Lt. INF. ARTICULAR FACET	75	10.6573	1.479858	13.95-7.85

Table 1: Descriptive Mean and S.D. of first cervical vertebrae (Atlas)

Observed Parameters	N	Mean	Std. Deviation	Range
WIDTH OF DENS AXIS	75	6.6413333	0.99224606	8.7-5.1
LENGTH OF DENS AXIS	75	12.9492	1.3951642	16.1-10.52
DISTANCE FROM TIP OF TRANSVERSE PROCESS TO MIDLINE	75	25.42266667	2.092570728	31.8-22
VERTEBRAL CANAL A-P DIAMETER	75	16.4818667	1.12344871	18.75-13.7
VERTEBRAL CANAL TRANSVERSE DIAMETER	75	19.81213333	1.177004091	22.5-16.5
A-P DIAMETER OF Rt. SUP. ARTICULAR FACET	75	14.65027	1.442236	17-12.37
A-P DIAMETER OF Lt SUP. ARTICULAR FACET	75	14.66133	1.708897	18.6-11.8
TRANSVERSE DIAMETER OF Rt. SUP.ARTICULAR FACET	75	13.34733	1.50453	17.5-10.5
TRANSVERSE DIAMETER OF Lt. INF. ARTICULAR FACET	75	13.37733	1.646686	17-9.5
A-P DIAMETER OF Rt. INF. ARTICULAR FACET	75	9.128	1.618948	13-4.5
A-P DIAMETER OF Lt. INF. ARTICULAR FACET	75	9.033867	1.673117	12.8-5.5
TRANSVERSE DIAMETER OF Rt. INF. ARTICULAR FACET	75	6.8592	1.322132	9.9-4.25
TANSVERSE DIAMETR OF Lt. INF. ARTICULAR FACET	75	6.923867	1.429014	10.8-4.5

Table 2: Descriptive Mean and S.D. of second cervical vertebrae (Axis)

RESULT AND DISCUSSION: Atlas supports the skull and is uniquely positioned in the atlantoaxial complex. As new surgical techniques and instruments for the treatment of unstable cervical spine continue to evolve, detailed knowledge about this bone become more essential. Calculated mean value for width of atlas in our study was 69.03 mm. Max and minimum value was observed as 74.75 and 60.6mm respectively. In previous studies sengul and Kogiglu et al calculated as 74.6mm. Lang et al calculate it as 78.2 mm. Shilpa N Gosavi et al in 2012 calculated the mean value for width of atlas 69.37 mm and maximum and minimum values were 85.02 and 56.36 respectively. T. Sharma observed the mean value of Atlas width as 77 and 68 mm for male and female Punjabi population. In present study the observed mean value for anterioposterior diameter of vertebral canal of atlas is 25.52 mm. Maximum and minimum value were evaluated as 32.1 and 20.5 mm. Shilpa N Gosavi in 2012 measured the maximum Anterioposterior Diameter as 27.89 and minimum diameter was 25.66 mm. Sengul et al in 2006 observed the maximum and minimum Anterioposterior diameter 46.2 and 31.4 mm respectively. H. R. Blackley observed the mean anterioposterior diameter for Chinese male and female through radiographs as 15.55-28.0 and 16.0-26.0 mm respectively. Stanley measured the mean Anterioposterior diameter of vertebral canal of first cervical vertebrae as 21.40 mm through computer tomography. In present study the mean calculated value for transverse diameter of

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vertebral canal of Atlas is 21.985 mm. maximum and minimum observed value for transverse Diameter is 27.5 and 18.25 mm. Sengul et al in 2006 observed the mean value of transverse diameter as 28.7mm, maximum and minimum value were 33.5 and 25.2 mm respectively. Heggeness et al observed the mean transverse diameter of Atlas 32 mm. Stanley et by CT observed the mean transverse diameter of vertebral canal as 28.20 mm. Calculated mean value for height of anterior arch was 7.42 mm. observed maximum and minimum value were 10.85 and 5.3 mm. for posterior arch height is calculated 5.3 mm. for posterior arch maximum observed value was 8.85 and minimum was 3.25mm. Shilpa N gosavi et al observed the height of anterior and posterior arch as 10.33 and 8.61 mm respectively. Observed minimum and maximum value for anterior arch height was 16.19 and 6.88 mm, for posterior arch maximum value is 14.11 mm and minimum was 4.88 mm. The mean value of Anteroposterior diameter of Rt. and Lt. Superior articular facet was calculated 17.99 and 18.29 mm respectively. Maximum and minimum value of A-P diameter of superior articular process was measured as 21.75 ± 2.03 and 12.75 ± 2.50 respectively. Calculated mean transverse diameter of Rt. and Lt. Superior articular process was 7.81 ± 1.28 and 8.33 ± 1.54 mm. Gupta et al observed the mean value of A-P superior articular facet in Indian population as 19.73 mm for both side. Kandziora et al calculated the mean value of A-P diameter of superior articular facet 25.3 ± 2.22 mm in Korean population. In our present study the calculated mean value of transverse diameter of superior articular facet was evaluated as 17.99 ± 2.03 mm and 18.29 ± 2.50 mm respectively. Koing et al observed the mean value of transverse diameter of superior articular facet of right and left side as 11.6 ± 2.0 and 11.2 ± 1.5 mm in German population. Shilpa N gosavi evaluate the mean value of transverse diameter of superior articular facet 10.36 ± 1.72 mm and 10.47 ± 1.61 mm respectively.

