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Morphometric Study of the Odontoid Process of Axis Vertebra and its Clinical Implications

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ABSTRACT

The distinguishing characteristic of the axis vertebra is the odontoid process. The axis vertebra has a very different form from the other cervical vertebrae. Surgery for axis vertebral fractures is very risky. These fractures are rather prevalent. As such, it is essential to have a solid grasp of the anatomical diversity prior to performing the surgery. Measuring the precise morphometric parameters of the odontoid process of the axis vertebra was the goal of the current investigation. This study analyzed 50 fully ossified human axis vertebrae of unknown gender and age, using a cross-sectional design. We measured various dimensions of the odontoid process, including its anterior height, anteroposterior (AP) diameter, maximum width, width and dens axis sagittal angle. A digital vernier caliper and conventional goniometer were used to measure different morphometry of the odontoid process. The data was collected, tabulated, and statistically analyzed using GraphPad Prism version 4.03. In our study, we found that the average height of the odontoid process of the axis vertebra was 14.81±1.17 mm, while the anteroposterior (AP) diameter was 10.05±0.88 mm. The maximum width of the odontoid process was 10.24±0.90 mm and the average width was 9.34±1.06 mm. Additionally, the dens axis sagittal angle was found to be 12.86±4.70 degrees. To help surgeons avoid and minimize complications like vertebral artery injury, cranial nerve damage and injury to other vital structures when performing any surgical or interventional procedure around the cranio-vertebral region the present study provided us with important anatomical data on various parameters of the axis of Indian origin.

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Key Words
Odontoid process, vernier caliper, axis vertebrae, morphometry

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INTRODUCTION

A mature human's vertebral column is made up of thirty-three vertebrae, which are separated into five regions four coccygeal, five lumbar, five sacral, seven cervical and twelve thoracic vertebrae[1]. With an odontoid process and superior articular facets with special characteristics the axis is an unusual second cervical vertebra. The atlantoaxial joint, which it forms pivotally with the atlas, permits the atlas to rotate, extending the head's range of motion[2,3]. The axis is an essential part of the craniocervical junction and is made up of the tip, body, neck and base[4]. The structural differences of the axis should be known to clinicians who work in the fields of diagnosis, treatment and operation[5]. The cervical region, which connects the head and body, is the most flexible part of the vertebral column. It houses several important structures. Dense axis fractures can be treated using conservative measures, surgery, or a combination of both. Treatment options for axis fractures may include surgical interventions such as plates and screws osteosynthesis, fusion of the first and second vertebrae (C1-C2), or using one or two screws to fix the axis dens fracture[6]. The ideal screw application depends on the kind of fracture and the odontoid process's structure[7]. Roughly 10-14% of all cervical region fractures are caused by a fracture of the dens of the axis[8]. For the right diagnosis and treatment, it is essential to comprehend the distinct anatomy and architecture of the axis, particular fracture patterns, and the mechanism and biomechanics of the dens. Prior knowledge of the anatomical structure is essential, particularly for anterior and posterior surgical fixation[9,10]. It should be mentioned that because of the intricate structure of the craniocervical region, even very little alterations in this area might result in quite serious consequences. For the purpose of placing components like screws and plates, several surgical techniques need the use of standard landmarks. Precise morphometric understanding is also required for the structural properties of the materials employed in the operation, including the thickness and length of the screw. It is important to know the key landmarks to reduce the time needed for surgery, minimize the occurrence of complications and identify variations among different populations before the procedure. In surgical procedures involving the odontoid process of the axis vertebra, understanding various morphometric parameters is crucial.

Aims and objective: The objective of this present study was to measure the detailed morphometric parameters of the odontoid process of the axis vertebra.

MATERIALS AND METHODS

In the current work, fifty ossified dried human axis vertebrae of unknown gender and age were examined in a cross-sectional fashion. These axis vertebrae were preserved well and were complete in all aspects, making them suitable for accurate morphometric observations of the odontoid process. They belonged to adult individuals and were obtained from the Department of Anatomy of Jannayak Karpoori Thakur Medical College, Madhepura, and Srikrishna Medical College, Muzaffarpur, Bihar.

Exclusion criteria: Any bones with severe abnormalities impacting the odontoid process, healed fractures, considerable destruction, or fragmentation were not included in the study. For the purposes of the investigation, only undamaged axis vertebrae devoid of congenital defects, osteophytes, or physical trauma were used. A digital vernier calliper, with a 0.01 mm sensitivity and a 0.01 mm least count detected, was used to obtain two linear measurements. A standard goniometer was used to measure each angular parameter. The analysis took into account the average of the two measurements. The following parameters were studied:

The anterior height of the odontoid process: This measurement is taken from the highest point of the odontoid process i.e. tip of the dens to the arbitrary horizontal line that passes the superior border of the superior articular facets. (AC in Fig. 1).

Anteroposterior (AP) diameter of the odontoid process: This is the measurement taken from the anterior surface to the posterior surface of the odontoid process.

Maximum width of the odontoid process: This measurement is taken as the maximum transverse width on the anterior surface from one end to the other end (DE in Fig. 1).

