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Original Research Article

MORPHOLOGY AND MORPHOMETRY OF ODONTOID PROCESS OF AXIS VERTEBRA AMONG THE NORTH INDIAN POPULATION: AN ANTHROPOMETRIC STUDY

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Abstract

Background: At the atlanto-axial joint, the head revolves around the pivot formed by the axis vertebra. The odontoid process (OP) is a blunt, rod-like projection on it. Seven to twenty percent of cervical spine fractures are odontoid fractures. Consequently, knowledge of the odontoid process's (dens) morphology and morphometry is necessary for complex spinal surgical procedures including laminectomy, decompression of spinal cord that requires placement of screws, hence the current investigation intended to assess the morphometry and morphology of the odontoid process of Axis vertebrae. **Materials and Methods:** 50 dried human axis vertebrae of Indian origin, available in the Department of Anatomy, SHKM Government Medical College, Nuh, Haryana were studied. Linear measurements were recorded using vernier caliper. **Result:** The Shape of odontoid were lordosis in 66%, kyphosis in 4% and straight in 30%. The shape of the Anterior odontoid facet were observed to be vertically elliptical in 82% and 18% were Oval shaped. The posterior odontoid facet shape was horizontally elliptical in 60% and Round in 40%. The mean odontoid process height was 19.63±2.01 mm, the mean odontoid process diameter was 10.77±2.07 mm, the mean anterior odontoid facet height and the mean anterior odontoid facet width were found to be 11.70±1.70 mm and 8.01±0.76 mm respectively. The maximum and minimum mean widths of the odontoid process ranged 9.60±1.00 mm and 8.03±0.84 mm, respectively. **Conclusion:** The knowledge of these parameters can help in planning surgical fixation of odontoid process fracture and in designing the screws and prosthesis required.

INTRODUCTION

The second cervical vertebrae, Axis with Atlas forms a pivot joint and helps in the rotation of head. Understanding the intricate anatomy and mechanics of the upper cervical spine is absolutely crucial. Along with the atlanto-occipital and atlantoaxial joints, it is made up of the occipital condyles, the atlas, and the axis. The atlanto-axial articulation's movements are restricted by the apical, alar, and cruciate ligaments.[1] Along with the posterior ligament complex, the anterior and posterior longitudinal ligaments also support the cervical spine. The second cervical vertebra has a distinctive odontoid feature that serves as the axis around which the head rotates at the atlantoaxial joint. [2,3] Hence, Axis vertebrae's odontoid process morphology and morphometry were the focus of the current investigation.

MATERIALS AND METHODS

An observational study was conducted using 50 adult human axis vertebrae that had been desiccated and were kept in the Department of Anatomy. The study used a consecutive sampling approach. To ensure accurate measurements, the study only included morphologically intact axis vertebrae. Each axis vertebra was meticulously cleaned and given a number between 1 and 50. Each bone was carefully examined, and nine factors, including morphometric and morphological parameters, were assessed.
The linear morphometric measurements were concentrated on the length, breadth, and height of the axis vertebrae's odontoid process. With an

accuracy of 0.1 mm, a Vernier calliper was used for all observations. The morphological characteristics of the odontoid process (OP) (Dens) of the axis included the macroscopic appearance of the odontoid process, the shape of the anterior facet on the OP, and the shape of the posterior facet on the OP. All values underwent statistical analysis and were compared to those from other investigations.

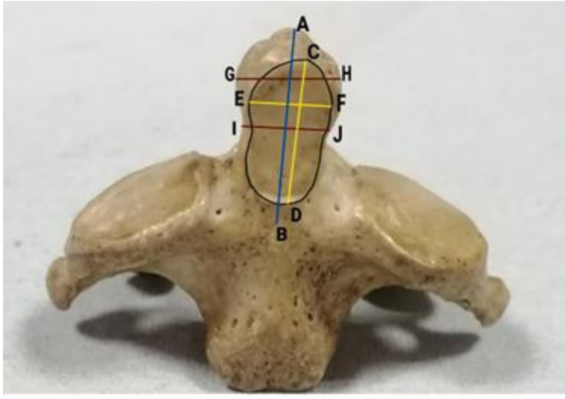

Figure 1: Anterior of Axis vertebra [AB: OP height, CD: Atlanto odontoidal facet height, EF: Atlanto odontoidal facet width, GH: OP max width, LJ: OP min width] where OP: Odontoid process.

