

# Morphometric analysis of cervical vertebrae with multidetector computerized tomography

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## Abstract

**Aim:** We aimed to present some morphometric values of the cervical vertebra in our study.

**Materials and Methods:** The study was performed on 100 individuals (50 females-50 males) aged between 20 and 80 years with multidetector computed tomography and cervical vertebrae. Parameters are measured and recorded in our work; sagittal diameter of foramen vertebra, transverse diameter of foramen vertebra, sagittal diameter of corpus vertebra, transverse diameter of corpus vertebra and corpus vertebra height.

**Findings:** We investigated whether there was a statistically significant difference between men and women. Sagittal diameter of corpus vertebra and transverse diameter of corpus vertebra values were significantly higher in all cervical vertebrae than in females ( $p < 0.05$ ). Corpus vertebrae height values were significantly higher ( $p < 0.05$ ) in men except C2 vertebrae.

**Conclusion:** As a result, the averages we obtained are important in terms of creating reference values in Turkish society. We think that these values will help radiologists for diagnosis and surgeons for surgical interventions.

**Keywords:** Vertebra; morphometry; anatomy.

## INTRODUCTION

While the cervical spine supports the head on the body, it also permits movement of the head of the three axes. Cervical spine provides joints and complex muscle structure to protect spinal cord and nerve roots. There are 33 vertebrae in human body, 7 of these are cervical vertebrae and the first, second and seventh are different from the others. The other 4 are similar. The vertebral body provides 2/3 of strength and support (1,2). The spinal canal's cervical area occupies more of the spinal canal. Because of this narrowing of the cerebrospinal fluid, the very absorbent feature of the traumatic side of the spinal cord is lower in the cervical region, and it is likely that the cervical spinal canal will be compressed when it is implanted into the bony structure or intervertebral disc into the canal. The cervical spinal canal is funnel shaped. The narrower the cut is at the C5-C6 level. For this reason, most of the cervical spine-derived sores originate at the C5-C6 level (3). Spinal stenosis is defined as the lateral

recession of the spinal canal or the narrowing of the neural foramina on a bone or soft tissue basis. Spinal stenosis was described by Verbiest in 1949 and has been treated for the last 30 years (4).

In this study, we aimed to reveal some morphometric values of cervical vertebrae. Thus, we both contributed to the establishment of a reference range of the Turkish society and looked at whether there was a difference between the sexes. We believe that these data will be useful in diagnosis and surgery.

## MATERIALS and METHODS

This is a retrospective study. The study was carried out on 100 individuals (50 females-50 males) with multidetector computed tomography (MDCT) and cervical vertebrae applied to the Department of Radiology, Konya Education and Research Hospital, University of Health Sciences. Individuals ranging in age from 20 to 80 were included in the study. The study was conducted on healthy individuals

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and individuals with vertebral pathology were excluded from the study.

In the first step of working; patients who had previously applied to the hospital and 64-section MDCT and cervical vertebra images were obtained from them. Morphological evaluation was then performed by detecting images on the sagittal, coronal, and axial planes. Morphometric measurements were made by the same person to minimize the error margin. Parameters that are measured and recorded in our present work; foramen vertebra sagittal diameter (FVSD), foramen vertebra transverse diameter (FVTD), corpus vertebra sagittal diameter (CVSD), corpus vertebral transverse diameter (CVTD), corpus vertebra height (CVH).

The averages of the data obtained were used to determine whether the difference between the means of both genders was using the T test. These details are given in table 1.

## RESULTS

Five different parameters of cervical vertebra were measured and mean values were determined. We investigated whether there was a statistically significant difference between men and women. CVSD and CVTD values were significantly higher in all cervical vertebrae than in females ( $p < 0.05$ ). CVH value in C2 was . what?? significantly ( $p < 0.05$ ) higher in men than in women. . No significant differences were found among the other values obtained and the data obtained by male and female sex were given in detail (Table 1).

## DISCUSSION

The dimensions of the cervical spinal canal are clinically important in traumatic and degenerative conditions (5). Spinal stenosis is a predisposing factor for cervical

myelopathy and spinal cord injury and plays a decisive role in the outcome of injury patterns. Degenerative cervical spinal diseases narrow the vital area of the spinal canal and thereby affect the smooth functioning of the neural elements at the level of the stenosis (6). The anterior-posterior diameter of the spinal canal is the distance from the posterior cortex of the vertebra corpus??what? to the laminar line of the same vertebra. Computerized tomography is quite successful in showing osteophytes and calcifying discs and evaluating the size of the spinal canal (7).

