

Morphometric Analysis of Odontoid in Nepalese Individuals of Eastern Nepal

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ABSTRACT

Introduction

There is ethnic variation in the morphometry of odontoid and it is always mandatory to know the anatomy of odontoid before surgery to achieve the success of the surgery either with 1 or 2 screws fixation. There is no literature on the morphometry of odontoids in the Nepalese population.

Methods

Two hundred and ten consecutive patients whose CT-scan of the head or cervical spine were done without any evidence of cervical injury or fracture were included in the study. Morphometric measurements were done using Horos software in axial, coronal, and sagittal planes.

Results

The mean age was 42.32 ± 16.16 (range 17-76) years including 104 males and 106 females. The mean screw length was 36.52 ± 3.14 mm and the screw insertion angle in relation to the inferior endplate of C2 vertebrae is 55.66 ± 4.74 degrees. The anteroposterior diameter of the odontoid was significantly more than the transverse diameter at the base and at the waist of the odontoid. A total of 97 (46.1%) individuals had their transverse waist diameter between 7.4 -9 mm and 31 (14.76%) had their dimension below 7.4 mm.

Conclusions

Almost 2/3rd of the Nepalese population has an inadequate diameter of odontoid for two 3.5 mm screws since the transverse waist diameter is less than 9 mm. Hence, either two 2.7 mm screws or a single 4.5 mm screw fixation should be considered in the majority of the cases but only after preoperative CT-scan-based morphometric measurement.

Keywords: morphometry; odontoid; CT- scan; fixation; Nepalese.

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INTRODUCTION

Fracture of dens of axis accounts for 50-60% of all fractures of the axis (C2) and 7-27% of all cervical spine fractures.^{1,2} Anderson D Alonzo³ classified odontoid fracture in 3 types and found type 2 i.e. fracture at the waist of odontoid being the most common (65-74%) because it is the narrowest part. Recently anterior screw fixation has become the preferred treatment for odontoid fractures^{4,5} but there is no consensus in the literature regarding the use of 1 screw or 2 screws in anterior odontoid fixation.

There are ethnic variations in the morphometry of odontoid⁶⁻⁸ and it has to be well known beforehand to achieve the success of the surgery either with 1 or 2 screws fixation. With this background, we analyzed the morphometry of odontoids in the Nepalese population and detected the feasibility of using 1 or 2 screws.

METHODS

It was a cross-sectional study conducted in the Department of Orthopedics and Department of Radiology of Birat Medical College and Teaching Hospital from June 2020 till June 2021. Two hundred and ten consecutive patients whose CT-scan of the head or cervical spine was done, without any evidence of cervical vertebrae injury or fracture, were included in the study. We used a 64 slice MDCT scanner (Somatom Perspective, Siemens, Erlanger, Germany) and the CT-scan cuts were taken at 1.2 mm intervals. Horos software (version v3.3.6) was used for taking exact morphometric measurements at a specific angle in the axial, coronal and sagittal planes. This project was started after approval by the institutional review committee.

A specifically designed proforma for the study was used to collect the available information. Various points and measurements were defined in the axial, sagittal, and coronal plane in CT-

scan. Screw length, screw insertion angle, and distance of screw exit from apex were measured in the sagittal plane. Anterior-posterior (AP) diameter and transverse diameter of the odontoid was measured in the axial plane at the base of the odontoid. AP and transverse diameter of odontoid was measured in the axial plane at the waist of the odontoid. The width of the odontoid was measured in the coronal plane at the waist of the odontoid. We illustrate the steps for performing the measurements in all three planes here:

1. Points and measurements in midsagittal plane (Figure 1)
 - A: Anteroinferior point of the C2 vertebral body
 - B: Posteroinferior point of the C2 vertebral body
 - C: Point along the anterior cortex of the odontoid such that distance AC is equal to distance AB
 - D: Apex of the odontoid

AE (Screw length): Axis of the odontoid screw. It is drawn such that it is located at a minimum perpendicular distance of 2.5 mm (1.75 mm is the radius of the 3.5 mm screw and 0.75 mm is the minimum cortical hold required for a proper purchase of the screw) from point C and directed towards the apex of the odontoid. Therefore, point E may either coincide with point D or be slightly posterior to it.

DE (Distance of screw exit from the apex): The horizontal distance between the point D and E

Angle EAB (Screw insertion angle): Screw insertion angle with respect to the inferior endplate of the C2 vertebral body.

2. Measurement in Axial plane: Cuts were advanced cranially from the C2 vertebral

body until well defined odontoid boundaries were identified. This represents the base of the odontoid (figure 2A). Anteroposterior (AP) (purple line) and transverse diameter (green line) of the odontoid were measured at this level.

The axial cuts were further advanced cranially until a constriction in the dimension of the odontoid was identified. This represents the waist of the odontoid (figure 2B). Anteroposterior (AP) (green line) and transverse diameter (purple line) of the odontoid were measured.

