

# Morphometric analysis of occipitocervical region and cervical height in the female and male

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## Summary

In this study, midsagittal magnetic resonance images of 194 adults (101 females, 93 males) were evaluated morphologically. It was aimed to reveal the relationship between occipitocervical region and cervical height. The height of cervical vertebral column, height of axis, the distance of foramen magnum, the diameter of spinal canal and spinal cord at the level of C3 were measured. The distance of foramen magnum opening was measured as the distance between basion and opisthion. The correlation of these measurements in males and females, the differences between both sexes and possible effect of age were evaluated. There were positive correlations between the height of cervical vertebral column and axis height and between the distance of foramen magnum opening and spinal canal diameter at the level of C3 in males. There were positive correlations between the height of cervical vertebral column, and axis height, the distance of foramen magnum opening and the diameter of spinal canal at the level of C3 in females. There were statistically significant differences between males and females for the height of cervical vertebral column, the distance of foramen magnum opening and the diameter of spinal cord at C3 level. Males had higher values for these measurements. There was a statistically significant difference between the males who were over 40 years old and less than 40 years old when the diameter of spinal cord at the level of C3 was considered. As a result it could be suggested that upper cervical vertebrae changes

are more evident in males whereas lower cervical vertebrae changes are more evident in females.

**Key words:** Female, magnetic resonance imaging, male, occipitocervical region

## Özet

**Oksipitoservikal bölge ve servikal yüksekliğin kadınlarda ve erkeklerde morfometrik analizi**

Bu çalışmada 194 erişkinin (101 kadın, 93 erkek) midsagittal manyetik rezonans görüntüleri morfolojik olarak değerlendirildi. Oksipitoservikal bölgenin servikal yükseklik ile ilişkisinin ortaya çıkarılması amaçlandı. Columna vertebralis'in servikal bölümünün yüksekliği, axis'in yüksekliği, foramen magnum'un çapı (basion-opisthion), C3 vertebra seviyesinden canalis vertebralis ve medulla spinalis'in çapı ölçüldü. Elde edilen ölçümlerin istatistiksel analizi yapılarak, kadınlarda erkeklerin ölçümlerinde farklılık olup olmadığına, her iki cinsin kendi içlerinde korelasyon olup olmadığına ve yaşın olası etkilerine bakıldı. Erkeklerde columna vertebralis'in servikal bölümünün yüksekliği ile, axis yüksekliği arasında ve foramen magnum çapı ile C3 vertebra hizasında spinal kanal çapı arasında pozitif korelasyon bulundu. Kadınlarda ise, columna vertebralis'in servikal bölümünün yüksekliği ile, axis yüksekliği, foramen magnum çapı, C3 vertebra hizasında spinal kanal çapı arasında pozitif korelasyon bulundu. Kadınlarda erkeklerin bulguları arasında columna vertebralis'in servikal bölümünün yüksekliği, foramen magnum çapı, C3 vertebra hizasında medulla spinalis çapı için istatistiksel olarak anlamlı farklılıklar bulundu. Bu ölçümler erkeklerde daha yüksekti. Kırk yaş altı ve 40 yaş üstü kadınlarda ve erkeklerde ölçümler arasındaki farklılıklara bakıldığında, istatistiksel olarak sadece erkeklerde C3 vertebra hizasında medulla spinalis çapı farklıydı. Tüm sonuçlar bir arada değerlendirildiğinde, erkeklerde üst servikal bölgeye ait patolojilerin kadınlarda ise alt servikal bölgeye ait patolojilerin daha çok görülebileceği kanısına varıldı.

**Anahtar kelimeler:** Kadın, manyetik rezonans görüntüleme, erkek, oksipitoservikal bölge

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## Introduction

Cervical spine is one of the most complicated joint systems in the human body. Thirty seven separate joints which participate in many movements of the head and neck are related with the trunk, eye, ear and tongue. During our daily activities, neck performs over 600 motions. Factors, such as daily stresses, normal movements, sitting, walking, rotation and lying, continuously change motion of cervical spine (1). In order to carry out all of these movements, atlantooccipital joint has a flexion-extension of  $\pm 15^\circ$ , and atlantoaxial joint has a rotation of  $\pm 25^\circ$ . Within whole cervical region, with the participation of zygapophysial joint,  $40^\circ$  of flexion,  $90^\circ$  of extension,  $\sim 40^\circ$  of lateral flexion (between C2-C7),  $45^\circ$  of rotation and circumduction, which is a combination of all these movements, could be possible (2). Normal structures of bones and joints are essential in order to protect the spinal cord, vascular supply and nerve fibers (1).