In our present study anteroposterior diameter of inferior articular facet of atlas was calculated as 13.35 ± 1.50 mm and 13.38 ± 1.65 respectively for right and left side. Gupta et al calculated the mean value of it as 15.6 mm for both right and left side. Cattrysse et al calculated the mean value of A-P diameter of right and left inferior articular facet 17.0 ± 1.8 and 16.6 ± 1.6 mm respectively in Belgian population. Kaur et al evaluate the mean value of A-P diameter of Rt. and Lt. Side inferior articular facet as 17.54 ± 1.50 and 17.70 ± 1.60 mm. In present study transverse diameter of inferior articular facet was observed as 6.86 ± 1.32 mm and 6.92 ± 1.44 mm respectively. Shilpa N Gosavi calculated this 7.13 ± 1.0 and 7.4 ± 1.67 mm for right and left inferior articular facet. Sengul et al calculated the mean value as 14.6 ± 2.5 mm for both side inferior articular facets in Turkish population.

The distinguish feature of axis is dens or odontoid process projecting superiorly from its body. Odontoid process is hold in position against the posterior aspect of the anterior arch of atlas by the transverse ligament. Measurements of axis have been summarized as mean and standard deviation. - In present study calculated mean value for width of dens was observed 6.64 ± 0.992 mm. Maximum and minimum values were observed as 8.7 and 5.1 mm respectively. Mean value for Length of dens was evaluated 12.95 mm. Maximum and minimum values for length of dens were observed as 16.1 and 10.52 mm. T Sharma et al in 2008 studied the dimensions of axis in Punjabi population and observed the mean value of length of dens axis as 18.4 and 15.5 mm for male and female. Range of dens length was seen 17.9-19.4 mm, which is higher than values observed in our study. Tulsi et al in 1978 observed the mean value of dens length in Australian population 14.4 and 13.7 mm for male and female respectively. Range varies from 11.0-18.0 mm. Calculated mean value for A-P diameter of vertebral canal was observed 16.48 ± 1.12 mm. Range varies from 18.75-13.7 mm. Mean value for

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transverse diameter was calculated as 19.81 ± 1.18 mm. Sengul et al calculated the mean value of A-P diameter of vertebral canals of axis 20.8 mm and transverse Diameter was 24.5 mm in Turkish population. Range variation for A-P diameter was 11.5-28.9mm and range for transverse diameter varies 24.7-28.3 mm which is higher than our values. Singh et al in 2013 calculated the mean A-P diameter of vertebral canal for C2 vertebrae by plane radiograph in eastern region of Nepal as 19.89 mm and 19.67 mm for male and female respectively. Calculated A-P diameter of Rt. Superior articular facet of axis was 14.65 ± 1.44 mm and for Lt. It was calculated 14.65 ± 1.44 mm. Koing et al calculated the mean value of A-P diameter of superior articular facet of axis as 19.1 ± 2.1 and 18.7 ± 2.2 in German population. Cattrysse et al observed the mean value of A-P diameter of superior articular facet of axis vertebrae in Belgian population as 17.9 ± 1.8 and 17.7 ± 1.4 mm.

Mean values of transverse diameter of superior articular process were calculated 13.35 ± 1.50 and 13.38 ± 1.65 mm for right and left side respectively. Kandziora et al in European population observed the mean value of transverse diameter of superior articular facet as 16.6 ± 1.25 . Sengul et al in Turkish population calculated it 14.1 ± 1.6 and 14.0 ± 1.5 mm for right and left side.

Mean value for A-P diameter of inferior articular facet of axis was calculated 9.13 ± 1.62 and 9.03 ± 1.67 mm for right and left side respectively. Maximum and minimum values for right side were observed as 13 and 4.5 mm and 12.8 and 5.5 mm for left side. Gomez-Olivencia et al in Spanish population observed the A-P diameter of inferior articular facet of axis 10.1 ± 1.4 for both side. Kaur et al observed the mean value of A-P diameter of inferior articular facet as 11.54 ± 1.66 and 12.14 ± 1.58 mm in Indian population.

Observed mean value for transverse diameter of inferior articular process of axis is 6.86 and 6.92 mm for right and left side respectively. Sengul et al observed the mean value of transverse diameter of inferior articular facet in Turkish population 9.6 ± 1.7 and 9.4 ± 1.5 mm for right and left side. Kaur et al observed the same parameter as 9.23 ± 1.70 and 9.41 ± 1.61 mm for right and left side respectively.

