

# Morphometric Analysis of The C2 Body and the Odontoid Process

## C2 Vertebra (Axis) Korpusu ve Odontoid Çıkıntısının Morfometrik Analizi

### ABSTRACT

**OBJECTIVE:** Many surgical procedures are performed to decompress or to stabilise anterior C2. The aim of this study was to analyze the C2 body and the odontoid process (OP) in 80 dry C2 vertebrae from the Turkish population.

**MATERIAL AND METHODS:** 15 parameters were measured using a Vernier caliper accurate to 0.1 mm and a goniometer in 80 dry C2 vertebrae. Parameters include height and transverse diameter of the OP and the anterior and posterior parts of the C2 body.

**RESULTS:** The anterior height of the OP was 15.5 mm, the posterior height of the OP was 15.4 mm; the anterior height of C2 (body and OP) was 38.7 mm, and the posterior height of C2 was 33.2 mm. The anteroposterior (AP) diameter of the narrowest part of the OP base was 11.1 mm; the largest AP diameter of the middle part of the OP was 11.3 mm. The transverse diameter of the narrowest part of the OP base was 9.3 mm, and the largest transverse diameter in the middle part of the OP was 10.5 mm. The AP diameter of the inferior surface of the C2 body was 15.8 mm and its transverse diameter was 18.1 mm. The height and transverse diameter of the OP-C1 facet were 10.5 mm and 8.8 mm, respectively.

**DISCUSSION:** Our findings are parallel with previously reported results. Measured morphometric data are thought to be helpful for spine surgeons during transoral odontoidectomy and C2-OP fixation procedures. However, because of individual variations, each case should be analyzed radiologically in the preoperative period.

**KEY WORDS:** Anatomy, Axis, C2 body, Odontoid process

### ÖZ

**AMAÇ:** C2 korpus ve odontoid çıkıntısı birçok dekompresyon ve fiksasyon işleminin hedefi durumundadır. Bu nedenle morfometrik analizinin yapılmasına gerek vardır. Bu çalışmanın amacı, Türk popülasyonundan elde edilmiş 80 kuru C2 vertebraında odontoid ve C2 korpusunun morfometrik analizini yapmaktır.

**GEREÇ VE YÖNTEM:** 80 kuru C2 vertebrada 15 parametre ölçüldü. Lineer ölçümler 0.1mm'ye duyarlı Vernier kalipometre ile, açı ölçümleri ise 1°'ye duyarlı açı ölçer ile yapıldı.

**BULGULAR:** Odontoidin anterior yüksekliği 15.5mm, posterior yüksekliği 15.4mm; C2 korpus ve odontoid çıkıntısının anterior yüksekliği 38.7mm, posterior yüksekliği ise 33.2mm'dir. Odontoid çıkıntısının AP (antero-posterior) çapı kaidede 11.1mm, odontoidin orta seviyesinde en geniş AP ise 11.3mm'dir. Odontoidin transvers çapı kaidede 9.3mm, odontoidin orta seviyesinde 10.5mm olarak ölçülmüştür. C2 korpusunun inferior yüzde AP çapı 15.8mm, transvers çapı ise 18.1mm olarak belirlenmiştir. Odontoid-C1 faset eklem yüzünün yüksekliği 10.5mm, genişliği ise 8.8mm;

**SONUÇ:** Bu çalışmada elde edilen veriler, literatür ile uyumludur. Saptanan morfometrik değerler, gerek transoral odontoidektomi, gerekse C2'yi kapsayan plaklama ve anterior odontoid vidalamada yardımcı olacak niteliktedir. Bununla birlikte kişisel varyasyonlar nedeni ile her olgu preoperatif dönemde ayrıca tomografik olarak incelenmelidir.

**ANAHTAR SÖZCÜKLER:** Anatomi, Axis, C 2 korpus, Odontoid proses

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**INTRODUCTION**

Odontoid fractures compose 7-20% of all cervical spine fractures (2,3,8,9,11). Anderson and D’Alonzo have published a classification of odontoid fractures (1). Type II and III fractures are among the common fractures of the odontoid process. Both odontoid fractures, and other pathological processes of the craniovertebral junction may require surgical procedures, including anterior craniovertebral junction stabilization, odontoid screw fixation and transoral odontoidectomy. This fact requires an understanding of the anatomy of the C2 body and the OP. The aim of this study was to measure important anatomical parameters of the C2 vertebra in terms of anterior C2 fixation.