Twelve per cent of women and 9% of men within the population complain of neck pain without any findings. There is no correlation between the clinical symptoms and radiological findings when neck and occipital pain without injury were evaluated. Especially, it has been reported that joint degeneration begins at over 40 years in old adults (1). Deformities of skull base and cervical spine will occur due to the softening of bone tissue during the development period. Magnetic resonance (MR) and computerized tomography (CT) images of a patient with the suspect of occipito-cervical pathology are very important. The height of dens axis, shortness of neck, diameter of foramen magnum play an important role in the changes in bone structures and joints of the skull base (3).

The aim of this study was to evaluate the height of cervical spine, diameter of foramen magnum, height of axis and diameter of spinal canal at C3 level, which is the narrowest diameter of spinal canal. Their effects on each other, and sexual differences and variations occurring with the advance of age were also evaluated.

## Material and Methods

This descriptive study was performed between September 2004 and March 2005. MR images of 194 adults (101 females, 93 males) aged between 21 to 75 years were evaluated for this study. Study group involved patients who do not have any congenital abnormalities, operations, trauma and who only have complaint of neck pain and minimal degeneration which is not enough to explain the pain. MR images were obtained from BEYTOM (An imaging center in

Zonguldak), using Vectra 0.5 Tesla MR imaging system. On T1-weighted images acquired in the midsagittal and axial plane, 5 parameters were measured by the same observer (4,5) (Figure 1).

1. Height of cervical spine: Distance between the apex of dens axis and posterior-inferior edge of C7 (h)
2. Height of axis: Distance between the apex of dens axis and base of axis (d)
3. Diameter of foramen magnum: Distance between the basion and opisthion (b-o)
4. Diameter of spinal cord at C3 (C3ms)
5. Diameter of spinal canal at C3 (C3sc)



**Figure 1.** Measurements of height of cervical spine (1), height of axis (2), diameter of foramen magnum (3), spinal cord at C3 (4) and spinal canal at C3 (5)

Statistical analysis of measurements was performed by the Department of Public Health, University of Zonguldak Karaelmas using SPSS for Windows 11.0.1. "t" test was used for the comparison of means, Pearson correlation test was used to evaluate correlation between measurements, independent sample t test was used to evaluate the differences between males and females, and Mann-Whitney "U" test was used to evaluate the differences between males and females over and under 40 years of age.

## Results

Mean values of the measurements are shown in Table I. Based on these results, differences between

males and females were evaluated. Correlations of 5 parameters for both males and females were also evaluated. In both males and females, significant differences over and under 40 years of age were evaluated. After taking the mean of 5 measurements, differences between males and females were examined and the following results were obtained.

**Table I.** Comparison of measurements according to gender

	Females (n=101)*	Males (n=93)*
Height of cervical spine (mm)**	96.71±6.97	104.46±8.03
Height of axis (mm)	27.59±4.2	28.41±4.97
Diameter of foramen magnum (mm)**	36.09±2.79	38.19±3.85
Diameter of spinal cord at C3 (mm)	8.25±0.95	8.41±1.18
Diameter of spinal canal at C3 (mm)**	12.77±1.25	13.33±1.34

\*: Values are given as mean±SD

\*\* : Statistical significance; p<0.05

There were statistically significant differences between males and females when height of cervical spine, distance between basion and opisthion and diameter of spinal canal at C3 were considered (p<0.05). The values of height of cervical spine, distance between basion and opisthion and diameter of spinal canal at C3 were higher than those of females.