Morishita et al. (5) reported that the mean foramen vertebra sagittal diameter was  $13.73 \pm 1.37$  mm for C3-C7. Evangelopoulos et al. (3) reported that the foramen vertebra sagittal diameter in males was  $13.59 \pm 1.62$  mm for vertebra C2,  $13.31 \pm 1.71$  mm for the vertebra C3,  $13.05 \pm 1.01$  mm for vertebra C4,  $13.43 \pm 1.22$  mm for vertebra C5,  $13.28 \pm 1.85$  mm for the vertebra C6 and in the women.  $13.25 \pm 1.27$  mm for vertebra C2,  $12.94 \pm 1.32$  mm for the vertebra C3,  $12.49 \pm 1.49$  mm for vertebra C4,  $12.66 \pm 1.68$  mm for vertebra C5, and  $12.52 \pm 1.76$  mm for the vertebra C6. Wang et al. (8) found that in the Northeast Chinese population the sagittal diameter of the foramen vertebrae of the vertebrae C7 was  $13.8 \pm 1.0$  mm in women and  $14.6 \pm 1.3$  mm in men. Payne and Spillane (9) found that the mean foramen vertebra sagittal diameter was in males 19.90 mm for vertebra C2, 18.60 mm for vertebra C3, 17.50 mm for vertebra C4, 17.80 mm for vertebra C5, 18.80 mm for vertebra C6, 17.80 mm for the vertebra C7 and 17.80 mm, 17.90 mm, 17.30 mm, 17.10 mm, 17 mm and 16.60 mm respectively for the women. Gupta et al (10) found that the average foramen vertebra sagittal diameter was in males 19.66mm for vertebra C2, C3. 17.07mm for vertebra C3, C4. 16.59mm for vertebra C4, C5. 16.65mm for vertebra C5, C6. 16.73mm for vertebra C6, C7.

**Table 1. Values of cervical vertebrae in men and women (mean $\pm$ SD)(mm)**

	FVSD	FVTD	CVSD	CVTD	CVH
<b>C2</b>	P>0.05	P>0.05	<b>P&lt;0.05</b>	<b>P&lt;0.05</b>	P>0.05
<b>Female</b>	14.86 $\pm$ 1.67	21.14 $\pm$ 2.18	15.64 $\pm$ 1.51	19.42 $\pm$ 2.39	10.64 $\pm$ 2.08
<b>Male</b>	15.05 $\pm$ 1.81	21.24 $\pm$ 1.91	17.63 $\pm$ 2.08	20.99 $\pm$ 2.80	10.79 $\pm$ 1.48
<b>C3</b>	P>0.05	P>0.05	<b>P&lt;0.05</b>	<b>P&lt;0.05</b>	<b>P&lt;0.05</b>
<b>Female</b>	12.73 $\pm$ 1.36	19.91 $\pm$ 2.08	14.33 $\pm$ 1.33	19.83 $\pm$ 2.40	9.71 $\pm$ 1.33
<b>Male</b>	12.95 $\pm$ 1.66	19.88 $\pm$ 1.92	17.19 $\pm$ 2.35	21.72 $\pm$ 2.10	10.69 $\pm$ 1.75
<b>C4</b>	P>0.05	P>0.05	<b>P&lt;0.05</b>	<b>P&lt;0.05</b>	<b>P&lt;0.05</b>
<b>Female</b>	12.42 $\pm$ 1.41	19.88 $\pm$ 2.33	14.26 $\pm$ 1.81	20.45 $\pm$ 2.25	9.54 $\pm$ 1.29
<b>Male</b>	12.13 $\pm$ 2.03	19.47 $\pm$ 1.80	16.65 $\pm$ 1.89	22.29 $\pm$ 2.39	10.45 $\pm$ 1.78
<b>C5</b>	P>0.05	P>0.05	<b>P&lt;0.05</b>	<b>P&lt;0.05</b>	<b>P&lt;0.05</b>
<b>Female</b>	12.27 $\pm$ 1.38	20.51 $\pm$ 2.40	14.38 $\pm$ 1.46	21.64 $\pm$ 2.98	9.09 $\pm$ 1.29
<b>Male</b>	12.05 $\pm$ 1.89	20.24 $\pm$ 1.94	17.01 $\pm$ 2.10	23.82 $\pm$ 3.19	9.98 $\pm$ 1.63
<b>C6</b>	P>0.05	P>0.05	<b>P&lt;0.05</b>	<b>P&lt;0.05</b>	<b>P&lt;0.05</b>
<b>Female</b>	11.98 $\pm$ 1.52	20.34 $\pm$ 2.31	14.70 $\pm$ 2.09	22.93 $\pm$ 2.98	9.26 $\pm$ 1.28
<b>Male</b>	12.20 $\pm$ 1.83	19.90 $\pm$ 2.19	17.30 $\pm$ 2.24	25.50 $\pm$ 3.60	10.38 $\pm$ 1.65
<b>C7</b>	P>0.05	P>0.05	<b>P&lt;0.05</b>	<b>P&lt;0.05</b>	<b>P&lt;0.05</b>
<b>Female</b>	12.14 $\pm$ 1.46	19.79 $\pm$ 2.17	15.00 $\pm$ 1.96	24.13 $\pm$ 3.80	10.69 $\pm$ 1.32
<b>Male</b>	12.60 $\pm$ 2.10	19.92 $\pm$ 1.94	17.38 $\pm$ 2.22	26.25 $\pm$ 3.48	12.16 $\pm$ 1.75

