

## MRI STUDY OF ODONTOID PROCESS OF AXIS VERTEBRA

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## ABSTRACT

**Background:** The features of the odontoid process and vertebral body of axis vertebra through MRI can be assessed. **Objective:** To evaluate the morphology of odontoid process and body of axis vertebra in male and female Pakistani population through MRI. **Methodology:** This cross sectional study was conducted on fifty males and fifty females (24 – 70 years of age) were randomly selected from the MRI suit of Radiology department Sheikh Zayed Hospital, from 1<sup>st</sup> June 2014 to 30<sup>th</sup> June 2015. Patients with gross pathology or degenerative bone disease and those with evidence of an injury to upper cervical spine were excluded from the study. The measurements of odontoid process (height, AP diameter & vertical angle) were assessed. Height of axis vertebra and various parameters of vertebral body of the axis were observed. The data was entered and analyzed by using SPSS version 24. **Results:** The mean height of odontoid process was 19.2 mm in females and 20.7 mm in males. The mean AP diameter of odontoid process was 10.1 mm in females and 10.6 mm in males. The mean vertical angle of odontoid process was 60.0° in females and 61.4° in males. The mean height of axis vertebra was 35.6 mm in females and 38.3 mm in males. Anterior body height of axis vertebra was 16.4 mm in females and 17.7 mm in males. Posterior body height was 13.9 mm in females and 14.5 mm in males. The mean AP diameter of the axis body was measured to be 15.9 mm in females and 17.0 mm in males. **Conclusion:** The findings in this study may be useful to the surgeons to avoid injury to vital structures while working around the axis vertebra. These observations may be helpful to devise new methods of fixation of fractures of odontoid process which may decrease the time of union and danger of nonunion.

**Keywords:** Odontoid Process, Axis vertebra, Vertical angle of dens, MRI.

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## INTRODUCTION

Morphology of odontoid process or dens of the second cervical vertebra (axis) has received relatively little attention in the literature despite the importance of this structure in cervical spine fractures. Odontoid fractures are common injuries occurring in 8-15% of patients with cervical fractures.<sup>1,2</sup> In younger group they are often secondary to high energy trauma as motor vehicle accidents. In elderly they appear as a result of low-energy impacts, such as falls from standing height.<sup>3,4</sup> Odontoid fractures are the most common cervical spine fractures for patients older than 70 years and are the most common spinal fractures in the patients older than 80 years.<sup>5</sup> The incidence of associated neurological injury has ranged from 2-27% across multiple studies.<sup>6-8</sup>

Because of the high risk of non-union in odontoid fractures and its associated neurological injuries, the investigators have recommended screw fixation techniques for the treatment of odontoid fractures. The odontoid screw fixation technique was first used by Nakanishi et al<sup>9</sup> in 1978. Later many other investigators<sup>10-13</sup> treated the odontoid fractures by using the technique of odontoid screw fixation.<sup>14</sup>

Few studies are available that are performed on human skeletal material which provides information about the axis vertebra and its odontoid process. It has been stated that the odontoid process is a conical, peg-like process that projects superiorly approximately 1.5 cm from the body of the second cervical (axis) vertebra; the odontoid process is also typically waisted near its basal region.<sup>15,16</sup> Keobke<sup>17</sup> and Reid & Leung<sup>18</sup> studied the shape and orientation of the odontoid process with regard to the body of the axis. Tulsi<sup>19</sup> examined only the structure of odontoid process from Australian aborigines and noted variability in the shape of the dens. There is scarcity in the literature regarding the study of axis vertebra and its odontoid process by MRI. The objective of the current study was to examine the morphology of the odontoid process and body of axis vertebra by MRI.

## METHODOLOGY

This cross sectional study was carried out at Sheikh Zayed Hospital, Rahim Yar Khan. Fifty male and fifty female cases were randomly selected from the MRI suit of Radiology department who visited the hospital for injury of the cervical region from 1<sup>st</sup> June 2014 to 30<sup>th</sup> June 2015. Those patients who suffered from gross pathology or degenerative bone disease

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and those with evidence of an injury to the upper cervical region (C1 & C2), were excluded from the study. All the selected images were from patients between 24 and 70 years of age at the time of MRI. All the MRIs were showing sagittal views of the axis vertebra and following measurements were made by using the software already fed in the computer system of MRI machine (Siemens Avanto Magnetom 1.5 Tesla, Germany).