Correlation of the height of cervical spine, height of axis, the distance between basion and opisthion, diameter of spinal cord at C3 and diameter of spinal canal at C3 were evaluated for females (Table II). There was a significant correlation between the height of cervical spine and height of axis. A significant correlation was found between the height of cervical spine with distance of basion and opisthion and diameter of spinal cord at C3. There was no correlation between the height of cervical spine and diameter of spinal canal at C3. A significant correlation was found between the height of axis with height of cervical spine, distance of basion and opisthion and diameter of spinal cord at C3. There was no correlation between the height of axis and diameter of spinal canal at C3. A significant correlation was found between the distance of basion and opisthion with height of cervical spine, height of axis and diameter of spinal canal at C3. There was no correlation between the distance of basion and opisthion and diameter of spinal cord at C3. A significant correlation was found between the diameter of spinal cord at C3 with height of cervical spine and height of axis. A significant correlation was not found between the diameter of spinal cord at C3 and diameter of spinal canal at C3. There was no correlation between the diameter of spinal cord at C3 and distance of basion and opisthion. A significant correlation was found between the diame-

ter of spinal canal at C3 and distance of basion and opisthion. A weak correlation was found between the diameter of spinal canal at C3 and diameter of spinal cord at C3. As a result, in women, height of cervical spine, height of axis, distance of basion and opisthion, diameter of spinal cord at C3 are in accurate and correct proportion. The diameter of spinal canal at C3 and diameter of spinal cord at C3 are in accurate and correct proportion.

**Table II.** Correlation analysis of measurements for females

	Height of cervical spine (mm)	Height of axis (mm)	Diameter of foramen magnum (mm)	Diameter of spinal cord at C3 (mm)	Diameter of spinal canal at C3 (mm)
Height of cervical spine (mm)	1				
Height of axis (mm)	0.687*	1			
Diameter of foramen magnum (mm)	0.310*	0.394*	1		
Diameter of spinal cord at C3 (mm)	0.299*	0.315*	0.089	1	
Diameter of spinal canal at C3 (mm)	0.124	0.172	0.279*	0.229*	1

\*: Statistical significance; p<0.05

The correlation results of male patients are as follows (Table III). A significant correlation was found between the height of cervical spine and height of axis, however there was no correlation between the height of cervical spine and other measurements. A significant correlation was found between the distance of basion and opisthion and diameter of spinal canal at C3. There was no correlation between the distance of basion and opisthion and other measurements. In summary, the male patients' height of cervical spine and height of axis are in accurate and correct proportion. Patients with greater distance of basion and opisthion also have a greater diameter of spinal canal at C3.

There were no statistically significant differences between the females over and under 40 years of age. There was a statistically significant difference between the males over and under 40 years of age for the diameter of spinal cord at C3 level (p<0.05).

## Discussion

Male patients who had high values of height of cervical spine also had greater values of height of axis.

**Table III.** Correlation analysis of measurements for males

	Height of cervical spine (mm)	Height of axis (mm)	Diameter of foramen magnum (mm)	Diameter of spinal cord at C3 (mm)	Diameter of spinal canal at C3 (mm)
Height of cervical spine (mm)	1				
Height of axis (mm)	0.641*	1			
Diameter of foramen magnum (mm)	0.019	-0.024	1		
Diameter of spinal cord at C3 (mm)	0.497	0.405	0.185	1	
Diameter of spinal canal at C3 (mm)	0.080	0.078	0.285*	-0.069	1
	0.447	0.455	0.006	0.512	

\*: Statistical significance;  $p < 0.05$

Additionally, the patients with greater distance of basion and opisthion also had greater diameter of spinal canal at C3. In addition, height of axis and distance of basion and opisthion had linear relationships. Distance of basion and opisthion and diameter of spinal canal at C3, diameter of spinal cord and diameter of spinal canal had also linear relationships.