Figure 2: Posterior view of Axis vertebrae [KL: Odontoid process diameter]

The current study measured and noted the following morphometric and morphological Odontoid process parameters. Morphometric parameters of odontoid process of axis:

1. The Odontoid Process Height (OPH) is one. It was indicated as AB = OPH after being measured from the superior border of the superior articular facets to the superior-most point of the odontoid process [Figure 1].
2. Odontoid Process Diameter (OPD): It was measured anterior to posteriorly from the odontoid process's anterior surface to its posterior surface, with the formula KL=OPD [Figure 2].
3. Atlanto-odontoidal Facet Height (AOFH): The greatest diameter across the superior margin of the facet and the inferior margin of the axis is marked by the notation CD=AOFH. [Figure 1].
4. Atlanto-odontoidal Facet Width (AOFW): The maximum transverse diameter of the atlantodental facet of the axis is represented by the notation EF=AOFW [Figure 1].
5. Odontoid Process Maximum width (OPMaxW): This width was calculated as the maximum transverse width on the anterior surface from one end to the other end and shown as GH =OPMaxW [Figure 1].
6. Odontoid Process width (OPMinW): The smallest distance on the front surface measured from end to end at the point where the dens and vertebral body meet was used to estimate the odontoid process width (OPIW), which is displayed as IJ =OPMinW [Figure 1].

Morphologic parameters of the odontoid process: [Figure 3]

1. Macroscopic appearance of odontoid process: Lordotic, Kyphotic and Straight.
2. Shape of anterior odontoid facet: Vertically elliptical and oval.
3. Shape of posterior odontoid facet: Horizontally elliptical and Round.

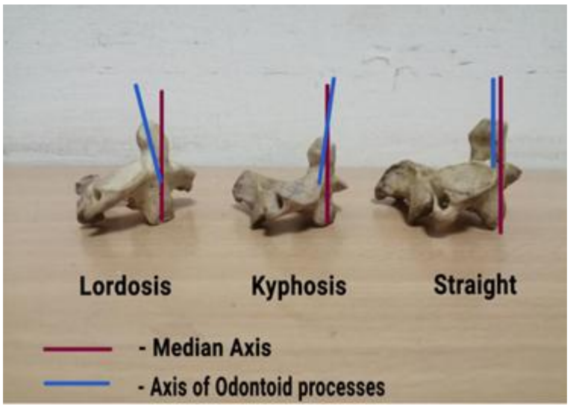

Figure 3: Various types of morphology of Odontoid process: Lordosis (backward bending), Kyphosis (Forward bending) and Straight.

RESULTS

Fifty morphologically complete Axis vertebrae were examined for morphological features and morphometrical parameters. The observations of morphological features of Odontoid process of axis vertebrae were as follows:

The Shape of Odontoid process in 33, 2, 15 Axis vertebrae were lordosis (66%), kyphosis (4%) and straight (30%) respectively. The shape of the Anterior Odontoid facet (AOF shape) were observed to be Vertically elliptical in majority 41 vertebrae (82%) and remaining 9 (18%) were found to be Oval shaped. Whereas horizontally elliptical type were more common in 30 axis vertebrae (60%) and Round in rest of 20 axis vertebrae (40%) while

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examining the posterior Odontoid facet shape (POF shape).

The mean Odontoid process height (OPH) was found to be 19.63±2.01 mm with a range of 16.04 - 24.23 mm. The mean Odontoid process diameter (OPD) was measured to be 10.77±2.07 mm and the range was 8.33 - 23.09 mm. The mean anterior Odontoid facet height (AOFH) and the mean anterior Odontoid facet width (AOFW) were found to be 11.70±1.70 mm (range: 6.94 - 15.68 mm) and 8.01±0.76 mm (range: 6.42 - 9.50 mm) respectively. The average of the maximum and minimum widths of the Odontoid process were 9.60±1.00 mm (range: 7.21 - 11.67 mm) and 8.03±0.84 mm (range: 5.60 - 9.63 mm) respectively.