**Height of Odontoid Process:** Height of the odontoid process was measured by a vertical line in its central axis from the apex to the level of a plane showing low-signal line or hypointense disc, horizontally placed, at the base of the odontoid process. (Figure II)

**Anteroposterior Diameter of Odontoid Process:** Anteroposterior (AP) diameter was measured by a horizontal line drawn in the center of the odontoid process. (Figure II).

**Vertical Angle of Odontoid Process:** The angle made by a vertical line, touching the anterior surface of the odontoid process, and a horizontal line, touching the anterior and posterior points of the inferior surface of the vertebral body (Figure I).

**Height of Axis Vertebra:** It was measured from tip of odontoid process to inferior surface of vertebral body anteriorly. (Figure II)

**Anterior Vertebral Body Height:** It was measured by a vertical line on the anterior surface of the body starting at the base of the dens (low-signal line) to the anteroinferior body surface. (Figure II)

**Posterior Vertebral Body Height:** It was measured by a vertical line on the posterior surface of the body starting at the base of the dens to the posteroinferior body surface. (Figure II).

**Anteroposterior Vertebral Body Diameter:** Anteroposterior (AP) diameter of the vertebral body was measured by a horizontal line drawn in the center of the vertebral body. (Figure II)

All the data were analyzed by using the SPSS software version 24.

## RESULTS

The mean height of odontoid process measured was  $19.2 \pm 0.18$  mm in females and  $20.7 \pm 0.19$  mm in males. The mean anteroposterior (AP) diameter in the center of the odontoid process was  $10.1 \pm 0.12$  mm in females and  $10.6 \pm 0.13$  mm in males. The mean dens vertical angle was  $60.0^\circ \pm$

$3.1$  in females and  $61.4^\circ \pm 3.2$  in males as shown in Table I.

**Table I: Measurements of odontoid process (dens) in both sexes through MRI.**

Sex	n	Height of Odontoid Process (mm)		A. P. Diameter of Odontoid Process (mm)		Mean Dens Vertical Angle	
		Mean (S.D.)	Range	Mean (S.D.)	Range	Mean (S.D.)	Range
Females	50	$19.2 \pm 0.18$	14.1 – 22.9	$10.1 \pm 0.12$	7.1 – 12.1	$60.0^\circ \pm 3.1$	$50^\circ - 68^\circ$
Males	50	$20.7 \pm 0.19$	16.0 – 24.1	$10.6 \pm 0.13$	7.4 – 13.6	$61.4^\circ \pm 3.2$	$52^\circ - 70^\circ$

**Table II: Total anterior height and vertebral body parameters of axis vertebra in both sexes measured through MRI.**

Sex	n	Total Anterior Height of Axis (mm)		Anterior Body Height (mm)		Posterior Body Height (mm)		A.P. Diameter of Body (mm)	
		Mean (S.D.)	Range	Mean (S.D.)	Range	Mean (S.D.)	Range	Mean (S.D.)	Range
Females	50	$35.6 \pm 0.31$	27.3 – 39.8	$16.4 \pm 0.19$	12.2 – 19.2	$13.9 \pm 0.24$	9.5 – 18.1	$15.9 \pm 0.20$	11.1 – 19.0
Males	50	$38.3 \pm 0.28$	31.4 – 43.2	$17.7 \pm 0.16$	13.4 – 21.0	$14.5 \pm 0.23$	9.6 – 19.1	$17.0 \pm 0.19$	10.7 – 20.5

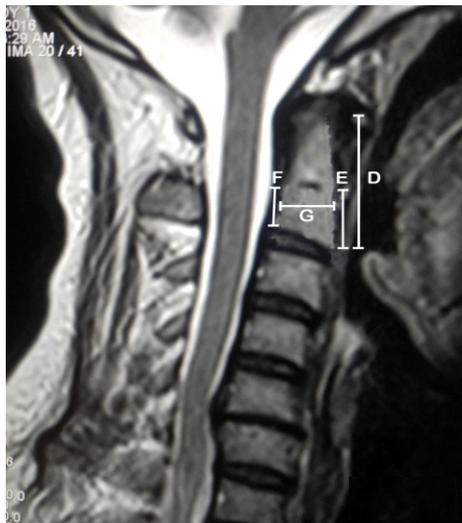
**Figure I: Various measurements of odontoid process. A = height, B = anteroposterior (AP) diameter, C = vertical angle.**



The mean total height of axis vertebra was  $35.6 \pm 0.31$  mm in females and  $38.3 \pm 0.28$  mm in males. The mean anterior body height of axis vertebra was  $16.4 \pm 0.19$  mm in females and  $17.7 \pm 0.16$  mm in males.

