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Morphometric Analysis of Body and Odontoid Process of Axis Vertebrae in North Indians: An Anatomical Perspective

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Abstract

Axis, the second cervical vertebra forms a pivot on which the atlas rotates carrying the head. Though this region is very small but can cause serious complications due to complex anatomy of the cranio-cervical junction. Odontoid fractures compose 7-20% of all cervical spine fractures. The vertebral artery may also be at risk as it is present on under surface of axis. Thus, thorough understanding of the anatomy of body of axis and its odontoid process(dens) is required in screw placement or other surgical interventions. Therefore, aim of the present study was to measure and present the detailed morphometric parameters of body of axis and its odontoid process. 60 dry axis vertebrae were obtained for anatomic evaluation focused on body and odontoid process. The morphometric measurements included linear measurements focused on length, breadth and height of body and odontoid process. Vertebral body length, superior width, inferior width, anterior height and posterior height were found to be 15.10±1.56mm, 15.48±2.09mm,15.83±2.12 mm, 19.28±2.24 and 16.26±1.73mm. Odontoid process height, diameter, maximum and minimum width were found to be 16.36±1.68 mm, 10.74±1.06 mm, 9.85±1.08 mm and 8.79±1.17 mm respectively. Morphological features of dens included its macroscopic appearance and shape of ventral and dorsal facets. Most common shapes of ventral and dorsal facets were found to be vertical elliptical 83.3 % and horizontal elliptical 76.66% respectively. The knowledge of these parameters is important for the surgeons while operating around axis in spinal surgical procedures like anterior atlanto-axial fixation, anterior odontoid screw fixation or odontoidectomy procedures.

Keywords

Axis, Atlanto-odontoidal facet, Body of axis, Morphometry, Odontoid Process, Vertebral artery.

Introduction

Axis, the second cervical vertebra, is moulded in a special way, so as to allow greater range of motion at the atlantoaxial joints (Madawi et al., 1997) and forms a pivot on which the atlas rotates carrying the head. (Bryce, 1915) It thus, acts as an axle for rotation of the atlas and head around the strong dens (odontoid process), which projects cranially from the superior surface of the body. (Anson & Rea,1966) The Odontoid Process or Dens is a large blunt tooth-like process which projects supe-

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riorly approximately 1.5 cm from the body of the axis. (Williams etal. 2005) It develops in the position of the centrum of the atlas and consists of a thick part, termed the head and a constricted part, the neck. (Bryce, 1915) The anterior aspect bears an ovoid articular facet for articulation with the anterior arch of the atlas to form the atlantodental articulation. The body or corpus of axis is deeper in front than behind and prolonged downward anteriorly so as to overlap the upper and front part of the third cervical vertebra. (Williams etal. 2005) Its undersurface is concave from before backwards and convex from side to side. (Anson & Rea,1966) The body consists of partly fused centra of the atlas and axis, and a rudimentary disc between them which usually remains detectable deep within the body of axis throughout life. There has been an increasing interest in the anatomical study of the axis and the point of interest often being screw fixation in cases of dens fractures (Xu et al. 1995) that comprise 7-20% of all cervical spine fractures. (Montesano et al., 1991; Castillo & Mukherji, 1996; Apfelbaum et al, 2000; Ochoa, 2005) Anderson and D'Alonzo have published a classification of odontoid fractures where Type II and III fractures are among the common fractures of the odontoid process. (Anderson and D'Alanzo, 1974) The knowledge about course of the vertebral artery in relation to axis is also very important because here the vertebral artery is present partially or completely on undersurface of axis while in others it is located entirely in relation to transverse foramen. (Gupta & Goel, 2000) This vital artery may be at risk during the operations especially with the lateral or posterolateral approaches, which are carried out to treat instability of the cranio-cervical junction. Other pathological processes like tumours, degenerative and inflammatory diseases, infections, vascular problems, congenital malformations are also associated with this junction. (Mummaneni & Haid, 2005) Thus Both, odontoid fractures, and craniovertebral junction pathologies may require surgical procedures, including anterior craniovertebral junction stabilization, odontoid screw fixation and transoral odontoidectomy. Such surgical approaches need the correct and common landmarks for placing materials like screws and plates. (Naderi et al, 2006) Structural features of the materials used in the surgery such as the thickness of the screw and screw length, also need accurate morphometric knowledge. These facts require thorough understanding of the anatomy of body of axis and its odontoid process. Therefore, aim of the present study was to measure and present the detailed morphometric parameters of body of axis and its odontoid process. The knowledge of these parameters will be helpful in safe and effective implementation of new interventional techniques or screw placement surgeries.