**MATERIAL AND METHODS**

This study was performed at the laboratory of the Anatomy Department of the Dokuz Eylul University School of Medicine. Fifteen parameters were measured using a Vernier caliper accurate to 0.1 mm in 80 dry C2 vertebrae. The measured parameters included parameters regarding the height, transverse diameter, and AP diameters of the OP and the C2 body from both anterior and posterior views (Table I, and Figures 1-4).

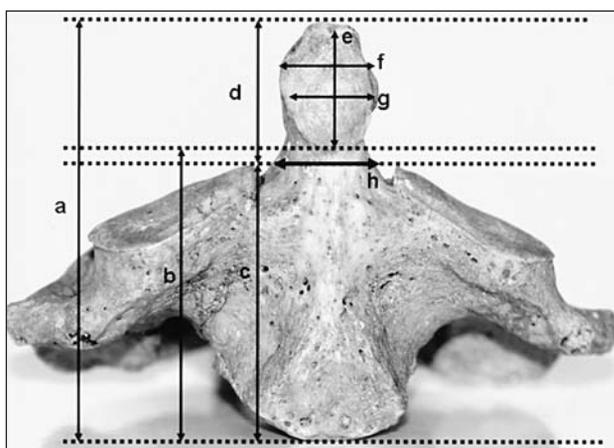
**RESULTS**

There was no variation in any of the measured parameters. The measurements of all parts of the C2 body and the OP showed uniformity.

The anterior and posterior heights of the OP were 15.5±1.8 mm and 15.4±1.9 mm, respectively. The

anterior and the posterior heights of the C2 body + the OP (i.e. the anterior and posterior C2 height) were 38.7 ± 2.9 mm and 33.2 ± 2.9 mm, respectively.

The anterior and the posterior heights of the C2 body were 23.2±2.4 mm and 17.9±2.2 mm, respectively. The AP diameter of the OP was measured as 11.1±1.3 mm and 11.3±1.0 mm at the base and at the mid-level of the OP, respectively.



**Figure 1:** The parameters regarding the anterior C2 body and the odontoid process a: The height of anterior C2; b: The distance between the inferior aspect of odontoid-C1 facet and inferior aspect of anterior C2 body; c: The height of the C2 body; d: The height of the odontoid process; e: the height of the odontoid-C1 facet; f: The largest transverse diameter of the odontoid, g: the transverse diameter of the odontoid-C1 facet; h: The transverse diameter of the odontoid at the base

**Table I:** The measured parameters

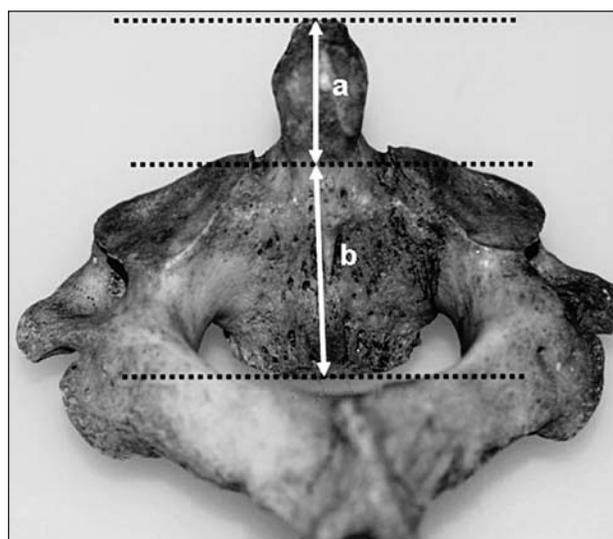
The C2 body and the odontoid process (OP)
1-2. Anterior and posterior heights of the OP
3-4. AP and transverse diameters of the narrowest part of base of OP
5-6. Height and transverse diameter of the OP-C1 facet
7-8. The largest AP diameter and width of the middle part of the OP
9. Distance between the most inferior point of the C2 body and the lowest point of OP- C1 facet
10-11. The anterior and posterior heights of the C2 body
12-13. AP and transverse diameters of inferior surface of the C2 body
14-15. The anterior and posterior height of the C2 body



**Figure 2:** AP (a) and transverse (b) diameters of inferior surface of the C2 body.



**Figure 3:** The parameters regarding diameters of the odontoid (a: The largest AP diameter of the odontoid, b: the AP diameter of the odontoid at the base)



**Figure 4:** The odontoid posterior height (a) and the C2 body posterior height (b), a+b: C2 posterior height

The transverse diameters of the OP were measured as  $9.3 \pm 0.9$  mm and  $10.5 \pm 0.9$  mm at the base and at the mid-level of the OP, respectively.

