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Morphometric Study Of Second Cervical Vertebra- A Dry Bone Study

Avisikta Mahata[1], Dr. Vanashri Dhananjay Shinde[*2]

[1]MBBS Student Dr. D. Y. Patil Medical college Hospital and Research Center Pimpri, Pune.

[*2]Assistant Professor, Department of Anatomy, Dr. D.Y. Patil Medical college Hospital and Research Center Pimpri, Pune.

***Corresponding Author:**

Dr. Vanashri Dhananjay Shinde

Email ID: add-vanashrishinde88@gmail.com

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ABSTRACT

Background: Amongst the seven cervical vertebrae, axis is one of the atypical cervical vertebra. Axis vertebra shows unique features, it includes modification of its body to odontoid process or dens, roomy vertebral canal; unique superior articulating facets make it different than others. The head rotates around the dens of an axis along with the atlas vertebra at the atlantoaxial joint, which permits the head to move freely.

Functionally cervical vertebrae protect the spinal cord, balance the movement of head and protect the vertebral arteries passing through their foramen transversarium. The intervertebral disc present between vertebral body acts as shock absorber.

Person in their life suffers from various disorders of cervical spine like degenerative disorders, disc pathologies, accidental injuries, osteoarthritis; spinal canal stenosis. Sometimes for treatment, surgical interventions are required. As per the literature there is racial variation is found in the dimensions of cervical vertebrae, and the space for surgical intervention is anatomically very complicated and significant. To avoid the fatal complications the instruments designed for the process must be according to the dimensions. The dimensions are also required for the anterior neurosurgical approach for the cervical reconstructions. Unfortunately, the implants are used globally, and it was observed that population variations exist in the measurements of the vertebrae. The study is carried out to provide a data of various dimensions of axis vertebra and to see the parameters which show the racial differences.

Present study is carried out with prior Ethics committee permission letter. It includes 100 dry human axis vertebrae from different medical colleges (Indian origin).Measurements are taken using digital vernier calliper and goniometer. Results are analyzed with appropriate statistical tests. Measurements are taken in millimeter, and angle in degree.

Results: Height of dens mean and SD is (14.67 ± 2.16) mm, circumference of dens Mean and SD is (33.12 ± 5.89) mm, width of dens Mean and SD is (9.95± 1.12) mm and total height of axis Mean and SD is (34.44 ±3.88) mm. In vertebral canal there is AP diameter Mean and SD is (18.19± 2.03), Transverse diameter is Mean and SD is (21.50 ±2.09). There was no statistically any significant difference about measurements of superior articulating facets of right and left side with p value much higher than(0.05). Range of dense –axis sagittal angle is 1 to 14.5 degree. Width of spinous process is more than length of spinous process. On comparison with other studies the width of dens and anterior-posterior, transverse diameter of the vertebral canal of Axis shows racial differences.

Conclusion: The dimensions will help the spine surgeons while dealing with the patients with cervical region pathology. It will also help in implants, screw, instruments designing. As the Racial differences are there in morphometry the study will helpful while treating patients of Indian origin. The findings of this study will help in Forensic and Anthropological point of view.

Keywords: *Axis vertebra, Odontoid process, Dens, vertebral Canal, Dens fracture, anterior odontoid screw fixation (AOSF), Superior articulating facets, Spinous process.*

1. INTRODUCTION

Amongst the seven cervical vertebrae, axis is one of the atypical cervical vertebra. Axis vertebra shows unique features, it includes modification of its body Odontoid process or dens, roomy vertebral canal; unique superior articulating facets make it different than others. The head rotates around the dens of an axis along with the atlas vertebra at the atlantoaxial joint, which permits the head to move freely [1]

Functionally cervical vertebrae protect the spinal cord, balance the movement of head and protect the vertebral arteries passing through their foramen transversarium. The intervertebral disc present between vertebral body acts as shock absorber.

Person in their life suffers from various disorders of cervical spine like degenerative disorders, disc pathologies, accidental injuries, osteoarthritis; spinal canal stenosis. Sometimes for treatment surgical interventions is required. As per the literature there is racial variation is found in the dimensions of cervical vertebrae, and the space for surgical intervention is anatomically very complicated and significant. To avoid the fatal complications the instruments designed for the process must be according to the dimensions. The dimensions are also required for the anterior neurosurgical approach for the cervical reconstructions [2]. Unfortunately, the implants are used globally, and it was observed that population variations exist in the measurements of the vertebrae [3].

Purpose of this study is to provide various dimensions of axis vertebra in population of Indian origin. It will helpful to surgeons to work on cervical region pathologies and implant designers to design implants and instruments. As per the literature there are racial differences in morphometry of Axis, so one of the objectives of this study is to find which parameter of the axis vertebra shows racial differences.