3. Measurement in the coronal plane (Figure 3): Similarly in the coronal plane at the waist, the width of the odontoid was measured (pink line).

SPSS software version 26 was used for statistical analysis. Two –tailed unpaired t-test was used to compare the means of male and female measurements. A *P*-value of < 0.05 was considered statistically significant.

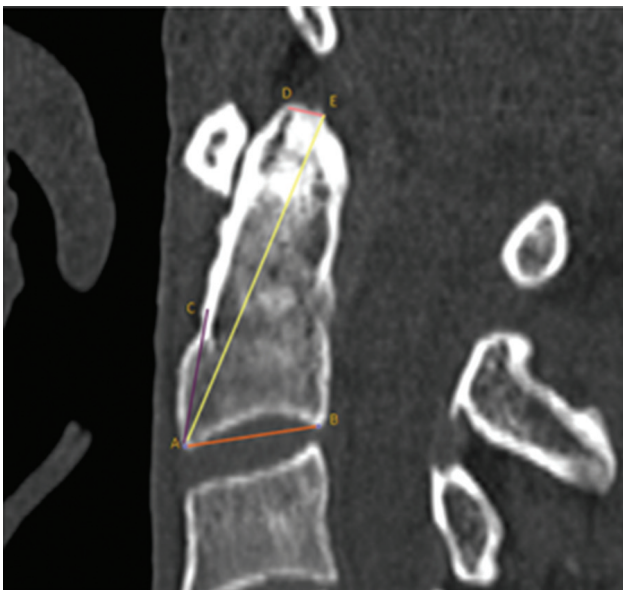


Figure 1. Measurements of Odontoid in the mid sagittal plane

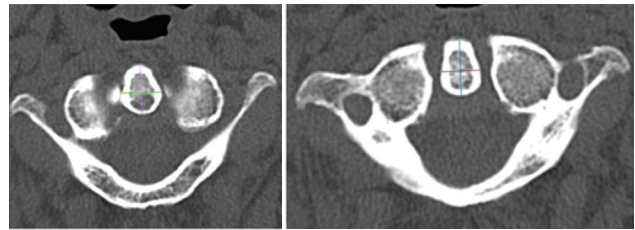


Figure 1. Measurement of Odontoid in Axial plane
A. Base B. Waist

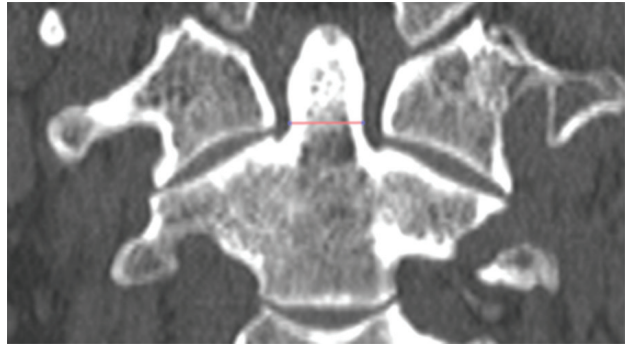


Figure 1. Measurement of Odontoid in the coronal plane

RESULTS

The mean age of the study population was 42.32 ± 16.16 years (range 17-76). There were 104 males and 106 females. AP diameter of the odontoid is larger than the transverse diameter at the base and waist of the odontoid. The mean distance between the apex of the odontoid and the screw exit point was 1.58 ± 0.92 mm (range, 0-3.8mm). (Table 1) The difference in the AP diameter and transverse diameter of odontoid at base and waist of odontoid on axial view were statistically significant *p*-value <0.001. (Table 2) In our study 97 (46.1%) of the Nepalese population had their transverse waist diameter in the axial section between 7.4-9 mm and 31 (14.76%) had their dimension below 7.4 mm. (Table 3) There was a statistically significant difference in all the measurements of the odontoid between the male and female population except in the transverse diameter of the base of odontoid in axial section (*P*-value 0.395) (Table 4)

Table 1. Measurement of different parameters.

	Age (yrs)	Sagittal screw length (mm)	Screw Angle	Axial Base AP (mm)	Axial Base TR (mm)	Coronal Waist TR (mm)	Axial Waist AP (mm)	Axial Waist TR (mm)	Screw tip apex distance (mm)
Mean	42.32	36.52	55.66	10.61	9.91	8.08	10.29	8.68	1.58
SD	16.16	3.14	4.74	0.94	1.00	0.97	0.80	0.92	0.92
Range	17-76	29.7-42	48-66	8.2-12.9	8.2-13.1	6.1-10.7	8.4-12.1	6.8-10.6	0-3.8

Table 2. Comparison of Anteroposterior Diameter with a transverse diameter of odontoid at base and waist of the odontoid

	Anteroposterior Diameter	Transverse Diameter	p-value
Base of Odontoid	10.61±0.94	9.91±1.00	<0.001
Waist of Odontoid	10.29±0.80	8.68±0.92	<0.001

Table 3. Distribution of population according to the transverse waist diameter on axial section

Transverse waist diameter on axial section (mm)	Male	Female
<7.4	8 (7.7)	23 (21.7)
7.4-9	49 (47.1)	48 (45.3)
>9	47 (45.2)	35 (33)
	104	106

Table 4. Comparison of different measurement parameters between male and female population.