Material and Methods

Material for the present study comprised of 60 axis vertebrae, obtained by maceration of the cadavers, made available for the purpose of dissection, in the department of anatomy, Government Medical College, Amritsar. The vertebrae were complete in all respects so as to give the correct measurements. All the axis vertebrae were thoroughly boiled, cleaned and numbered from 1-60. Each bone was meticulously examined and fourteen parameters were studied including both morphometric and morphological features. The morphometric measurements included linear measurements, focused on length, breadth and height of body and odontoid process of axis verte-

brae (Table 1). (Gilad and Nissan 1985; Schaffler et al., 1992; Xu et al., 1995) All the measurements were made using a vernier caliper accurate to 0.1 mm. Morphological features of odontoid process (OP) (Dens) of axis included macroscopic appearance of odontoid process, shape of ventral facet on the OP and shape of dorsal facet on OP (Table 4). (Koebke, 1979) All the values were statistically analysed and compared with other studies. (Table 2, 3, 4).

Following are the measured and observed parameters of body and odontoid process (OP) of Axis vertebrae in present study:

Vertebral Body

1) Vertebral Body Length (VBL): It was measured as anteroposterior diameter across the base of vertebral body and shown as AB =VBL (Figure 1)
2) Vertebral Body Superior Width (VBSW): The diameter was measured as the transverse width of the base of superior aspect of vertebral body and shown as CD=VBSW (Figure 1)
3) Vertebral Body Inferior Width (VBIW): The diameter was measured as the transverse width of the base of inferior aspect of vertebral body and shown as C'D'=VBIW (Figure 1)
4) Vertebral Body Anterior Height (VBAH): It is measured in the anterior midline of vertebral body from the inferior anterior edge to the superior border, which was defined by a line drawn at the superior aspect of the superior articular facets and marked as A'B'=VBAH (Figure 2)
5) Vertebral Body Posterior height (VBPH): Posterior vertebral body height was measured in the posterior midline of the vertebral body from the posterior inferior edge to the superior border and shown as A"B"=VBPH (Figure 1)

Odontoid Process (Dens)

6) Odontoid Process Height (OPH): It was measured from the superior border of the superior articular facets to the superior most point of the odontoid process and shown as QR= OPH (Figure 2)

Table 1. The results of the measured parameters of body and Odontoid Process (OP) of axis vertebra in the present study.

S. No.	Parameters	Mean (mm)	Range (mm)	S.D
1.	Vertebral Body Length (VBL)	15.10	9.30-14.00	1.56
2.	Vertebral Body Superior Width (VBSW)	15.48	10.20-18.40	2.09
3.	Vertebral Body Inferior Width (VBIW)	15.83	12.80-20.40	2.12
4.	Vertebral Body Anterior Height (VBAH)	19.28	15.30-25.20	2.24
5.	Vertebral Body Posterior height (VBPH)	16.26	13.40-19.80	1.73
6.	Odontoid Process Height (OPH)	16.36	13.60-19.40	1.68
7.	Odontoid Process Diameter (OPD)	10.74	7.10-12.90	1.06
8.	Odontoid Process Maximum width (OPAW)	9.85	7.40-13.00	1.08
9.	Odontoid Process Minimum width (OPIW)	8.79	4.90-10.60	1.17
10.	Atlanto-odontoidal Facet Width (AOFW)	7.89	4.90-9.40	1.15
11.	Atlanto-odontoidal Facet Height (AOFH)	8.87	5.90-12.90	1.77