16.42mm for the vertebra C7 and 18.60mm, 16.13mm, 15.60mm, 15.72mm, 15.84mm and 15.54mm respectively for the women. In our study, the size of the foramen vertebra sagittal diameter was in women, 14.86±1.67 mm for the vertebra C2, 12.73±1.36 mm for the vertebra C3, 12.42±1.41 mm for vertebra C4, 12.27±1.38 mm for the vertebra C5, 11.98±1.52 mm for vertebra C6, 12.14±1.46 mm for vertebra C7 and in males, 15.05±1.81 mm for vertebra C2, 12.95±1.66 mm for vertebra C3, 12.13±2.03 mm for the vertebra C4, 12.05±1.89 mm for the vertebra C6, 12.20±1.83 mm for vertebra C7, 12.60±2.10 mm for the vertebra C7. The values we find are in accordance with the literature.

The sagittal and transverse dimensions of the canalis vertebralis, which contains the medulla spinalis are important. Pathological narrowing of canalis vertebralis, known as spinal canal stenosis, can cause neurological problems due to compression of medulla spinalis (11).

Wang et al. (8) found that the transverse diameter of the foramen vertebrae in the northeastern Chinese population is 21.7±1.0 mm for the vertebra C3, 22.7±1.5 mm for the vertebra C4, 23.9±1.7 mm for the vertebra C5, 24.1±1.5 mm for the vertebra C6, 23.7±1.5 mm for vertebra C7 and for men, 22. ±1.2 mm for the vertebra C3, 24.3±1.6 mm for the vertebra C4, 25.4±1.6 mm for the vertebra C5, 25.6±1.7 mm for vertebra C6, and 24.9±1.9 mm for the vertebra C7. Tatarek et al. (12) found that the transverse diameter of the foraminal vertebrae in the African American population was 23.39±1.23 mm for vertebra C2, 23.32±1.2 mm for the

vertebra C3, 24.31±1.23 mm for vertebra C4, 25.02±1.36 mm for vertebra C5, 25.46±1.44 mm for vertebra C6, 24.48±1.31 mm for the vertebra C7 and for women. 22.52±1.39 mm for vertebra C2, 22.68±1.34 mm for the vertebra C3, 23.47±1.48 mm for vertebra C4, 23.98±1.46 mm for vertebra C5, 24.49±1.60 mm for vertebra C6, and 23.53 ± 1.35 mm for the vertebra C7. In the Caucasian population of the same group, the transverse diameter of the foramen vertebra was 23.79±1.47 mm for vertebra C2, 23.43±1.35 mm for vertebra C3, 24.13±1.46 mm for vertebra C4, 24.86 ± 1.60 mm for vertebra C5, 25.21±1.65 mm for vertebra C6, 24.336±1.61 mm for vertebra C7 and for women. 22.90±1.51 mm for vertebra C2, 22.48±1.31mm for vertebra C3, 23.47±1.29 mm for vertebra C4, 24.20±1.28mm for vertebra C5, 24.32±1.41 mm for vertebra C6, and 23.41±1.33mm for the vertebra C7. In our study, according to the measurement results made in the Turkish population, the transverse size of the foramen vertebra was 21.14±2.18 mm for the vertebra C2, 19.91±2.08 mm for the vertebra C3, 19.88±2.33 mm for vertebra C4, 20.51±2.40 mm for vertebra C5, 20.34±2.31 mm for vertebra C6, 19.79±2.17 mm for vertebra C7 and for males 21.24±1.91 mm for the vertebra C2, 19.88±1.92 mm for the vertebra C3, 19.47±1.80 mm for vertebra C4, 20.24±1.94 mm for the vertebra C5, 19.90±2.19 mm for vertebra C6, and 19.92±1.94 mm for the vertebra C7. The values we find are compatible with the literature information.

