

Morphometric Analysis of the Foramen Magnum by Computed Tomography

Foramen Magnumun Bilgisayarlı Tomografi ile Morfometrik Olarak Değerlendirilmesi

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Abstract

Purpose: Since great vital important neuroanatomical structures passing through the foramen magnum, morphometric evaluations are so important especially to establish the most proper operational techniques. The purpose of this study was to clarify and establish exact anatomical definition of interested area by documented morphometric analysis which was evaluated by computed tomography (CT).

Material and Methods: A fifty-four (29 female, 25 male) cranial CT scans obtained from the archives of Department of Radiology were evaluated. The age group who completed of the skull bony maturation was included. The cases having any cranial deformity or structural disorder which could be affect the Foramen Magnum's measurements were not included.

Results: It was found significant positive correlations ($r= 0.63$; $p< 0.05$) between the transverse diameter and anteroposterior diameter of the Foramen Magnum. There was a significant difference between the anteroposterior diameter of male and female cases ($p<0.05$).

Conclusion: Morphometric analysis of Foramen Magnum shows variations so that interested region should be known in detail. Documenting of morphometric values of Foramen Magnum on different populations is still important.

Key words: **Foramen Magnum; Occipital Bone.**

Özet

Amaç: Hayati önem taşıyan nöroanatomik yapılar Foramen Magnum'dan geçtiğinden, özellikle morfometrik değerlendirmeler en uygun operasyon tekniğinin seçiminde çok önemlidir. Kranial bilgisayarlı tomografi görüntüleri üzerinde yapılan ölçümler ile Foramen Magnum anatomisine açıklık getirilmesi amaçlanmıştır.

Gereç ve Yöntem: Çalışmamızda radyoloji bölümü arşivinden elde edilen, 54 vakaya ait (29 kadın, 25 erkek) kranial bilgisayarlı tomografi görüntüleri değerlendirildi. Vakalar, kafatası kemikleşme matürasyonunu tamamlamış yaş gruplarını içerdi. Foramen magnum ölçümlerini etkileyebilecek kranial deformitesi veya kemik yapısında bozukluk olanlar değerlendirmeye alınmadı.

Bulgular: Foramen Magnum ölçümlerinde, transvers çap ile antero-posterior çap (opisthion-basion arası mesafe) arasında anlamlı pozitif ilişki vardı ($r=0,63$; $p<0,05$). Kadın ve erkeklere ait antero-posterior çap değerlerinin farklılıkları karşılaştırıldığında, fark istatistik olarak önemli bulundu; kadınlara ait anteroposterior çap değerleri daha küçüktü ($p<0,05$).

Sonuç: Foramen magnum'un morfometrik analizleri varyasyonlar göstermektedir, bu nedenle ilgili bölgenin detaylı bilinmesinde fayda vardır ve hala farklı popülasyonlarda bu analizlerin dökümente edilmesi, araştırılması önemini korumaktadır.

Anahtar Sözcükler: **Foramen Magnum; Oksipital Kemik.**

Introduction

Foramen magnum (FM) is the oval shape opening situated at the base of the skull, and surrounded by the basillar, squamous, and two lateral parts of the occipital bone (1-3). Studies related with morphometric analysis of antero-posterior diameter (APD) and transverse diameter (TD) of FM showed differences (4, 5, 6), and has an extremely important neuroanatomic location with cranio-vertebral junction (1, 7, 8). Furthermore, the various congenital anomalies occur and many pathological conditions which will be necessary neurosurgical interventions occupied in the interested region (8). Because of these issues, it still remains necessary to report morphometric measurements of FM. It is obvious that, FM evaluations are very important in not only to establish the most proper operational techniques, but also to obtain useful data for unknown sex estimation and determination and identity in forensic medicine. Considering above mentioned importance, the purpose of this study was to clarify and establish exact anatomical definition of FM by documented morphometric analysis which was evaluated by Computed Tomography (CT).

Material and Methods

A fifty-four (29 female, 25 male) cranial CT scans were evaluated from the subjects administrated to Department of Radiology. Our cases were included the age group who completed of the skull bony maturation, the youngest subject was 15 and the oldest was 71 year old (6). It was assumed that as a healthy cases who had minor headache or diseases but no any other cranial deformities or structural disorders which could affect the FM measurements. Imaging was obtained by using PQS 2000 Picker spiral CT scanner. A consecutive CT slices were parallel to orbito-meatal line in 5 mm thickness in axial mode. The best appearance images of FM were selected. Values of the APD and TD of FM were automatically given by cranial CT by expressing as millimeters.

The value of APD on cranial CT was calculated from the distance between the opisthion and basion (sagittal), and TD value from the widest distance between the incisures (Fig. 1). Index of FM was calculated by formula; transverse diameter x 100 / antero-posterior diameter (9).

Data were compared using the Mann-Whitney U test and correlation coefficient was used to examine the association between variables. A P-value less than 0.05 were considered statistically significant.

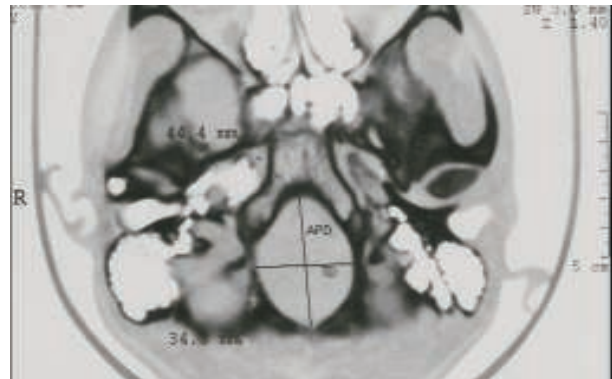


Figure 1. Measurements of antero-posterior diameter (APD; distance between the opisthion and basion), and transverse diameter (TD; the widest distance between the incisures) on cranial computed tomography of Foramen magnum.