2. MATERIAL AND METHODS

The study is conducted with prior ethics committee's permission letter; in the period of year 2024 to 2025.One hundred dry human axis vertebrae are included in the present study from the various medical colleges in the Pune city, Maharashtra (Indian origin). Sample size is calculated by the convenient method of sampling.

Following are Inclusion and Exclusion criteria for present study-

Inclusion criteria-

1) Dry, fully ossified human Axis vertebra of unknown age and gender.

Exclusion criteria-

1) Vertebra with congenital anomalies.

2) Fracture, healed fracture.

3) Considerable destruction and disfigurement

Parameters-

Table 1- Parameters of Axis vertebra.

Sr. No.	PARAMETERS Measurements are taken in (mm) millimeter and angle in degree
1.	Height of dens [4] (fig 1)
2.	Maximum circumference of dens(fig 1)
3.	Maximum width (diameter) of dens [4](fig 1)
4.	Dense - axis sagittal angle [5](fig 1)
5.	Total height of vertebra (Anterior)[4] (figure 1)
6.	Antero-posterior diameter of inlet of vertebral canal [4](fig2)
7.	Transverse diameter of inlet of vertebral canal [4](fig2)
8.	Length of spinous process (fig 2)
9.	Width of spinous process (fig 2)
10.	Superior articulating facet [4](SAF) fig 2 Antero-posterior diameter (Right)
11	SAF -Transverse diameter (Right) fig 2
12.	SAF-Antero-posterior diameter(Left)
13.	SAF-Transverse diameter (Left)

Parameters selected are the as shown in table 1

Height of dense is measured from margin inlet of vertebral canal of axis to tip dens of axis, Total height of axis measured from anterior side from base of the body to tip of dens, dens axis angle is measured using standard goniometer with sagittal

axis as one reference line and measure the deviation of dense from sagittal plane as shown in figure 1. Maximum circumference of dens measured using thread around dense and scale, where maximum width was measured using digital vernier caliper.

Vertebral canal diameters are measured at inlet of the canal, spinous process diameters measured at maximum expansion of spinous process length measured from inlet to tip of spinous process and width is between two farthest points. In superior articulating facets measurements are taken on both right and left side AP diameter and transverse diameter using digital vernier calliper[4] with considering two farthest points. Measurements will be taken in the millimeter (mm), and angle in degree, by using vernier caliper and goniometer (Figure 2).Data is analyzed and various statistical tests are applied wherever required, study compared with the studies available of Indian and other racial origin, to arrive at conclusion.

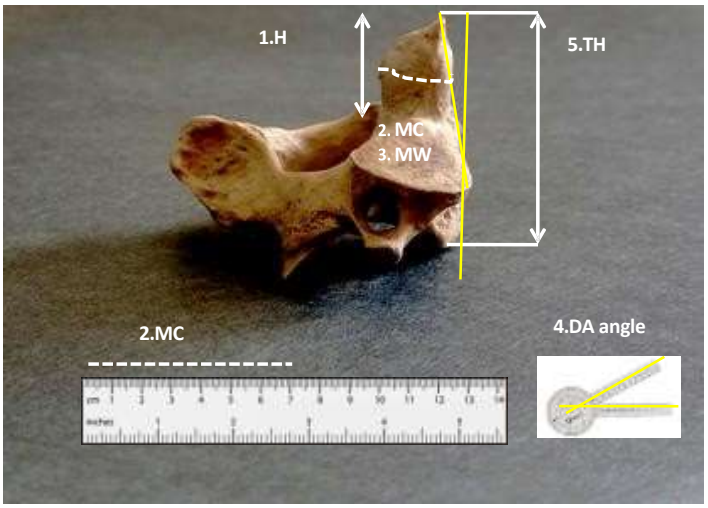

Figure 1- Methods of taking measurements.

(1.H-Height of dens,2.M- Maximum circumference of dens,3.MW- Maximum width of dens,4.DA angle- Dens –axis saggital angle,5.TH –total Height of axis)

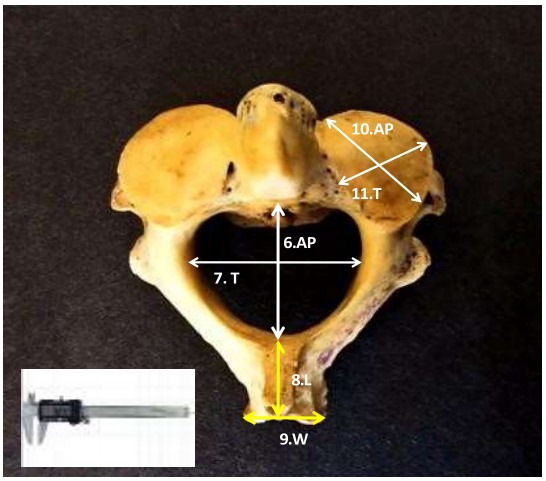

Figure 2- Methods of taking measurements

(6.AP- Anterio-posterior diameter of vertebral canal,7.T- Transverse diameter of vertebral canal,8.L- Length of Spinous process,9.-Width of Spinous Process, 10.AP- Anterio-posterior diameter of superior articulating facet, 11.T Transverse

diameter of superior articulating facet)

3. RESULTS

Table2- Mean, SD and Range of various parameters of Axis vertebra.