Designing spinal implants containing cervical vertebrae and not injuring regional vital structures in surgical

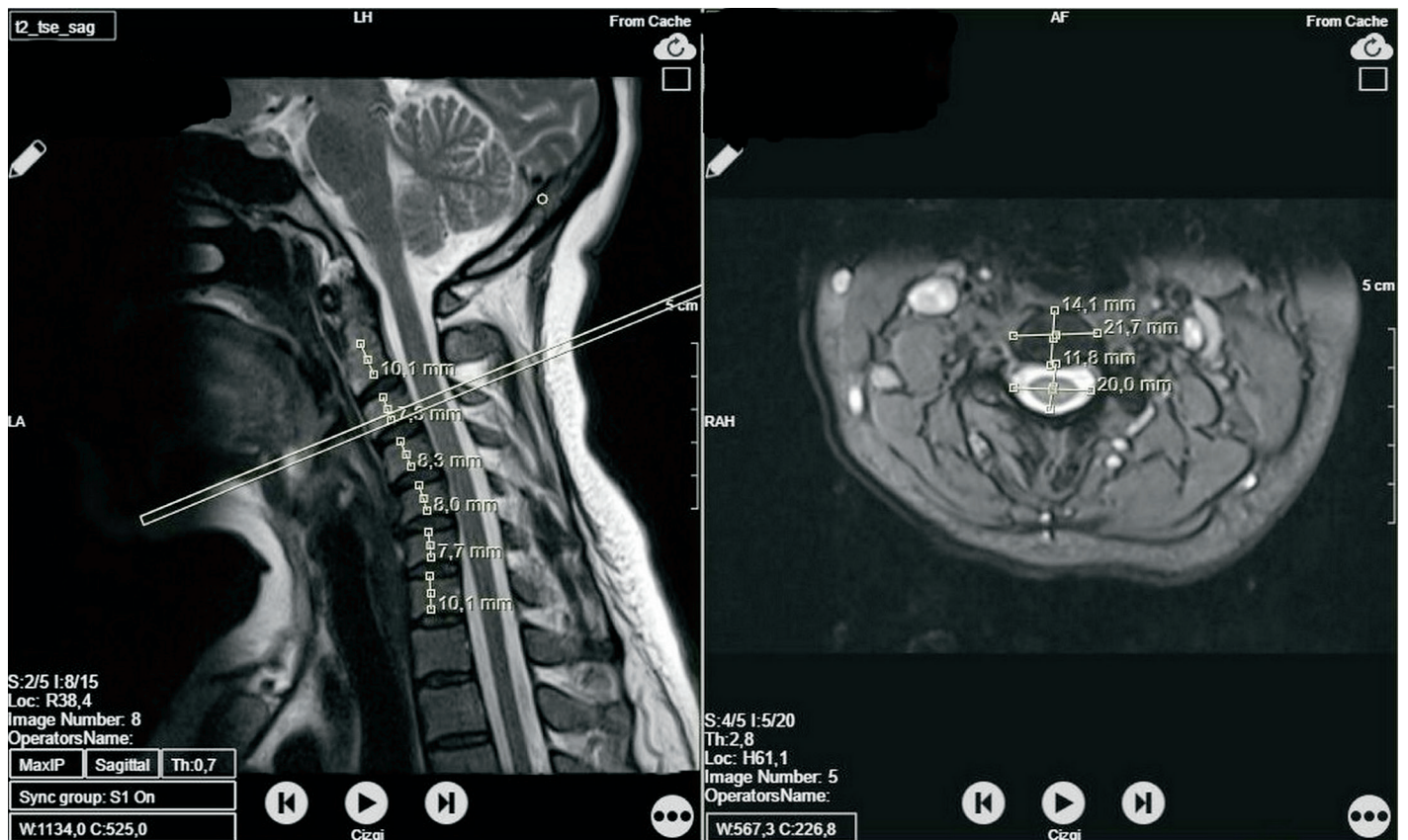


Figure 1. Measurement of cervical vertebral parameters



procedures requires detailed anatomic knowledge. However, variability in vertebral dimension is present between different breeds and prevents standardization of measurements (13).