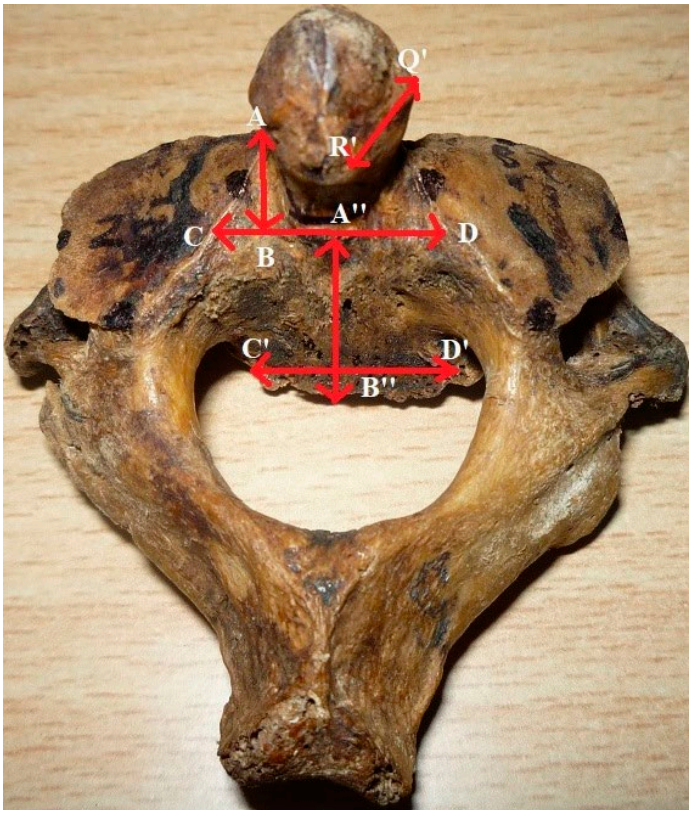

Figure 1. Superoposterior view of axis vertebra showing-
AB: Vertebral Body Length (VBL)
CD: Vertebral Body Superior Width (VBSW)
C'D': Vertebral Body Inferior Width (VBIW)
A"B": Vertebral Body Posterior height (VBPH)
Q'R': Odontoid Process Diameter (OPD)

7) Odontoid Process Diameter (OPD): It was taken as anteroposterior measurement from anterior surface to the posterior surface of odontoid process and shown Q'R'=OPD (Figure 1)
8) Odontoid Process Maximum width (OPAW): It was measured as the maximum transverse width on the anterior surface from one end to another end and shown as q"r"=OPAW (Figure 2)
9) Odontoid Process width (OPIW): It was measured as the minimum width on the anterior surface from one end to another end at the junction of dens with the vertebral body and shown as q'r'=OPIW (Figure 2)
10) Atlanto-odontoidal Facet Width (AOFW): It is the maximum transverse diameter of atlantodental facet of axis and shown as c'd'=AOFW (Figure 2)
11) Atlanto-odontoidal Facet Height (AOFH): It is the maximum diameter from superior margin of facet to inferior margin of axis and shown as a'b'=AOFH (Figure 2)