The AP and the transverse diameters of the inferior surface of the C2 body were measured as  $15.8 \pm 1.7$  mm and  $18.1 \pm 1.8$  mm, respectively.

The height and the transverse diameter of the OP-C1 facet were measured as  $10.5 \pm 1.8$  mm and  $8.8 \pm 1.2$  mm, respectively. The distance between the lowest point of the C2 body and the lowest point of the OP-C1 facet was measured as  $24.7 \pm 2.0$  mm (Table II).

### DISCUSSION

The results of this study provided us information useful for anterior C2 surgery. The fact that these results were obtained from cadavers of Turkish population is of importance. The C2 body, and particularly the OP, has been the focus of a variety of spinal surgical procedures, including odontoidectomy, anterior odontoid screw fixation, anterior C1-2 fixation, and anterior occipito-cervical fixation procedures. Odontoidectomy procedures can be performed using a transoral route or less commonly using a posterolateral approach. Regardless of the

**Table II:** The results of the measured parameters: Odontoid Process (OP)

The parameters (mm)	Mean	SD	Min	Max
Anterior height of the OP	15.5	1.8	11.5	19.8
Posterior height of the OP	15.4	1.9	11.5	20.7
Anterior height of the C2 body	23.2	2.4	17.8	34.5
Posterior height of C2 body	17.9	2.2	13.6	27.5
Anterior C2 height (body+OP)	38.7	2.9	33.0	46.6
Posterior C2 height (body+OP)	33.2	2.9	27.5	42.4
The largest AP diameter of the middle part of the OP	11.3	1.0	9.3	13.8
The largest transverse diameter of the middle part of the OP	10.5	0.9	8.0	12.5
AP diameter of the narrowest part of base of the OP	11.1	1.3	9.3	20.1
Transverse diameter of the narrowest part of base of the OP	9.3	0.9	7.5	12.9
AP diameter of inferior surface of the C2 body	15.8	1.7	12.5	20.2
Transverse diameter of inferior surface of the C2 body	18.1	1.8	14.7	24.7
Height of odontoid-C1 facet	10.5	1.8	7.2	15.0
Transverse diameter of OP-C1 facet	8.8	1.2	6.0	11.1
Distance between the most inferior point of the C2 body and the lowest point of OP- C1 facet	24.7	2.0	20.0	31.0

approach used for odontoidectomy, some anatomic data may help the surgeon during the surgical procedure. This study showed that the anterior and posterior heights of the OP were almost the same at

15.5 mm. Our results are in line with the results reported by Schaffer et al (12) and Xu et al (13). On the other hand, the height of the OP was reported to be 20.3 mm by Kandziora (6) (Table III).