The mean posterior body height was  $13.9 \pm 0.24$  mm in females and  $14.5 \pm 0.23$  mm in males. The mean anteroposterior (AP) diameter of the body was  $15.9 \pm 0.20$  mm in females and  $17.0 \pm 0.19$  mm in males as shown in Table-II.

**Figure II: Total height and vertebral body measurements of axis vertebra. D = total height of axis, E = anterior vertebral body height, F = posterior vertebral body height, G = anteroposterior (AP) diameter of vertebral body.**



## DISCUSSION

MRI is one of the useful diagnostic tool to assess vertebral bones. Our study revealed that MRI has capability of demonstrating the remnant of dentocentral synchondrosis in sagittal images. Our study demonstrated that the height of the odontoid process was  $19.2 \pm 0.18$  mm in females with range of 14.1 – 22.9 mm and  $20.7 \pm 0.19$  mm in males with range of 16.0 – 24.10 mm. Our results were comparable with those of Kandziora et al<sup>20</sup> which reported to be  $20.3 \pm 1.90$  mm. Our results showed higher values when compared with other studies<sup>21-24</sup> which might be due to the techniques used by these researches because most of the authors utilized dried bones for their research.

Our study revealed the anteroposterior (AP) diameter of odontoid process in the center as  $10.1 \pm 0.12$  mm in females with range of 7.1 – 12.1 mm and  $10.6 \pm 0.13$  mm in males with range of 7.4 – 13.6 mm. Our findings of AP diameter of odontoid process are comparable to the rest of the previous studies as shown in Table-III.

The vertical angle of the odontoid process (dens) in our study was  $60.0^\circ \pm 3.1$  in females with range of  $50^\circ - 68^\circ$  and  $61.4^\circ \pm 3.2$  in males with range of  $52^\circ - 70^\circ$ . Search of literature revealed that only Xu et al<sup>24</sup> and Gosavi & Swamy<sup>22</sup> studied this vertical angle of dens while performing their studies on dried bones. Xu et al<sup>24</sup> reported the

vertical angle as  $64.3^\circ \pm 3.8$  in females with range of  $60^\circ - 71^\circ$  and  $64.1^\circ \pm 3.9$  in males with range of  $58^\circ - 75^\circ$ . Gosavi & Swamy<sup>24</sup> reported this angle as  $53.6^\circ$ . These results coincide well with our present study.