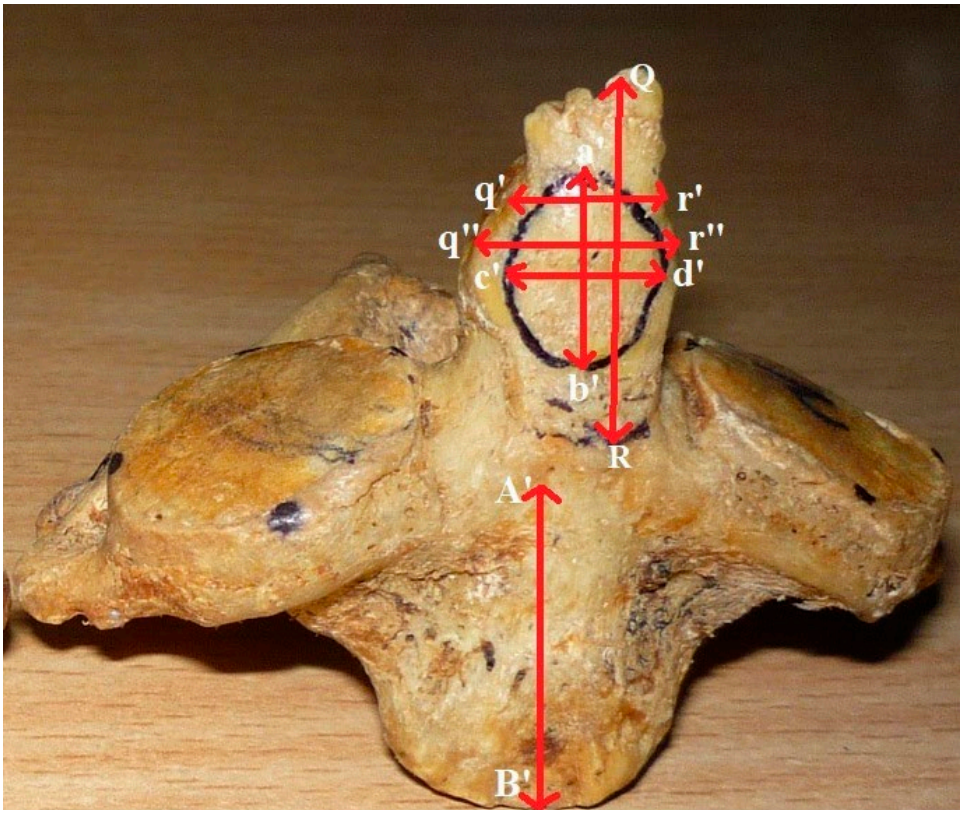

Figure 2. Anterior view of axis vertebra showing-
A'B': Vertebral Body Anterior Height (VBAH)
QR: Odontoid Process Height (OPH)
q"r": Odontoid Process Maximum width (OPAW)
q'r': Odontoid Process Minimum width (OPIW)
c'd': Atlanto-odontoidal Facet Width (AOFW)
a'b': Atlanto-odontoidal Facet Height (AOFH)

Morphological features of odontoid process of axis

12) Macroscopic appearance of odontoid process: It was observed ss Lordotic, Kyphotic and Straight.
13) Shape of ventral facet on odontoid process: It was observed as Vertical, elliptical and Oval.
14) Shape of dorsal facet on odontoid process: It was observed as Vertical, elliptical and Round.

Table 2. Comparison of results of body of axis reported in the present study and series reported in the literature.