**Table III:** The results reported in the present series and the series reported in the literature:

(mm)	Naderi et al	Xu et al	Heller et al	Schaffer et al	Kandziora et al
A	15.5±1.8 (11.5-19.8)	Female 14.6±1.5 (12-17) Male 15.5±1.8 (11-18)	-	14.4±1.6 (10.9-20.3)	20.3±1.90 (15.2-25.4)
B	15.4±1.9 (11.5-20.7)	-	-	-	-
C	23.2±2.4 (17.8-34.5)	Female 19.5±1.7 (17-23) Male 21.1±1.7 (18-24)	-	23.4±2.2 (18.1-30.1)	21.9±1.67 (17.0-28.4)
D	17.9±2.2 (13.6-27.5)	Female 15.3±1.1(14-18) Male 16.5±1.6 (14-20)	-	19.7±2.1 (15.0-25.5)	17.8±1.45 (11.4-22.1)
E	38.7±2.9 (33.0-46.6)	-	37.8±2.8 (30.4-44.5)	-	-
F	33.2±2.9 (27.5-42.4)	-	34.0±2.8 (27.3-44.2)	-	-
G	11.3±1.0 (9.3-13.8)	Female 9.6±0.9 (8-11) Male 10.3±0.7 (7-11)	-	11.6±1.2 (8.5-18.6)	10.9±0.81 (8.8-13.9)
H	10.5±0.9 (8.0-12.5)	Female 9.6±0.8 ( 8-11) Male 10.0±0.9 (8-15)	-	10.9±1.1 (8.1-14.7)	10.8±0.84 (8.6-13.6)
I	11.1±1.3 (9.3-20.1)	-	10.5±0.9 (8.4-12.8)	10.5±0.9 (8.4-12.8)	9.5±0.78 (7.4-13.4)
J	9.3±0.9 (7.5-12.9)	Female 8.3±0.6 (7-9) Male 8.7±1.2 (6-10)	9.3±0.9 (7.4-12.2)	9.3±0.9 (7.4-12.2)	9.7±0.79 (7.8-13.2)
K	15.8±1.7 (12.5-20.2)	Female 15.0±1.7 (12-18) Male 16.1±1.5 (14-20)	-	-	16.7±1.30 (13.6-20.0)
L	18.1±1.8 (14.7-24.7)	Female 18.7±2.5 (15-25) Male 19.0±2.0 (14-23)	-	-	15.9±1.45 (12.2-20.1)

**A:** Anterior height of the OP (odontoid process), **B:** Posterior height of the OP, **C:** Anterior height of the C2 body, **D:** Posterior height of the C2 body, **E:** Anterior C2 height, **F:** Posterior C2 height, **G:** The largest AP diameter of the middle part of OP, **H:** The largest transverse diameter of the middle part of OP, **I:** AP diameter of the narrowest part of base of OP, **J:** Transverse diameter of the narrowest part of the base of the OP, **K:** AP diameter of the inferior surface of the C2 body, **L:** Transverse diameter of the inferior surface of the C2 body.

Type 2 and 3 odontoid fractures may require odontoid screw fixation. This requires knowledge regarding the diameter of the odontoid process. Large odontoid processes can be fixated with two screws, whereas narrow odontoid processes can be fixated with one screw. The current study revealed that the largest AP and transverse diameters of the OP were 11.3 mm and 10.5 mm, respectively. These results also are parallel to the previous results reported by others (6,12,13). The AP and transverse diameters of the OP at the base of the OP were found to be 11.1 mm and 9.3 mm, respectively, which were consistent with results reported by Xu et al. (13), Schaffer et al. (12), Kandziora et al. (6), Heller (5) and Lu et al (7). These diameters are appropriate for one screw in all cases. However, if 4 mm screws are used, the use of 2 screws needs to be checked radiologically before surgery.

A transoral odontoidectomy requires the detachment of the OP from the C1-odontoid joint. The height and transverse diameter of this facet was found to be 10.5 mm and 8.8 mm, respectively. This morphometric data has not been reported in the previous studies.

On the other hand, anterior transodontoid screw fixation used for odontoid fractures, and anterior C1-2 or occipitocervical fixation procedures used for upper cervical spine instabilities require information regarding the OP and the C2 body.

The anterior C2 height (OP+ C2 body) was found to be 38.7 mm (range: 33-46.6 mm) in the current series. This parameter was reported to be 37.8 mm by Heller et al (5), and 39.9 mm by Doherty et al (4). This reflects the length of screw necessary for anterior transodontoid screw fixation. Therefore a 36 mm screw seems to be appropriate in most cases.

On the other hand, the anterior C2 body may be used for anterior craniovertebral junction fixation. The anterior height of the C2 was found to be 23.2 mm in our series. This is, to some extent, larger than the results reported by Xu (14), Schaffer (12), Kandziora (6) and Lu (7).

The AP and transverse diameters of the C2 body were found to be 15.8±1.7 mm, and 18.1±1.8 mm, in our study, respectively. This is in line with results reported by Lu et al (7), and Panjabi et al (10). This

parameter can be taken into consideration during the anterior plating of the C2 body using screws to detect the screw length.

In summary, the results determined in the current study are in general, in line with results reported in the literature. These results will help the surgeon during many surgical procedures for decompression and/or fixation of the anterior craniovertebral junction. This is, to best of our knowledge, the first published study on C2 and the OP using the Turkish population's vertebrae. However, the preoperative use of computed tomography is recommended to avoid variation-related complications.

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