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Original Research Article

MORPHOMETRY OF THE VERTEBRAL CANAL OF ATLAS AND AXIS

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ABSTRACT

Background: The vertebral canal at the level of atlas and axis vertebrae holds unique and vital anatomy. The knowledge of its various diameters is important in clinical practice. Keeping this in mind a study was carried out on atlas and axis vertebrae.

Materials and Methods: Hundred dried human atlas and axis vertebrae (50 each) available in the Deptt. of Anatomy, DMCH Ludhiana,were studied.

Results: **Atlas vertebra:** the mean of maximum antero-posterior diameter (max. APD) and maximum transverse diameter (max. TD) of vertebral canal at superior level was measured as 29.91 ± 2.60mm and 26.56 ± 2.10mm, respectively. The mean of the mean of max. APD and max.TD of vertebral canal at inferior level was measured as 28.81 ± 2.20mm and 26.92 ± 2.50mm, respectively. **Axis vertebra:** The mean of max.APD and max.TD of vertebral canal at superior level was measured as 19.06 ± 1.83 mm and 23.12 ± 1.75mm, respectively. The mean of max.APD and max.TD of vertebral canal at inferior level was measured as 15.24 ± 1.33 mm and 23.90 ± 1.86mm, respectively.

Conclusion: The parameters measured in the present study add to the knowledge in the Indian population.

KEY WORDS: Spinal Stenosis, Atlas, Axis, Vertebral Canal.

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INTRODUCTION

The cervical spine is remarkable in its ability to provide optimal positioning of the head for the key sense organs of vision and hearing through a wide array of head and neck movements [1]. The structure of the complex cranio-vertebral junction seems to play a significant role in global kinematics of the cervical spine to maintain head in upright posture [2].

It is a compromise between the stability of the vertebral column, the protection of spinal cord and the need for the movement of head on neck [1]. The stability of the cervical spine is violated by various traumatic and non-traumatic causes. Spinal stenosis is a major predisposing factor for cervical myelopathy and spinal cord injury and plays a decisive role on the outcome of injury patterns [3].

There is a strong correlation between stenosed spinal canal and injuries of cervical segment of

spinal cord so also in diseases involving cervical spinal canal and cervical spinal cord like Cervical spondylotic myelopathy, cervical neurapraxia [4]. Narrowing (stenosis) of the vertebral canal may occur at single or multiple spinal levels, and mainly affects the lumbar and cervical region [5]. In the region of cervical spine, the stenosis maybe central or foraminal. Central stenosis denotes involvement of the area between the facet joints, which is occupied by dura and its contents [6]. .

It can be either congenital or secondary to changes of degenerative disease [7].

Bony causes like osteophytes, hard discs, compression fractures, spondylolisthesis, and disc herniation may lead to degenerative changes [8].

Two distinct regions characterise the cervical spine; the occipitoatlantoaxial region (C1-C2) and the sub-axial region (C3-C7) [9].

The atlas (C1), is unique in that it fails to incorporate a centrum, whose expected position is occupied by the dens of the axis. Its two lateral masses are connected by a short anterior and a longer posterior arch. The transverse ligament retains the dens against the anterior arch. The transverse ligament divides the vertebral canal into two compartments. The anterior third (approximately) of the canal is occupied by the dens. The posterior compartment is occupied by the spinal cord and its coverings, and the cord itself takes up about half of this space (i.e. the cord, like the dens, occupies one third of the canal [5].

The axis is often described as a transitional vertebra. The weight of cranium is transferred from the occipital condyles and lateral masses of atlas to lateral masses of axis. From here the weight is transferred anteriorly to the axis body and subsequently to vertebral bodies of lower cervical vertebra. The spinal canal is more capacious at C1-2 than anywhere else, and the spinal cord is located close to instantaneous axis of rotation, which minimises distortion of spinal cord during rotation [10].

CT and MR imaging are commonly used in the evaluation of patients with symptoms related to cervical spinal stenosis. Key parameters for CT and MR evaluation of cervical stenosis include the levels of involvement, degree of stenosis, and causes of stenosis [11]. Plain radiographs provide assessment of bony structures. Neuroforaminal narrowing, facet joint space narrowing, disc space narrowing are evident using antero-posterior, lateral and oblique films in the cervical region [8].

Parameters like the sagittal and transverse diameters of the cervical canal are useful in the evaluation of stenosis.

Surgical procedures and instrumentation for management of unsteady cervical spine has evolved in recent days. The atlantoaxial region exhibits variable anatomy and there are vital neurovascular structures in its proximity [12,13]. Keeping this in mind a study was carried out on the morphometry of the diameters of vertebral canal of atlas and axis vertebra.