Worker & Year	Population	N	VBL Mean(mm) & S.D Range (mm)	VBSW Mean(mm) & S.D Range (mm)	VBIW Mean(mm) & S.D Range (mm)	VBAH Mean(mm) & S.D Range (mm)	VBPH Mean(mm) & S.D Range (mm)
Anderson 1883 [20]	Belfast	23	15.6 (14-17)	19.0 (14-21)	-	19.5 (18-22)	-
Francis 1955 [18]	White Males	109	16.1±1.3 (13-19)	19.5±1.7 (15-24)	-	39.9±2.4 (33-47)	-
	White Females	27	14.7±1.1 (13-17)	17.9±1.5 (15-22)	-	36.6±2.0 (32-40)	-
	Negro Males	135	17.3±1.4 (14-21)	20.3±1.2 (17-24)	-	38.6±2.4 (33-43)	-
	Negro Females	57	15.6±1.3 (13-19)	18.6±1.4 (16-22)	-	35.7±2.4 (31-40)	-
Gilad & Nissa1985 [14]	Israel	130	-	12.6±2.1	15.3±1.6	16.6±2.5	19.0±3.2
Mazzara & Fielding 1988 [19]	American	103	19.0± 2.2 (12-30.2)	22.8±1.5 (19.0-26.5)	-	-	-
Schaffler et al 1992 [15]	Black & White Males	59	-	-	-	24.3±1.9 (19.6-30.1)	20.4±1.9 (15.8-25.3)
	Black & White Females	59	-	-	-	22.6±2.0 (18.1-27.0)	18.9±1.9 (15.0-25.5)
Xu et al. 1995 [5]	Ohio Males	30	16.1±1.5 (14-20)	19.0±2.0 (14-23)	-	21.1±1.7 (18-24)	16.5±1.6 (14-20)
	Ohio Females	20	15.0±1.7 (12-18)	18.7±2.5 (15-25)	-	19.5±1.7 (17-23)	15.3±1.1 (14-18)
Doherty & Heggeness 1995 [23]	American	-	-	-	18.7	23.3	-
Kandziora et al 2001 [21]	European	-	16.7±1.30 (13.6-20.0)	-	15.9±1.45 (12.2-20.1)	21.9±1.67 (17.0-28.4)	17.8±1.45 (11.4-22.10
Naderi et al 2006 [13]	Turkish	80	15.8±1.7 (12.5-20.2)	-	18.1±1.8 (14.7-24.7)	23.2±2.4 (17.8-34.5)	17.9±2.2 (13.6-27.5)
Gosavi & Swami, 2012 [22]	Maharashtrian	-	-	-	15.99	20.49	-
Present Study 2019	North Indians	60	15.1±1.56 (9.30-14.00)	15.48±2.09 (10.20-18.40)	15.83±2.12 (12.80-20.40)	19.28±2.24 (15.30-25.20)	16.26±1.73 (13.40-19.80)

Vertebral Body Length-VBL, Vertebral Body Superior Width-VBSW, Vertebral Body Inferior Width VBIW, Vertebral Body Posterior height-VBPH, Vertebral Body Anterior Height-VBAH

Table 3. Comparison of results of odontoid process of axis reported in the present study and series reported in the literature.

Worker & Year	Population	N	OPH Mean (mm) & S.D Range (mm)	OPD Mean (mm) & S.D Range (mm)	OPAW Mean (mm) & S.D Range (mm)	OPIW Mean (mm) & S.D Range ( )	AOFW Mean (mm) & S.D Range (mm)	AOFH Mean (mm) & S.D Range (mm)
Francis 1955 [18]	White Males	109	17.5±1.7 (14-22)	12.2±1.0 (10-14)	10.7±0.8 (9-13)	-	8.7±1.3 (6-14)	10.6±1.9 (6-16)
	White Females	27	16.6±1.7 (13-19)	11.1±0.9 (10-13)	10.1±0.6 (8-11)	-	8.2±1.0 (6-10)	10.3±1.7 (8-14)
	Negro Males	135	16.7±1.6 (13-21)	11.8±0.8 (10-13)	10.4±0.8 (9-12)	-	9.0±1.1 (7-12)	11.3±1.9 (8-17)
	Negro Females	57	15.9±1.5 (13-20)	10.8±0.9 (9-13)	10.0±0.(9-12)	-	8.8±1.0 (6-10)	11.1±2.1 (7-15)
Tulsi 1978 [28]	Australian Males	59	14.4±2.19 (11.5-18)	10.29±0.63 (9-12)	-	-	-	-
	Australian Females	48	13.7±1.19 (11-16)	9.54±0.68 (8-11.5)	-	-	-	-
Mazzara & Fielding 1988 [19]	American	103	15.4±2.4 (7-22)	11.0±1.0 (8-13)	10.5±1.0 (8.8-14.5)	-	8.7±1.4 (5-13.3)	11.0±2.4 (7-19)
Schaffler et al 1992 [15]	Black & White Males	59	14.7±1.7 (11.3-20.3)	11.0±0.9 (8.2-12.8)	11.0±1.2 (8.1-14.7)	9.5±0.9 (8.0-11.7)	-	-
	Black & White Females	59	14.0±1.4 (10.9-17)	10.1±0.7 (8.5-11.5)	10.7±1.0 (8.8-13.0	9.1±0.9 (7.4-12.2)	-	-
Xu et al 1995 [5]	Ohio Males	30	15.5±1.8 (11-18)	10.3±0.7 (7-11)	10.0±0.9 (8-15)	8.7±1.2 (6-10)	-	-
	Ohio Females	20	14.6±1.5 (12-17)	9.6±0.9 (8-11)	9.6±0.8 (8-11)	8.3±0.6 (7-9)	-	-
Kandziora et al 2001 [21]	European	-	20.3±1.90 (15.2-25.4)	10.9±0.8 (8.8-13.9)1	10.8±0.84 (8.6-13.6)	9.7±0.79 (7.8-13.2)	-	-
Naderi et al 2006 [13]	Turkish	-	15.5±1.8 (11.5-19.8)	11.3±1.0 (9.3-13.8)	10.5±0.9 (8.0-12.5)	9.3±0.9 (7.5-12.9)	8.8	10.5
Senegul &Kodiglu 2006 [29]	Turkish	-	14.5	11.2	11.2	-	-	-
Gosavi , Swamy 2012 [22]	Maharashtrian	100	14.86	9.92	9.28	-	-	-
Present Study 2019	North Indian	60	16.36±1.68 (13.60-19.40)	10.74±1.06 (7.10-12.90)	9.85±1.08 (7.40-13.00)	8.79±1.17 (4.90-10.60)	7.89±1.15 (4.90-9.40)	8.87±1.77 (5.90-12.90)