	Age (yrs)	Sagittal screw length (mm)	Screw Angle	Axial Base AP (mm)	Axial Base TR (mm)	Coronal Waist TR (mm)	Axial Waist AP (mm)	Axial Waist TR (mm)	Screw tip apex distance (mm)
Male (n = 104)									
Mean	40.12	37.78	55.22	10.81	9.89	8.38	10.55	8.81	1.47
SD	16.06	2.68	4.36	0.89	0.92	0.99	0.92	0.85	0.88
Range	17-73	32-42	48-66	9.5-12.9	8.2-12	6.5-10.7	8.4-12.1	6.9-10.6	0-3.5
Female (n = 106)									
Mean	44.48	35.27	56.09	10.41	9.92	7.78	10.03	8.55	1.70
SD	16.05	3.07	5.07	0.95	1.07	0.84	0.54	0.97	0.96
Range	17-76	29.7-40.5	48-66	8.2-12.6	8.3-13.1	6.1-9.8	8.8-11.1	6.8-10.2	0-3.8
P-value		<0.001	0.093	<0.001	0.395	<0.001	<0.001	0.019	0.035

DISCUSSION

Bohler⁹ introduced the anterior odontoid fixation technique with two screws emphasizing its advantage on better rotational stability. There was no statistically significant advantage in the union rate of odontoid fracture while using two 3.5 mm screws over one 3.5 mm screw.¹⁰⁻¹³ The minimum transverse diameter of the odontoid for placement of two 3.5 mm screws is 9mm.¹⁴ Morphometric studies on the various ethnic groups had shown that many of the times it would be difficult to accommodate two 3.5 mm screws in odontoid, for example 5% of the people in North America¹⁴, 30% in Europe¹⁵, 35% in Brazil¹⁶, 33% in Malaysia¹⁷, 55% in India⁷, 61% in Kuwait¹⁸ and 54% in Egypt⁶ had their odontoid dimension below 9 mm. Under this background, few surgeons came with the idea of using two 2.7mm screws or a single 4.5 mm herbert screw.¹⁹ Considering the fact that there should be at least 0.5 mm of cortical bone all around the screw for a nice purchase, two 2.7 mm screws required minimum odontoid diameter of 7.4 mm¹⁷, and one 4.5 mm herbert screw requires a minimum diameter of 5.5 mm.

The smallest diameter of the odontoid is at the attachment of the transverse ligament of the atlas.²⁰ The AP diameter of the odontoid is significantly larger than the transverse diameter in various literature and a similar finding was observed in our study.^{17,20}

We have observed that almost 46.1% and 14.76% of the Nepalese population had their odontoid dimension between 7.4- 9 mm and below 7.4 mm respectively. Which makes almost 61% of the total population's odontoid dimension below 9 mm. Hence, surgeon should be cautious before fixing the odontoid using a 2 screw technique (either 3.5 mm or 2.7 mm screws) or a single 4.5 mm screw. 21.7% of Nepalese women had

odontoid diameter below 7.4 mm in comparison to males who had only 7.7% of the population with odontoid diameter below 7.4 mm. Hence, more precise morphometric calculation and preoperative planning have to be made in the case of a female patient whose anterior odontoid fixation is planned.

The screw exited from 1.5±0.9 mm posterior to the apex of the odontoid. This finding proves even more significant when using the 2 screws in AP orientation, where the posterior screw will exit far more posteriorly from the posterior wall of the odontoid, thereby, increasing the risk of thecal sac injury by the screw tip.

We must keep in mind that axial cut waist diameter is not the only factor in deciding fracture treatment. The surgeon must take into account the fracture configuration, osteoporosis, status of the transverse ligament, type of fracture (traumatic versus pathological versus nonunion), length of the neck, cervical kyphosis, and presence of barrel chest before deciding on the operative technique, because this will greatly affect the operative management and the clinical outcome. Observer bias could be there while doing the measurement in Horos software this could be the limitation of this study

CONCLUSIONS

The surgeon should always study the anatomy of the fracture and odontoid dimension from a CT scan before deciding on the operative techniques. In this study, we observed that almost 2/3rd of Nepalese females have an inadequate diameter of odontoid for two 3.5 mm screws hence either 2.7 mm screw or single screw fixation technique has to be considered in the majority of the cases. Moreover, if the odontoid diameter is not adequate for even a single screw fixation, then an alternate fixation technique should be considered.

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