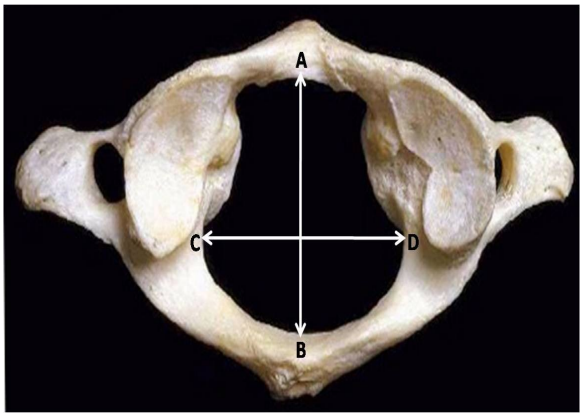
MATERIALS AND METHODS

Fifty atlas and fifty axis vertebrae, available in the Department of Anatomy, Dayanand Medical College and Hospital, Ludhiana were studied. The specimens selected were dry, complete, human cadaveric vertebrae of Indian origin. Vertebrae with gross vertebral pathology were excluded.

Various dimensions were taken with the help of Vernier Calipers, metric scale and graph paper. All the measurements were recorded in millimetres. The measured data was statistically analysed including test of significance (paired t-test). Comparison was done with existing studies.

RESULTS

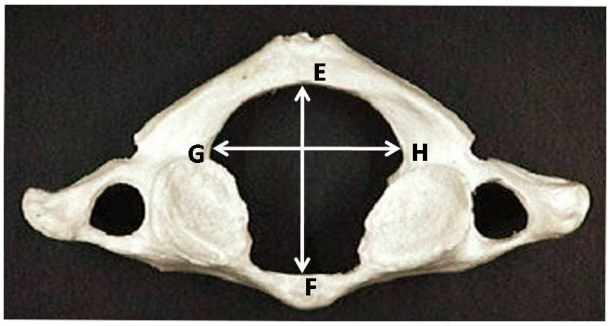
Fig. 1: Atlas Vertebra – Superior View



A–B : Maximum Antero-Posterior Diameter of Vertebral Canal

C–D : Maximum Transverse Diameter of Vertebral Canal

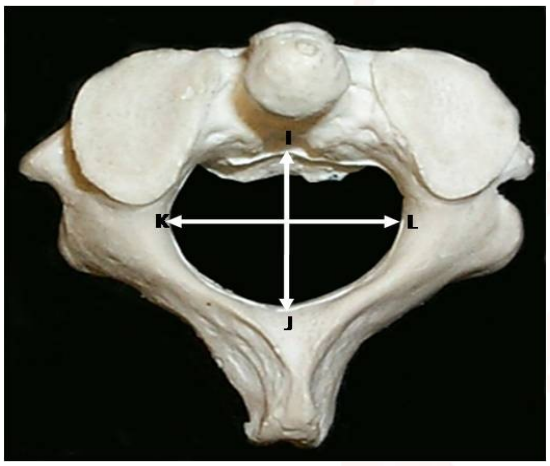
Fig. 2: Atlas Vertebra – Inferior View.



E– F : Maximum Antero-Posterior Diameter of Vertebral Canal

G – H : Maximum Transverse Diameter of Vertebral Canal

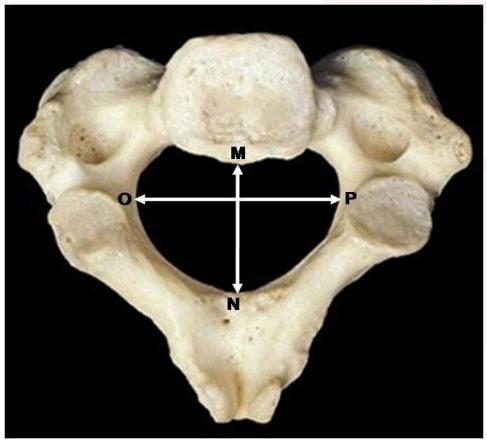
Fig. 3: Axis – Superior View.



I – J : Maximum Antero-Posterior Diameter of Vertebral Canal

K – L : Maximum Transverse Diameter of Vertebral Canal

Fig. 4: Axis – Inferior View.



M–N : Maximum Antero-Posterior Diameter of Vertebral Canal

O–P : Maximum Transverse Diameter of Vertebral Canal

The results obtained on atlas and axis are shown in Table1. Observations were recorded and tabulated. Standard statistical analysis was done. Test of significance (paired t-test) was carried out for comparison. The p value < 0.05 was considered to be significant and > 0.05 was considered to be insignificant.

Table 1: Results comparisons between Atlas and Axis.

Dimensions	ATLAS		AXIS	
	Range (mm)	Mean (mm)	Range (mm)	Mean (mm)
Max. APD (superior level)	25.16 – 35.68	29.91 ± 2.60	14.00 – 22.46	19.06 ± 1.83
Max. APD (inferior level)	24.70 – 33.68	28.81 ± 2.20	12.16 – 17.60	15.24 ± 1.33
Max. TD (superior level)	22.88 – 32.70	26.56 ±2.10	19.80 – 27.48	23.12 ± 1.75
Max. TD (inferior level)	23.10 – 36.36	26.92 ± 2.50	19.98 – 27.62	23.90 ± 1.86

Table 2: Diameters of Vertebral Canal in Atlas.