Odontoid Process Diameter-OPD, Odontoid Process Height-OPH, Odontoid Process Maximum width-OPAW, Odontoid Process Minimum width-OPIW, Atlanto-odontoidal Facet Width-AOFW, Atlanto-odontoidal Facet Height-AOFH

Table 4. Macroscopic appearance of dens and shape of ventral and dorsal facet in the present study.

Features		Present study (2019) N=60 North Indians		Koebke (1979) [16] N=52 German	
	Type	N	%	N	%
Macroscopic appearance of odontoid process	Lordotic	44	73.33	Most common	
	Kyphotic	10	16.66	4	-
	Straight	6	10.00	-	
Shape of ventral facet on odontoid process	Vertical Elliptical	50	83.30	-	
	Oval	10	16.66	-	
Shape of dorsal facet on odontoid process	Horizontal Elliptical	46	76.66	-	70
	Round	14	23.33	-	30

Results

The present study showed the vertebral body length (VBL), vertebral body superior width (VBSW) and vertebral body inferior width (VBIW) to be 15.1±1.56mm, 15.48±2.09mm, 15.83±2.12mm respectively. Vertebral body anterior height (VBAH) and vertebral body posterior height (VBPH) were 19.28±2.24mm, 16.26±1.73mm respectively. (Table 1)

Odontoid process height (OPH) and diameter (OPD) were measured as 16.36±1.68mm and 10.74±1.06mm respectively. Odontoid process maximum width (OPAW) and minimum width (OPIW) were found to be 9.85±1.08mm and 8.79±1.17mm. Facet for atlanto-odontoidal articulation included measurement of its width (AOFW) and height (AOFH) which were found to be 7.89±1.15mm and 8.87±1.77mm respectively. (Table 1)

On the basis of macroscopic features of odontoid process, the most common type was viewed as lordotic (73.33%) followed by kyphotic 16.66% and then straight 10.00%. (Table 4) On the gross appearance of ventral and dorsal facets present on odontoid process, the vertical elliptical shape was found to be 83.30% and oval shape was 16.66% for the ventral facets whereas for the dorsal facets the most common shape was found to be horizontal elliptical 76.66% and round shape was found to be 23.33%.(Table 4)

The results of parameters of vertebral body and odontoid process of axis vertebrae are shown in (Table 1), the comparative data in (Table 2 & Table 3) and the results of macroscopic appearance of OP and shape of dorsal and ventral facets and its comparison are shown in (Table 4).