Table 1: Comparison of Morphological features of Odontoid process of present study and other studies (original)

Features	Type	Present study n= 50		Lalith et al (2019) n=60	
		N	%	N	%
Shape of OP	Kyphosis	2	4%	10	16.66%
	Lordosis	33	66%	44	73.33%
	Straight	15	30 %	6	10.00%
AOF Shape	Vertically elliptical	41	82%	50	83.30%
	Oval	9	18%	10	16.66%
POF Shape	Horizontally elliptical	30	60%	46	76.66%
	Round	20	40%	14	23.33%

Table 2: Comparison of Morphometrical parameters of Odontoid process of present study and other study.

S.no	Author & Year	n	OPH Mean ± SD (mm)	OPD Mean ± SD (mm)	AOFH Mean ± SD (mm)	AOFW Mean ± SD (mm)	OPMaxW Mean ± SD (mm)	OPMinW Mean ± SD (mm)
1.	Lalith et al (2019)	60	16.36+1.68	10.74+1.06	8.87+1.77	7.89+1.15	9.85+1.08	8.79+1.17
2.	Gosavi et al (2012)	100	14.86 ± 1.54	9.92 ± 0.94	9.39 ± 1.95	7.47 ± 1.29	9.28 ± 1.07	8.76 ± 0.88
3.	Teo EC et al (2017)	5	17.8 +1.0	12.4 +1.5	-----	-----	11.5 +0.8	11.2 +0.8
4.	Naderi et al (2006)	120	15.5±1.8	11.3±1.0	10.5	8.8	10.5±0.9	9.3±0.9
5.	Present study	50	19.63±2.01	10.77±2.07	11.70±1.7	8.01±0.76	9.60±1.00	8.03±0.84

DISCUSSION

The axis is frequently referred to as a transitional vertebra. The occipital condyles and lateral masses of the atlas transfer the weight of the head to the lateral masses of the axis. From this point, the weight is carried anteriorly to the axis body and from there to the lower cervical vertebral bodies. The spinal cord is situated near to the instantaneous axis of rotation and the spinal canal is larger at C1-2 than anywhere else, minimising spinal cord distortion during rotation. [3]

A tooth-like, blunt projection called the odontoid process or the dens emerges from the superior surface of the axis vertebra's body. [4] It forms at the centre of the atlas and is made up of the thick head and the narrow neck. The atlantodental articulation is formed by the anterior surface of odontoid process, which has an oval articular facet for articulation with the anterior arch of the atlas. The body of the axis extends downward anteriorly and is deeper in the front than the back, covering the top and front portion of the third cervical vertebra. Due to its ligamentous attachments, the odontoid process serves as the atlanto-axial joint's primary source of support.[5] Fractures of the second cervical vertebra, which account for around one-third of all cervical spine fractures, are the most frequent injury seen in spine surgery.

In younger patients, the aetiology is high-energy processes, while in the elderly population, it is low-energy trauma. Odontoid fractures are the C2 spinal injury subset that occurs most frequently. Accurate radiological evaluation and assessment of the morphometric parameters of the odontoid process are essential for achieving stable fixation and fusion of odontoid fractures. Odontoid process fractures account for 50–60% of all C2 fractures, 7%–27% of cervical vertebral column fractures, and 1%–2% of all vertebral column fractures. Degenerative illnesses, inflammatory illnesses, cancers, and congenital C2 abnormalities (such odontoideum and odontoid agenesia) are also well-known. Internal fixation is necessary for instability at the atlas and axis in order to achieve a solid fusion by providing both short-term stability and long-term immobility. This can be accomplished using a wide range of surgical techniques, such as anterior odontoid screw fixation or posterior fusion techniques like the Brooke-Jenkins approach, interlaminar clamps, etc. The size of the odontoid process has a direct impact on the method of internal fixation used. High consolidation rates, improved rigidity, and increased rotational stability are all benefits of two-screw fixation.[6-8]

The knowledge about the morphology, morphometry of Odontoid process of axis vertebra is very important and essential at the time of surgical approach during correction of odontoid process of axis fracture. Following are the morphological and morphometrical parameters of present study in comparison with that of the other studies.