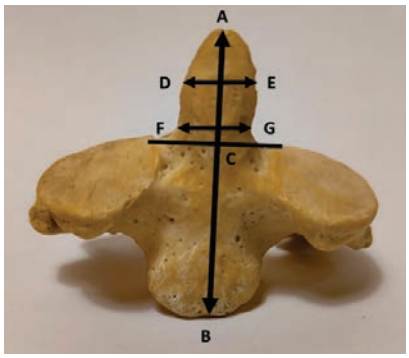

Fig. 1: Showing different points used for the morphometric measurement of the odontoid process. AC: Anterior height, DE: Maximum width, FG: Width of the odontoid process

Table 1: Showing different morphometric parameters of the odontoid process

Parameters	Mean (mm)±SD	Range (mm)
Anterior Height	14.81±1.17	12.59-17.90
Anteroposterior (AP) diameter	10.05±0.88	8.21-11.89
Maximum width of odontoid process	10.24±0.90	8.48-12.33
Width of odontoid process	9.34±1.06	7.11-11.69
The dens axis sagittal angle (in degree)	12.86±4.70	2º-24º

Table 2: Showing comparison of different morphometric parameters of the odontoid process observed by other authors

Authors (year)	Anterior height (mm)	Anteroposterior (AP) diameter (mm)	Width of odontoid process (mm)	The dens axis sagittal angle (in degree)
Doherty and Heggeness[11]	----	11.2	10.8	---
Xu *et al*.[13]	Male: 15.5±1.8			
Female: 14.6±1.5	Male: 10.3±0.7			
Female: 9.6±0.9	Male: 10.0±0.9			
Female: 10.0±0.9	---			
Naderi *et al*.[14]	15.5±1.8	11.3±1.0	10.5±0.9	---
Senegul and Kodiglu[12]	14.5	---	11.2	9.7
Gosavi Swamy[15]	14.86	9.92	9.28	---
Singla *et al*.[16]	14.66±1.37	10.1±0.91	9.32±1.05	13.23±4.36
Teo *et al*.[17]	17.8	9.4	12.4	59.7
Yousuf *et al*.[18]	15.8	10.7	10.3	52.2
Present study[19]	14.81±1.17	10.05±0.88	9.34±1.06	12.86±4.70

Width of the odontoid process: This is the smallest distance on the front surface measured from end to end at the point where the dens and vertebral body meet (FG in Fig. 1).

The dens axis sagittal angle: This is the angle formed by a vertical line on a sagittal plane and an axis that runs longitudinally via the Dens Axis. A mini-inclinometer is used to measure this angle. The data was collected, tabulated and statistically analyzed using Graph Pad Prism version 4.03. Mean and standard deviation were used to express continuous variables in this study.

RESULTS

In our study, we found that the average height of the odontoid process of the axis vertebra was 14.81±1.17 mm the anteroposterior (AP) diameter was 10.05±0.88 mm and the maximum width of the odontoid process was 10.24±0.90 mm. Additionally, we observed that the average width of the odontoid process was 9.34±1.06 mm and the dens axis sagittal angle was 12.86±4.70 degrees. (Table 1).

DISCUSSIONS

The axis is characterized by the presence of specialized superior articulating facets and dens or odontoid processes extending superiorly from its body. For the assessment of various clinical issues, it is necessary to know the precise measurements and form of this bone[11]. Various surgical procedures, such as interlaminal clamping, interspinous wire and plate and screw fixation, are required to treat instability in the atlantoaxial complex or occipito-cervical junction that can be caused by a range of traumatic and non-traumatic disorders. While transpedicular screw fixation in the cervical column has many benefits, there is ongoing debate about possible risks. Adjacent critical tissues, including the spinal cord, nerve roots, cranial nerves and vertebral arteries, may suffer damage from improper pedicle screw implantation[12]. There are hints that our understanding of the geometry and size of the axis is improving as novel internal fixing techniques develop[11]. It is important to consider the morphometric parameters of the odontoid process of the axis vertebra when performing various surgical procedures. In Table 2, we have compared the parameters of the odontoid process from our study to those reported by other researchers in previous studies.

Our observations are very near to the findings of Naderi *et al*.[14], Senegul and Kodiglu[12] and Singla *et al*.[16]. The discrepancies observed in the parameters between research could potentially be attributed to the disparities in the ethnic backgrounds of the vertebrae included in each study. In the event of a fracture, it is crucial to determine the diameter and length of the odontoid process when choosing between using one or two screws. A thorough understanding of the technical aspects and bone quality is essential before performing a surgical fixation. These variables dictate how the odontoid process fracture line is treated[19]. When the fracture happens at the base of the odontoid process where it connects to the axis's body the best course of treatment is up for debate. The typical process entails posterior fusion arches of the axis and atlas but for stabilization to be effective, this may need extra external immobilization. Although this method improves spinal stabilization, it has drawbacks in that it limits the normal rotation between the atlas and axis, which typically accounts for over half of the cervical spine's normal axial rotation[16].

Limitations of the study: The age and sex of the axis vertebra were not examined in this investigation due to its unavailability.

CONCLUSIONS

To help surgeons avoid and minimize complications like vertebral artery injury, cranial nerve damage and injury to other vital structures when performing any surgical or interventional procedure around the cranio-vertebral region the present study provided us with important anatomical data on various parameters of the axis of Indian origin.

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