Discussion

The body of second cervical vertebra and its odontoid process has been the focus of a variety of spinal surgical procedures like anterior atlanto-axial, anterior

occipito-cervical fixation, anterior odontoid screw fixation, odontoidectomy and other surgical procedures. (Naderi et al., 2006) The parameters in the present study like vertebral body length (VBL), vertebral body superior width (VBSW), vertebral body inferior width (VBIW), vertebral body anterior height (VBAH) and vertebral body posterior height (VBPH) were measured and compared with those reported in previous studies by other authors. (Table 2) These series of measurements of axis vertebrae can be taken into consideration during the anterior plating of the C2 body using screws to detect the screw length. (Naderi et al., 2006) These parameters may also be helpful for anthropologists and forensic experts in knowing the racial differences. As stated by Wood Jones (1938), in Australian natives, axis of cervical vertebrae was especially small.

It is depicted from Table 2 that in the present study, the mean value of VBL was 15.1mm. Francis (1955) measured the same parameter with its value 14.7mm in white females (Francis, 1955) and Xu et al (1995) found this parameter as 15.0mm in Ohio females. whereas Mazzara & Fielding (1988) reported VBL as 19mm in American population.

VBSW in the present study was found to be 15.48mm. (Table 2) Gilad & Nissan (1985) reported this parameter to be 12.6mm in Israel population. However, the findings in the present study are, to some extent, smaller than the results reported by Anderson (1883), Francis (1955), Mazzara & Fielding, 1988, Xu et al. (1995).

Table 2, in the present study, shows that VBIW was 15.83mm and these values are in line with results reported by Gilad & Nissan (1985), Kandziora et al (2001), Gosavi & Swami, (2012). Doherty & Heggeness (1995) and Naderi et al (2006) reported this parameter as 18.7 mm and 18.1 mm respectively. This parameter can be taken into consideration during the anterior plating of the C2 body using screws to detect the screw length.

The mean value of VBAH in the present study (Table 2) was 19.28mm which concurs well with the findings of Anderson (1883) in Belfast and Xu et al (1995) in Ohio females. The total height of axis. (DH+VBAH) reflects the length of screw necessary for anterior trans-odontoid screw fixation which was found to be 35.64mm in the present study. This parameter was reported to be 37.8 mm by Heller et al (1992), 39.9 mm by Doherty & Heggeness, (1995) and 38.7 mm by Naderi et al. (2006). Therefore a 36 mm screw seems to be appropriate in most cases. (Naderi et al., 2006) Francis (1955) reported the same parameter in a range of 31-47mm in White & Negro males and females whereas Cyriax (1920) found this to be as 39.22mm.

The present study revealed VBPH as 16.26 mm which is parallel with the values given by Xu et al (1995) in Ohio males as 16.5mm. Gilad & Nissan (1985) measured this height as 19.00mm, (Table 2). Schaffler et al. (1992) found this value in a range of 15.0-25.5mm in Black & White males and females. Xu et al. (1995) found this in a range of (14-20) mm in Ohio males and females. Kandziora et al. (2001) reported this parameter to be 17.8mm while Naderi et al. (2006) found this value as 17.9mm.

Hypertrophic dens of axis is known to cause atlanto-dental instability and neurological complications. (Singh, 1998) Osteoarthritis of atlantoaxial joint is associated with upper cervical myelopathy. Patients usually have hypertrophic dens having anteroposterior diameter as 15-16mm. Association between atlanto-dental instability and formation of pseudotumor around dental process has also been reported. (Okada et al., 2000) Odontoidectomy procedures can be performed using a transoral route

or less commonly using a posterolateral approach. Regardless of the approach used for odontoidectomy, some anatomic data may help the surgeon during the surgical procedure. Thus odontoid process (OP) of axis was studied for OP height (OPH), OP diameter (OPD), OP maximum width (OPAW) and OP minimum width (OPIW). (Table 3) Facet for atlanto-odontoidal articulation includes measurement of its width (AOFW) and height (AOFH). Odontoidal facet dimensions are useful in evaluating sexual dimorphism. In males it is found to be more as compared with females. (Schaffler et al., 1992) Os-odontoideum may be a profound medicolegal importance as it could be due to fracture of dens in early life and confused with congenital absence and hypoplastic dens. (Tulsi, 1978)