The findings of the morphological features of Odontoid process from the present study were compared with the findings of the study did by Lalith et al (2019) as follows, the shape of the Odontoid process were majorly lordotic than kyphosis same as in the present study, the Odontoid process were mostly lordotic (66%) than kyphosis (4%) and straight in 30% of axis vertebrae. In present study and Lalith et al AOF shape were mostly vertically elliptical 82% and 83.30% Repectively and rest were oval, 18% in present study and 16.66% in Lalith et al. And shape of POF were mostly horizontally elliptical in 30 (60%) in present study and in 46 axis (76.66%) as studied by Lalith et al [Table 1].

The mean Odontoid process height (OPH) was observed to be 19.63±2.01 mm in present study, and 16.36+1.68 mm by Lalith et al (2019), 14.86 ± 1.54 mm as measured by Gosavi et al (2012), 17.8 +1.0 mm by Teo EC et al (2017) and 15.5±1.8 as reported by Naderi et al (2006). The Height of the Odontoid process is greater in the present study [Table 2].

The mean Odontoid process Diameter (OPD) was found to be 10.77±2.07 mm in present study. And it was 16.36+1.68 mm, 14.86 ± 1.54 mm, 17.8 +1.0 mm and 15.5±1.8 mm by Lalith et al (2019), Gosavi et al (2012), Teo EC et al (2017) and Naderi et al (2006) respectively [Table 2].

Anterior Odontoid facet height and width were measured to be 11.70±1.70 mm and 8.01±0.76 mm respectively during the present study. Anterior Odontoid facet height (AOFH) was observed as 8.87+1.77 mm by Lalith et al (2019) , 9.39 ± 1.95 mm by Gosavi et al (2012) and 10.5 mm by Naderi et al.[9] Anterior Odontoid facet width was found as 7.89+1.15 mm, 7.47 ± 1.29 mm and 8.8 mm by Lalith et al (2019), Gosavi et al (2012) and Naderi et al (2006) respectively [Table 2].

The mean values of Odontoid process width, maximum and minimum observed in present study were 9.60±1.00 mm and 8.03±0.84 mm respectively. The Maximum and minimum values of Odontoid process width found by other studies were 9.85+1.08 mm and 8.79+1.17 mm by Lalith et al (2019), 9.28 ± 1.07 mm and 8.76 ± 0.88 mm by Gosavi et al (2012), 11.5 +0.8 mm and 11.2 +0.8 mm by Teo EC et al,[10] and 10.5±0.9 mm and 9.3±0.9 mm as study done by Naderi et al.[9] [Table 2].

CONCLUSION

This anthropometric study of Odontoid process of axis vertebrae provides information regarding the morphometric dimensions of odontoid process which will be beneficial for spinal surgeons and orthopedicians during any surgical procedure on the axis and for a safe and efficient application of the novel orthopaedic interventional techniques, including the prediction of screw size during occipito-cervical fixation procedures or anterior trans-odontoid screw fixation for odontoid fractures. This study may help radiologists in measuring the parameters of the axis vertebra in CT and MRI if necessary. The biomedical industry can use this information to create trans pedicle, trans laminar, and trans odontoid screws and prosthesis that are employed during second cervical vertebra surgery. A thorough understanding of the cervical spine and its surrounding anatomy is necessary as these surgical procedures and tools continue to advance. The study may also be helpful for anthropologists and forensic experts in knowing the racial differences. To prevent any variation-related surgical difficulties, it is advised to perform a CT scan before to surgery.

Limitations: At least half of the bones from the same cadaver from which the axis was taken must be used in order to accurately determine the sex and age of any bone. The department's collection of individual axis vertebrae is used in this investigation. Therefore, the axis vertebrae's age and gender are not taken into account in the current study.

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