CONCLUSION: Morphometric data's can provide more accurate measurements of anatomical elements of cervical spine that could facilitate diagnosis and preoperative planning, thus avoiding possible trauma during tissue dissection and instrument application. The first two vertebrae are particularly unique and allow the movement of the head. The results of this investigation will allow for more accurate modeling of this region, in order to assist in the development of improved spinal implants as well as more efficient surgical device placement techniques. Additionally these statistics will lead to better understanding of cervical spine functionality and its susceptibility to failure. The complex structure of the cranio- vertebral junction plays a significance role in global kinematics of the cervical spine to maintain head in upright posture. Instability at the atlas and axis requires internal fixation for immediate stability and for long term immobility. These surgical techniques and instruments continue to evolve. Transarticular screw fixation has become one of the primary treatment options for C1-C2 instability.

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Fig. 1: Width of Atlas

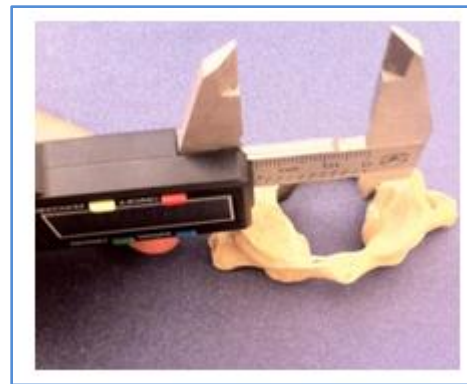


Fig. 2: Transverse diameter of vertebral canal of atlas

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Fig. 3: Height of anterior arch of atlas

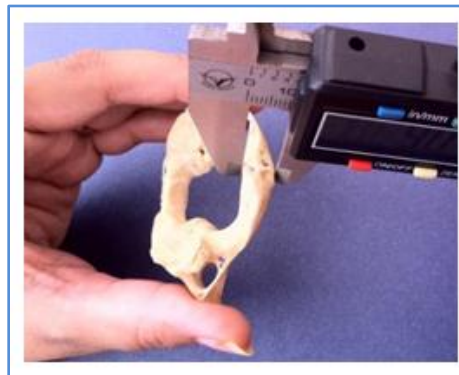


Fig. 4: Height of posterior arch of atlas



Fig. 5: A-P diameter of superior articular facet



Fig. 6: A-P diameter of vertebral canal of atlas



Fig. 7: A-P diameter of inferior articular Facet of atlas



Fig. 8: Transverse diameter of superior articular facet of atlas

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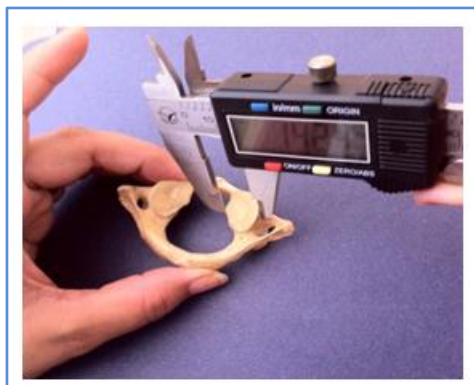


Fig. 9: Transverse diameter of inferior articular facet



Fig. 10: Width of dens of axis of atlas



Fig. 11: A-P diameter of inferior articular facet

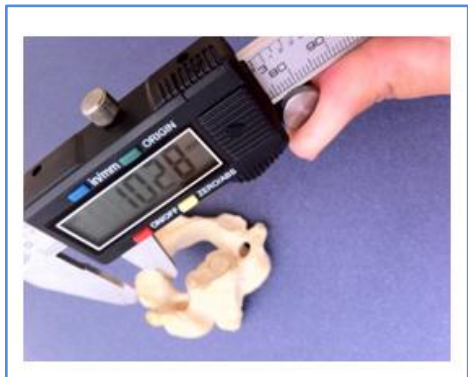


Fig. 12: Transverse diameter of inferior articular facet



Fig. 13: Transverse diameter of superior articular facet of axis



Fig. 14: A-P diameter of vertebral canal of axis



Fig. 15: A-P diameter of superior Articular facet of axis

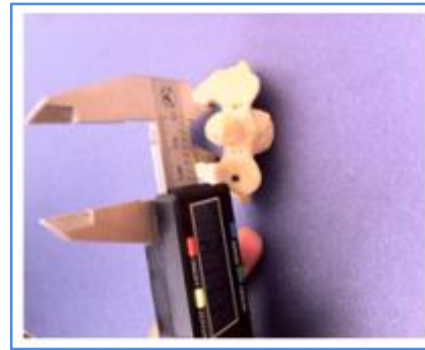


Fig. 16: Transverse diameter of vertebral canal of axis

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