Positional variations of dens axis may affect the movements of upper cervical spine. Changes in the upper cervical spine may cause pain and dysfunction (6). The posterior bulging of the dens axis in foramen magnum shows risk of basilar impression (7-9). For those patients CT and MR imagings are necessary. Short neck and long dens axis increase the risk of basilar impression (3). In our study, male patients with long cervical spine also had high height of axis. Therefore, the distance of basion-opisthion is not in linear relationship with other measurements, basilar impression incline is present. In this study, height of cervical spine and height of axis were in correlation in males, but there was no correlation between the height of cervical spine and distance of basion-opisthion and height of axis distance of basion-opisthion. Therefore this suggests that there is a high risk of basilar impression in male patients. Headache may be first and only sign of basilar impression (10).

In our study, we found that the height of cervical vertebrae, distance of basion-opisthion and diameter of spinal canal at C3 level are statistically higher in males, when compared with females. In general the measurements in male were larger than those in females (11).

Significant differences were found between the male and female parameters at all of the cervical measurements (12). Furthermore it is stated in the literature that loss of height of cervical vertebrae is present in about 24% between 45 to 64 years of age and 67% after 64 years of age. In this study, there were no differences in the height of cervical vertebrae in relation to age but the height of cervical vertebrae was low in women with a statistically significant difference. Loss of height causes flattening of cervical lordosis and this results in kyphosis with the advance of age (5,13,14). Kyphosis increases the risk of spinal stenosis and extensor muscles' effort (15). A great majority of the patients with headache were found also to have straightened cervical spine (16). Therefore, the risk of flattening of cervical lordosis and kyphosis is expected to be high in females compared with males.

If sagittal spinal canal diameter is less than 13 mm, the spinal canal is considered to be narrow (5). In our study, spinal canal diameter is found to be  $12.77 \pm 1.25$  mm in women. Minor osteoporosis formed in the vertebral bodies causes a decrease in height of cervical spine in geriatric age group. Weakening of the fibrous tissue that supports the vertebral spine and atrophy in muscle tissue increases the load of vertebral spine and instability. This is the second stage of spinal degeneration. In third stage of geriatric differences, osteophytes and hypertrophic facet joints expand the weight bearing surface of vertebral bodies and decrease spinal canal diameter. Spinal canal diameter has been reported to be generally narrow at C3-4 (5). Because of this, we preferred to measure the spinal canal diameter at C3. In the age group of over 60 years, the mid-sagittal diameters of spinal canal were smaller than those of younger generations at all levels (17). Finally in our study, we did not establish differences in spinal canal in relation to age but we showed that spinal canal is narrower in women, when compared to men. Women with higher cervical spine is found to have higher height of axis and distance of basion-opisthion. It could be suggested that women carry no risk for basilar impression.

It is reported that there are individual differences between the volume of spinal cord and spinal canal (1,18). Wide spinal canal and thin spinal cord are the ideal morphological form. In our study a positive correlation between the spinal canal and spinal cord was found. In the study of Ishikawa et al, it was reported that there was no correlation between the age and diameter of spinal cord (19). In our study we did not establish a relationship between the diameter of spinal cord and age. With the onset of changes in the curve of spinal

cord and cranio-cervical junction occipital headache may start with even slight extension (20). Increasing level of degeneration of spinal cord can cause chronic pain symptoms (21).

Numerous pathological conditions can destabilize the occipitocervical junction, atlantoaxial articulation and subaxial cervical spine. Common mechanisms of instability include trauma, rheumatoid arthritis, inflammatory or infectious lesions, neoplasms, and congenital deformity (22). Cervicomedullary compression may occur secondary to calcium pyrophosphate crystal deposition in the occipitocervical region (23). Common to all these processes is the resulting neural compression and/or craniospinal or spinal instability. The cervical spine presents a challenge to the spinal surgeon because of the neural and vascular structures contained within the spine, and the frequent variation in anatomy among patients (22). Knowledge about the occipitocervical region could be beneficial for the anthropologists, forensic scientists and spinal surgeons. In conclusion, this study suggests that men have high risk for cranio-cervical junction pathologies. The height of cervical spine and diameter of spinal canal at C3 level are significantly low in women, when compared to men. Flattening of cervical lordosis has a tendency to kyphosis. This study suggests that the reason of headache may result from upper cervical region in men and lower cervical region in women. Alterations of upper cervical spine are mainly expected in men, whereas alterations of lower cervical spine are mainly expected in women.

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