Results

The mean age of the female cases was 47.17±17.68 and mean age of the male cases was 39.52±24.55. In comparison between the age of two sex groups, there was no significant statistical difference (p>0.05).

There was a significant positive correlation between the values of TD and APD of FM measurements (r= 0.63; p< 0.05; Table I). The comparison of the difference between the TD and APD values in male and female subjects showed statistically significance in terms of size. In male subjects, the APD and TD values were longer than females (p<0.05) whereas index of FM correlation between the both sexes was not significant different (p>0.05). Index of FM was showed in Table II.

Table I. The Morphometric Measurements of Foramen Magnum (n= 54).

	X	SD
Age (Year)	43.63	21.28
TD (mm)	29.84	2.90
APD (mm)	35.58	4.11
Index*	84.36	8.40

*Transverse diameter x 100/antero-posterior diameter

Table II. Evaluation of morphometric measurements (X±SD) of Foramen Magnum According to Sex.

	Female (n= 29)	Male (n= 25)	Mann-Whitney U Test	P
TD (mm)	29.98±2.78	30.75±2.81	2.196	0,028
APD (mm)	34.41±3.89	36.95±4.01	2.143	0,032
Index	84.94±7.67	83.70±9.27	1.206	0.228

Discussion

It is well documented that a number of vital important neuroanatomic structures pass through of the FM (1, 10-12). Furthermore, intradural and extradural tumors (8), common congenital anomalies such as FM syndrome caused by atlanto-occipital assimilation (8, 13), and cerebellar tissue herniations which invaginated into the FM may lead to neural compression and even death are frequently encountered pathological conditions in this region (12, 14). Since FM has a critical neuroanatomic location for operational approaches, George et al. (15) discussed the safest and the most effective operational techniques on 40 cases with FM meningiomas in detail. Similarly, in cases who had mucopolysaccharidoses size of FM were observed to be narrower than its normal size (16). In the study, carried on neuroanatomic measurements, mean index of FM was found to be 86.40 in male and 85.82 in female, respectively, whereas it was 87.39 in unknown sex groups, and in total in these three group index were 86.52 (4).

In our study, mean index of FM of 54 cases was calculated as 84.36±8.40 without consideration of sex difference. It was observed that our result included middle type group of FM index according to Martin-Saller's scala, while result of Çalgüner et al. included wide type of FM index (4). In comparison with that study, considering to sex differences index of FM values had lower in both sex, but in our study index value in females were a little bit higher than male in contrast to the literature.

The TD, Diameter of the distance between the widest appearance of the incisures, was reported as 3-3.5 cm, and the APD 3-4 cm in the reference book, and the APD of FM was given as 35±4 mm in the literature (1,17). Lang et al. found the APD of FM to be 35.33 mm, and the TD 29.67 mm (6). In the study that carried on 95 adult dry skull the APD was calculated as 3.63±0.27cm, and the TD 3.04±0.27cm (5).

In another research performed on 87 males, 44 females and 34 unknown sexes, totally 165 dry adult skulls, value of APD was 36.75 mm in male and 35.90 mm in female, whereas 36.23 mm in undetermined sex groups. According to the mean value of these three groups; the TD was 31.40 mm in male, 30.90 mm in female, and 31.58 mm in undetermined sex group (4). Similarly Bozbuğa et al.

performed morphometric analysis, in 76 dry skulls and 8 adult cadaver heads in respect of the surgical anatomy of the interested region. The minimum and maximum values of APD were 27.8 mm and 43.2 mm, the mean of APD was 36.6 mm (7). On the other hand, CT measurements of 23 outpatients revealed that mean of APD value was 36.4±2.8 mm, and that the mean of TD value was 30.0±1.4 mm (18).

In our study, without consideration of the sex difference, there were positive correlation between the APD and TD. Present findings were compatible with the Çalgüner et al.'s findings both in APD, TD, and sex (4). Moreover, APD values were in accordance with the other literature (6, 8, 17), but without considering sex, observed a minor decrease was observed in terms of both APD and TD values in comparing with the literature (18). Furthermore, our male cases' APD values were compatible with the study of Sindel et al, however there was minor difference in the TD values (5). These minor controversies may be resulted from differences of the selected population, used parameters, methodologic difference of data assessment, ignoring sex differences, and results of the studies based on dry skulls or cadaveric material.

Since the FM includes specific neuroanatomic structures (1, 10-12) and lesions occupied in that area which need especially microsurgical intervention (11), choosing and establishing the most appropriate surgical techniques require a meticulous planning mainly based on the FM sizes to refrain from any neurological impairment (11, 15, 16). In addition, it is quite difficult to detect many pathological situations not only by neurological examination but also needs support with the radiological findings (13, 11). Besides its clinical importance, FM diameters are also used as significant criteria in forensic medicine. It is reported that sex discrimination was diagnosed by using the diameters of the FM. Accuracy of estimations were detected in a preciseness of 71.4% in females and 84.0% in males (19).

Thus, it is a common statement that variations in size and morphometry of the interested region should be known by detail (13, 15, 16, 19), so it is still remain important, to investigate and document of morphometric values of FM obtaining by CT and their relation to sex and populations.

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