SR.	PARAMETER	MEAN AND SD	RANGE
1.	Height of dens	14.67±2.16	7-19
2.	Maximum circumference of dens	33.12±5.89	12.6-42
3.	Maximum width(diameter) of dens	9.95±1.12	6-12.7
4.	Dens- axis sagittal angle In degree	6.41±2.62	1-14.5
5	Total height of vertebra(Anterior)	34.44±3.88	19.7-43.3
6.	Antero-posterior diameter of inlet of vertebral canal	18.19±2.03	9.6-23.2
7.	Transverse diameter of inlet of vertebral canal	21.50±2.09	8-25.2
8.	Length of spinous process	14.59±3.32	7.2-23.9
9.	Width of spinous process	16.76±2.56	11.1-22.7
10.	Superior articulating facet (SAF) Antero-posterior diameter Right)	17.48±2.04	9.5-22.3
11	Transverse diameter SAF (Right)	15.00±1.59	7.5-18.6
12.	Antero-posterior diameter SAF(Left)	17.53±2.10	9.5-22.3
13.	Transverse diameter SAF(Left))	15.21±2.71	6.4-18.6

As seen in table 2-**Findings are -Height of dens** mean and SD is (14.67 ± 2.16) mm, **circumference of dens** Mean and SD is (33.12 ± 5.89) mm, **width** Mean and SD is (9.95± 1.12) mm and **total height of axis** Mean and SD is (34.44 ±3.88) mm.

In vertebral **canal** there is **AP diameter** Mean and SD is (18.19± 2.03) mm, **Transverse diameter** is Mean and SD is (21.50 ±2.09) mm.

There was no statistically any significant difference about measurements of **superior articulating facets** of right and left side with p value much higher than (0.05). The measurements on both sides are almost similar or mirror images.

Range of **dense –axis** sagittal angle is (1 to 14.5) degree.

Width of spinous process is more than **length of spinous process**. There is highly statistical difference between means of length and width of spinous process of axis vertebra with p value (0.0002) calculated using two sample t- test.

4. DISCUSSION

The parameters selected in this study are depends on the area of easy approach in surgical point of view, the area where on instrumentation minimum or no damage to the vital structure can occur like spinal cord, vertebral artery, spinal nerves. To correct the Dens fracture or for atlanto-axial stability easy approach is anterior approach through body of axis, dens, Superior articulating facets where minimum or no harm.

Table 3- comparison of dimensions of dens of axis with other studies.

Sr.	PARAMETER	Present study	Dr.Shilpa Gosavi et al.[4]2012	Joshi, Anagha et al.[5] (2017). MRI 2017	Goksin Sengul et al.[6] (Turkey)2006	Dr.Mukesh Singla et al. [7] 2015	Javed Alam etal.[8] 2024
1.	Height of dens	14.67±2.16	14.86± 1.54	14.73±1.52	14.5 ±2.3	14.66±1.37	14.55±1.07
2.	Maximum circumference of dens	33.12±5.89	-	-	-	-	-
3.	Maximum width of dens (diameter)	9.95±1.12	9.28±1.07	9.8±1.25	11.02 ±1.8	9.32±1.05	9.16±1
4.	Dense axis sagittal angle	6.41±2.62	-	16.02±3 (Range9-21)	9.7 ±4	13.23±4.36	13.18±4.80 (Range=2-26)
5.	Total height of axis Anterior	34.44±3.88	34.17±3.21	31.07±2.4	-	34.33±2.69	

In case of maximum width of dense in Indian population, though the study was done using MRI the result are same but in Goksin Sengul et al. [6] 2006 (Turkey) width is far more than the Indian population (11.02 ±1.8 Turkey)> (9.95+1.12 India), indicates racial difference in width of dens. As shown in table 3.

On comparison**,** Height of dens of present study with other studies measurements found are same.

In dens –axis saggital angle there is deviation of axis from sagital palne is there seen in all studies but the measurements varies in different studies. Manual error can be there. On should relay on studies done using MRI (Joshi Anagha et al. 2017) [5] for this angle as the measurements taken are in situ.

Total height of axis vertebra is almost same in all studies.

As per the parameters we recorded in dense of axis vertebra these are mean diameter of dense is 9.95 ±1.12 mm.