Author	Origin	Year	APD (mm)	TD (mm)
Mazzara et al 1988 [16]	American	1988	30.1 ± 2.0	28.8 ± 2.4
Doherty et al 1994 [15]	European	1994	31.7 ± 2.2	32.2 ± 2.3
Konig et al 2005 [18]	German	2005	31.0 ± 3.0	30.0 ± 3.7
Sengul et al 2006 [14]	Turkish	2006	46.2 ± 6.0	28.7 ± 1.8
Rocha et al 2007 [17]	American	2007	32.6 ± 1.8	29.7 ± 1.7
Gomez-Olivencia et al 2007 [23]	Spanish	2007	30.2 ± 1.9	29.0 ± 2.1

Table 3: Diameters of Vertebral Canal in Axis.

Author	Origin	APD (mm)	TD (mm)	APD (Inferior level)
Macalister 1894 [22]	Unknown	-	22.5	15
Mazzara et al 1988 [16]	American	19.0 ± 2.2	22.8 ± 1.5	
Doherty et al 1994 [15]	American	16.5 ± 1.7	23.6 ± 1.6	
Konig et al 2005 [18]	German	23.3 ± 2.8	17.1 ± 2.1	
Sengul et al 2006 [14]	Turkish	20.8 ± 2.7	24.7 ± 2.6	
Gomez-Olivencia et al 2007 [23]	Spanish	-	23.1 ± 1.3	16.5 ± 1.5
Wescott 2000 [24]	American			Male – 16.35 ± 1.58 Female - 16.14 ±1.58

DISCUSSION

Atlas and axis being unique, a lot of work on their morphometry has been done. Various authors have studied the diameters of vertebral canal of these vertebrae. Table 2 depicts the comparison of the studies on atlas. There is a wide range of normal, varying from 29.91 ± 2.60mm (present study) to 46.2±6.0 mm measured by Sengul et al[14], when analyzing APD of previous studies. Similarly, the TD also varies from 26.56±2.10 mm (present study) to 32.2±2.3 mm measured by Doherty et al[15]. There is a wide range of values possibly due to racial variation. Mazzara et al [16] and Rocha et al[17] studied in Americans whereas Konig et al[18] in Germans. This is observed that in Indian population (present study) the values are least but comparable with Europeans and Americans. These variations are possibly due to racial variations. Doherty et al[15] noted that there were nearly equal measurements for the

sagittal and transverse diameters. Oon CL[19] who studied on oriental population reported that the sagittal diameter of cervical canal and other diameters are less compared to Western studies.

No comparable data with respect to the diameters of vertebral canal at inferior level could be obtained to the best of our knowledge. Hence it is not possible to make a comparison table.

When comparing the APD at superior and inferior levels the difference in values was statistically significant. This work has not been reported by any other author to the best of our knowledge. So again no comparison could be done.

As the Table 3 shows many studies have been conducted on the APD and TD of the vertebral canal of axis. The APD ranges from 16.5 ± 1.7 mm as reported by Doherty et al[20] to 23.3±2.8 mm as reported by Konig et al[18]. The TD varies from 17.1±2.1 mm which is measured by Konig et al[18] to 24.7±2.6 mm reported by Sengul et al[14]. Wood- Jones[21] found that the TD of spinal canal of aboriginal axis is almost as large and relatively far larger than that of Europeons. The values measured in our studies fall within this range. It can also be observed that the TD is greater than APD in all the studies including present study, except in case of Konig et al[18]. While comparing the diameters at inferior level, present study depicts both the APD and TD which are 15.24±1.33mm and 23.90±1.86mm, respectively. To the best of our knowledge no study could be found that had measured the TD, so no comparison could be made. Whereas on comparing the APD measured by Macalister et al[22], Gomez-Olivencia et al[23] and Wescott[24] there are marginal differences (table 3). These variations can be attributed to racial differences. The difference of APD at superior and inferior level is statistically significant and possibly due to the relationship of dens and body. The TD is less variable because of the relatively parallel orientation of the medial walls of lateral mass of C2. In the cervical spine an average canal diameter of < 10 mm indicates cervical stenosis.[25] Disc herniation, extra dural mass, osteophyte formation, ligamentum flavum hypertrophy, various C2 compression fractures and spondylolisthesis can be some of the causes of cervical spine stenosis. Only bony structures can be well visualized on a plane X-ray. CT and MR imaging is considered the diagnostic tool of choice as soft tissue pathologies can also be well visualized. Present study will help to give the range of normal in Indian population.

CONCLUSION

Morphometric study on the diameters vertebral canal of atlas and axis have been done. Antero-posterior and transverse diameters were measured both from superior and inferior levels. This data provides valuable information on the Indian population.

Conflicts of Interests: None

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