**Table III: Comparison of results reported in the present study and the studies reported in the literature.(in mm)**

Parameters	Present Study	Singla et al. <sup>21</sup> 2015	Gosavi&Swamy <sup>22</sup> 2012	Naderi et al <sup>23</sup> 2006	Kandziora et al <sup>20</sup> 2001	Xu et al <sup>24</sup> 1995	Schaffer et al <sup>14</sup> 1992
<b>A: Dens Height</b>	Fm: $19.2 \pm 0.18$ (14.1–22.9) M: $20.7 \pm 0.19$ (16.0–24.1)	$14.66 \pm 1.37$	$14.86 \pm 1.54$	$15.5 \pm 1.8$ (11.5–19.8)	$20.3 \pm 1.90$ (15.2–25.4)	Fm: $14.6 \pm 1.5$ (12–17) M: $15.5 \pm 1.8$ (11–18)	$14.4 \pm 1.6$ (10.9–20.3)
<b>B: AP Dia of Dens</b>	Fm: $10.1 \pm 0.12$ (7.1–12.1) M: $10.6 \pm 0.13$ (7.4–13.6)	$10.1 \pm 0.91$	$9.92 \pm 0.94$	$10.5 \pm 0.9$ (8.0–12.5)	$10.8 \pm 0.84$ (8.6–13.6)	Fm: $9.6 \pm 0.8$ (8–11) M: $10.0 \pm 0.9$ (8–15)	$10.9 \pm 1.1$ (8.1–14.7)
<b>C: Vertical Angle of Dens</b>	Fm: $60.0 \pm 3.1^\circ$ ( $50^\circ - 68^\circ$ ) M: $61.4 \pm 3.2^\circ$ ( $52^\circ - 70^\circ$ )	---	$53.6 \pm 6.55^\circ$	---	---	Fm: $64.3 \pm 3.8^\circ$ ( $60^\circ - 71^\circ$ ) M: $64.1 \pm 3.9^\circ$ ( $58^\circ - 75^\circ$ )	---
<b>D: Total Height of Axis</b>	Fm: $35.6 \pm 0.31$ (27.3–39.8) M: $38.3 \pm 0.28$ (31.4–43.2)	$34.33 \pm 2.69$	$34.17 \pm 3.21$	---	---	---	---
<b>E: Ant. Vertebral Body Height</b>	Fm: $16.4 \pm 0.19$ (12.2–19.2) M: $17.7 \pm 0.16$ (13.4–21.0)	$19.67 \pm 1.81$	$20.49 \pm 2.25$	$23.2 \pm 2.4$ (17.8–34.5)	$21.9 \pm 1.67$ (17.0–28.4)	Fm: $19.5 \pm 1.7$ (17–23) M: $21.1 \pm 1.7$ (18–24)	$23.4 \pm 2.2$ (18.1–30.1)
<b>F: Posterior Vertebral Body Height</b>	Fm: $13.9 \pm 0.24$ (9.5–18.1) M: $14.5 \pm 0.23$ (9.6–19.1)	$16.67 \pm 1.73$	$16.07 \pm 2.11$	$17.9 \pm 2.2$ (13.6–27.5)	$17.8 \pm 1.45$ (11.4–22.1)	Fm: $15.3 \pm 1.1$ (14–18) M: $16.5 \pm 1.6$ (14–20)	$19.7 \pm 2.1$ (15.0–25.5)
<b>G: AP Dia of Vertebral Body</b>	Fm: $15.9 \pm 0.20$ (11.1–19.0) M: $17.0 \pm 0.19$ (10.7–20.5)	$15.42 \pm 1.78$	$14.77 \pm 1.73$	$18.1 \pm 1.8$ (14.7–24.7)	$15.9 \pm 1.45$ (12.2–20.1)	Fm: $18.7 \pm 2.5$ (15–25) M: $19.0 \pm 2.0$ (14–23)	---

Fm= female, M= male,  $\pm$  = S.D (standard deviation)

The mean height of anterior aspect of axis measured from the tip of the odontoid process to the inferior aspect of the anterior surface of the body of axis was  $35.6 \pm 0.31$  mm in females with range of 27.3 – 39.8 mm and  $38.3 \pm 0.28$  mm in males with range of 31.4 – 43.2 mm. Our results are comparable with other studies. (Table-III)

Anterior vertebral body height measured was  $16.4 \pm 0.19$  mm in females and  $17.7 \pm 0.16$  in males. The posterior vertebral body height in our study was  $13.9 \pm 0.24$  in females and  $14.5 \pm 0.23$  mm in males. Our study showed less values when compared with other studies. (Table-III) These variations are perhaps due to the difference in the ethnicities to which these vertebrae belong in various studies as well as due to different techniques employed in the measurements during these studies.

The anteroposterior (AP) diameter of vertebral body of axis in our study was  $15.9 \pm 0.20$  mm in females and  $17.0 \pm 0.19$  mm in males which corroborates with the studies of Kandziora et al<sup>20</sup> and Singla et al.<sup>21</sup> The AP diameter of vertebral body of axis was higher (1:0.62) when compared with the AP diameter of odontoid process. The height of odontoid process showed higher values when compared with the anterior and posterior vertebral body heights. T-test was applied as the variable under study was continuous in nature. The difference between height

of odontoid process and anterior & posterior vertebral body heights found was significant. ( $p < 0.05$ )

This data of odontoid process and body of axis vertebra may be helpful to guide the surgeons for the management of odontoid fractures while performing anterior odontoid screw fixation. Anterior screw fixation of the odontoid has the potential to maintain rotational motion at the atlantoaxial joint.<sup>25</sup> Several authors have favoured surgery in elderly patients because non-operative treatment strategies are associated with a high incidence of morbidity and mortality.<sup>26-29</sup>

## CONCLUSION

The findings in this study may be useful to the surgeons to avoid injury to vital structures while working around the axis vertebra. These observations may be helpful in selection of correct screw thickness, length, & angle and are also useful to devise new methods of fixation of fractures of odontoid process which may decrease the time of union and danger of nonunion.

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