It is interpreted from Table 3 that the OPH in the present study was 16.36mm. Our results are in line with the results reported by Francis (1955) in white females and Negro males and females both, Mazzara & Fielding 1988, Xu et al. (1995) and Naderi et al. (2006). This is, to some extent, larger than the results reported by Tulsi (1978), Schaffler et al. (1992), Senguel & Kodiglu (2006), Gosavi & Swamy (2012). On the other hand, the height of OP was reported to be 20.3 mm by Kandziora et al (2001).

The OPD, as depicted from Table 3, in the present study was found to be 10.74mm which supports the findings given by Francis (1955), Mazzara & Fielding (1988), Schaffler et al (1992), Xu et al (1995), Kandizora et al (2006), Naderi et al 2006 and Gosavi & Swamy (2012). It was reported to be 10.29mm and 9.54mm in Australian males and females respectively by Tulsi (1978). (Tulsi, 1978). On the other hand Francis (1955) reported the same parameter to be 12.2mm in white males. (Francis, 1955)

Table 3 also depicts the values of maximum (OPAW) and minimum (OPIW) width of odontoid process of axis as 9.85mm and 8.79mm respectively. OPAW and OPIW showed no major difference when compared with the works done by various authors.

A transoral odontoidectomy requires the detachment of the OP from the atlanto-odontoidal joint. A glance at table 5 elucidates that both AOFW and AOFH were found to be 7.89mm and 8.87mm respectively in the present study. There values were found to be consistent with the works done by Francis, (1955), Mazzara & Fielding, (1988) and Naderi et al. (2006)

The odontoid process is prone to numerous developmental anomalies or variations and many of these are so bizarre that there is no problem in identifying them as such. These variations may be observed regarding the relation of height of OP to anterior arch of atlas like hypoplastic odontoid process when the odontoid tip lies below the level of the superior margin of the anterior arch of atlas or hypertrophic OP where it may even invaginate the foramen magnum and compress the brain stem. (Wackenheim & Wenger, 1973) The Variations may also be observed with regard to longitudinal orientation of the dens and most common being Os Odontoideum in which a variable portion of the upper part of the dens is demarcated from the rest of the bone. (Trivedi, 2003)

A well marked movement of flexion and extension can be realised only in presence of lordotic dens. Kromptic –Nemanic and Keroes (1973) proposed a functional adaption of odontoid process to the degree of cervical lordosis and bending of base of skull. (Koebke, 1979) Thus, Macroscopic classification of dens was also done on the basis of ventral and dorsal facets present on the dens. The comparative data from table 4 depicts that in the present study the most common type of dens on macroscopic appearance was viewed as lordotic which stood equivalent to that of Koebke

(1979). Gross appearance of ventral facets & dorsal facets on odontoid process of axis were also observed. (Table 3) For ventral facets the vertical elliptical shape was found to be (83.30%) and oval shape (16.66%). However, not much quantitative anatomic data was available in the accessible literature except for the types given by Koebke (1979). For dorsal facets the most common shape was found to be horizontal elliptical in (76.66%) of cases which is in accordance with work of Koebke (1979). The observations thus obtained in axis in the present study tallied with the results of previous workers with slight differences, which could be due to racial factors, living habits, native place or different environmental or working conditions.

Conclusion

This study provides information regarding the morphometric dimensions of body of axis and its odontoid process which is critical to safe and effective implementation of the new orthopaedic interventional techniques, to predict the screw size in anterior trans-odontoid screw fixation for odontoid fractures or occipito-cervical fixation procedures. However, the preoperative use of computed tomography is recommended to avoid variation-related complications. The study may also be helpful for anthropologists and forensic experts in knowing the racial differences.

Conflict of Interest

The authors declare that they have no conflict of interest.

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