Matveeva et al. (14) recorded the mean sagittal diameter of the corpus as 14.03±1.04 mm in women and 16.55±1.26 mm in men. Abuzayed et al. (15) found that the sagittal diameter of the corpus in the Anatolian population was 15.6±2.52 mm for the vertebra C3, mean for the vertebra C4 was 16.2±2.18 mm, the average for vertebra C5 was 15.6±2.02 mm, 16.8±2.15 mm for the vertebra C6, and 17.6±2.38 mm for the vertebra C7. Bazaldúa et al. (16) found that the sagittal diameter of the corpus in the measurement results of dry bone in a population from northeastern Mexico was mean of 14.68±2.63 mm for the vertebra C3, mean 16.36±0.99 mm for the vertebra C4, mean for the vertebra C5 was 17.45±1.29 mm, mean for the vertebra C6 was 17.47±1.48 mm, and an average of 17.42±1.33 mm for the vertebra C7. In our study, we measured the sagittal diameter of corpus was for the vertebra C2 15.64±1.51 mm, 14.33±1.33 mm for the vertebra C3, 14.26±1.81 mm for vertebra C4, 14.38±1.46 mm for the vertebra C5, 14.70±2.09 mm for vertebra C6, 15.00±1.96 mm for the vertebra C7 and for the males, 17.63±2.08 mm for vertebra C2, 17.19±2.35 mm for the vertebra C3, 16.65±1.89mm for vertebra C4, 17.01±2.10 mm for vertebra C5, 17.30±2.24 mm for vertebra C6, for the vertebra C7 17.38±2.22 mm. The values we find are in accordance with the literature.

Abuzayed et al. (15) found that the transverse diameter of the corpus in the Anatolian population was mean of 22.3±1.8 mm for the vertebra C3, mean 22±2.5 mm for the vertebra C4, mean for the vertebra C5 was 23.5±2.72 mm, mean of 24.5±3.07 mm for the vertebra C6, recorded an average of 26.7±3.1 mm for the vertebra C7. Bazaldúa et al. (16) found that the transverse diameter of the corpus in the measurement results of dry bone in a population from northeastern Mexico was mean of 19.17±3.04 mm for the vertebra C3, mean for the vertebra C4 was 20.75±1.86 mm, mean of 20.88±3.73 mm for the vertebra C5, mean of 22.17±2.17 mm for the vertebra C6, they recorded an average of 23.44±3.48 mm for the vertebra C7. In our study, the transverse diameter of corpus was 19.42±2.39 mm for the vertebra C2, 19.83±2.40 mm for the vertebra C3, 20.45±2.25 mm for the vertebra C4, for vertebra C5 21.64±2.98 mm, 22.93±2.98 mm for vertebra C6, 24.13±3.80 mm for the vertebra C7 and for the male. 20.99±2.80 mm for vertebra C2, 21.72±2.10 mm for the vertebra C3, for the vertebra C4, 22.29±2.39 mm, for vertebra C5, 23.82±3.19 mm, 25.50±3.60 mm for the vertebra C6, and 26.25±3.48 mm for the vertebra C7. The values we find are in accordance with the literature.

Radiologic lateral radiographs are an important tool in the evaluation of vertebral morphometry, particularly in the diagnosis of diseases such as osteoporosis. Researchers noted that the anterior and posterior heights of the

vertebrae are important. These heights and rates are a quantitative method for identifying osteoporotic fractures (17).

Saluja et al. (13) recorded the mean corpus height as 11.39±1.08 mm for C3-C6 in the measurements of dry bones from the Indian population. Abuzayed et al. (15) studied the Anatolian population in the front face of the corpus. The height of the vertebra C3 was 13.8±1.93 mm, The height of the vertebrae C4 was 12.95±1.74 mm, the height of the vertebra C5 was 12.82±1.96 mm, the height of the vertebra C6 was 13.89±2.37 mm, the height of the vertebrae C7 was 15.38±1.18 mm. The height of the vertebra C3 was 13.35±2.21 mm, The height of the vertebra C4 was 13.75±1.69 mm, the height of the vertebra C5 was 13.2±1.63 mm, the height of the vertebra C6 was 13.2±1.69 mm, the height of the vertebrae C7 was recorded as 14.55±1.79 mm. In our study, the corpus height was in women. for vertebra C2 10.64±2.08 mm, 9.71±1.33 mm for the vertebra C3, 9.54±1.29 mm for the vertebra C4, 9.09±1.29 mm for the vertebra C5, for the vertebra C6 9.26±1.28 mm, 10.69±1.32 mm for vertebra C7 and for males, 10.79±1.48 mm for the vertebra C2, 10.69±1.75 mm for the vertebra C3, 10.45±1.78 mm for the vertebra C4, for the vertebra C5 9.98±1.63 mm, 10.38±1.65 mm for vertebra C6, for the vertebra C7 was 12.16±1.75 mm. The values we find are in accordance with the literature.

## CONCLUSION

The resulting averages are important in terms of creating reference values in Turkish society. We think that these values will help surgeons for radiologists and surgical interventions for diagnosis.

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