Formula to calculate circumference is

Circumference = 2. Π. (d/2) (where “d” is diameter)

Circumference = 2 X 3.14 X (9.95/2)

Circumference = 31.243

This is same to the circumference obtained by present study that is 33.12 ± 5.89 mm (table 2)

Which indicate that’s on transverse section or cross section the shape of dense of cervical vertebra at its maximum width is circular.

In 1974, Anderson and D’Alonzo[9] classified odontoid fractures as

1) Type I, fracture through the upper portion of the dens (tip); 2) Type II, fracture at the base of the dens, in the junction with the axis body (most common); and 3) Type III, fracture extending into the body of the axis, possibly also involving the atlantoaxial joint.

Odontoid process or dence of axis is 20% of all cervical spine fracture. Type II, most common in older patients above 70 years. Surgery is recommended in patients with Type II odontoid fracture and age above 50 years , and in patients with risk

of nonunion.

In operative management are with anterior odontoid screw fixation (AOSF) or posterior cervical fusion with or without supplemental screw fixation. [10, 11, 12, 13, 14]

Two screws inserted in coronal plane give better stability than a single screw; however, insertion of the second screw can be difficult if the dens may be too narrow in some individuals [15, 16- 18]. The minimum transverse diameter (TD) that can accommodate two 3.5 mm screws is 9.0 mm, while the minimum transverse diameter (TD) that can accommodate two 2.7 mm screws is 7.4 mm [9, 19].

Vertebral canal-

Spinal canal stenosis is term used in conditions when there is narrowing of vertebral canal because of various reasons including degenerative changes. Nerve compression give rise to symptoms like numbness, loss of sensations symptoms are progressive.

Study is carried out to know the bony diameters axis vertebral canal inlet.

Table-4: Comparison of dimensions of vertebral canal of with other studies.

Sr.No.	Parameters	Present study Indian	Dr. Shipa Gosavi [4]et al.2012 Indian	Dr.Mukesh Singla et al.2015 Indian[7]	Mzzara et al.1988 America[20]	Goksin Sengul et al. 2006 Turkey[6]
1.	Antero-posterior diameter of inlet (mm) vertebral canal	18.19±2.03	18.47±1.68	18.31± 2.05	19.0±2.2	20.8± 2.7
2.	Transverse diameter of inlet(mm) of vertebral canal	21.50±2.09	21.59±1.77	22.37± 1.73	22.8±1.5	24.7 ±2.6

Transverse diameter of vertebral canal is more than AP diameter of vertebral canal. On comparison the dimensions of present study with other studies, AP diameter of present study is 18.19±2.03 mm which is same as study done by Dr.Shipa Gosavi et al.2012 Indian [4] and Dr.Mukesh Singla et al.2015 Indian [7] but on comparision with study done by Mzzara et al.1988 America[20] and Goksin Sengul et al. 2006 Turkey [6] the dimensions are more in their studies. On comparison with other studies of vertebral canal of American and Turkish origin is roomy than Indian origin. The parameter will be useful to the Forensic and anthropology point of view. Vertebral canal of axis vertebra shows racial differences amongst other parameters of axis.

The width of spinous process of axis is more than length of spinous process.

Superior articulating facets-

Axis vertebra shows unique superior articulating facets, on both sides of these facets foramen transvesarium exists, which allow passage of the very vital structure the vertebral arteries through it. So the area where surgeon can work safely is areas of superior articulating facets.

Table 5- comparision of dimensions of superior articulating facets with other studies.

Sr.no.	Parameters	Present study	Dr.Shipa Gosavi [4]et al.2012 Indian	Goksin Sengul et al. 2006 Turkey[6]	Dr.Mukesh Singla et al.2015 Indian[7]
1.	**Superior articulating facet[4]**	17.48±2.04	16.64±1.54	17.5±1.4	16.61±1.33

	Antero-posterior diameter (Right)				
2.	SAF Transverse diameter(Right)	15.00±1.59	14.44±1.65	14.16±1.6	14.92±1.7
3.	SAF Antero-posterior diameter(Left)	17.53±2.10	16.66±1.76	17.5±1.5	16.7±1.49
4.	SAF Transverse diameter (Left)	15.21±2.71	14.64±1.42	14±1.5	14.79±1.95

AP diameter is more than Transverse diameter, and measurements are same , on right and left side there is no statically significant difference .On comparison the dimensions of **Superior articulating facet** of present study with other studies it was found they are almost same without racial difference.

5. CONCLUSION

The dimensions will help the spine surgeons while dealing with the patients with cervical region pathology. It will also help in implants, screw, instruments designing. As the Racial differences are there in morphometry the study will helpful while treating patients of Indian origin. The findings of this study will help in Forensic and Anthropological point of view.

Abbreviations- TH-total height, AP-anterio-posterior, H- height, mm- millimeter, SAF –superior articulating facet, AOSF-anterior Odontoid screw fixation

Conflict of interest- Nil

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