Int. J. Morphol.,
37(3):845-851, 2019.

Morphometric Study of Dried Cervical Vertebrae

Estudio Morfométrico de Vértebras Cervicales Secas

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POLAT, S.; GÖKER, P.; YÜCEL, A. H. & BOZKIR, M. G. Morphometric study of dry cervical vertebrae. *Int. J. Morphol., 37(3)*:845-851, 2019.

SUMMARY: The aim of this study was to emphasize the clinical importance of morphometry and the surgical parameters of the cervical vertebrae. The present study was carried out on ninety six adult dry cervical vertebrae (C3-C7, 96) of unknown gender of Turkish population. The various dimensions of the cervical vertebrae (from C3 to C7) were measured with using a digital caliper accurate to 0.01 mm. Linear parameters including vertebral body anteroposterior width (14.03 mm), vertebral body transverse width (24.45 mm); vertebral body height (10.64 mm); pedicle length (R:5.65±1.91 mm, L:5.65±1.76 mm); pedicle width (R:3.72 mm, L:3.61 mm); lamina height (R:9.87 mm, L:9.86 mm); lamina transverse length (R:13.41 mm, L:13.49 mm); superior articular process anteroposterior width (R:7.26 mm, L:7.46 mm); superior articular process transverse diameter (R: 9.87 mm, L:9.58 mm); superior articular process height (R:16.41 mm, L:16.08 mm); inferior articular process anteroposterior width (R: 7.67 mm, L:7.44 mm); inferior articular process transverse diameter (R: 10.32 mm, L:10.09 mm); inferior articular process height (R:12.72 mm, L:12.67 mm); spinous process length (17.91 mm); uncinate process width (R:4.37 mm, L:3.78 mm); uncinate process height (R:4.58 mm, L:3.93 mm); uncinate process length (R:9.28 mm, L:9.12 mm); vertebral foramen anteroposterior width (13.85 mm); vertebral foramen transverse diameter (20.88 mm); foramen transversarium anteroposterior width (R:4.23 mm, L:4.28 mm); foramen transversarium transverse diameter (R:4.78 mm, L:4.95 mm) were measured. Additionally, the distance of the apex of the uncinate process to foramen transversarium (R:2.91 mm, L:2.70 mm), and the distance of the apex of the uncinate process to intervertebral foramen (R: 5.77 mm, L:5.66 mm) were also calculated. There were found significant differences between two sides in the uncinate process width and height, and distance between uncinate process and foramen transversarium. Present measurements suggest that parameters relevant cervical vertebrae can be used as reference and anatomical landmark for evaluating pathologic changes and minimizing complications in the cervical spine.

KEY WORDS: Cervical vertebrae, uncinate process, foramen transversarium, morphometry.

INTRODUCTION

Vertebral column formed of thirty three (33) vertebrae, is divided into five groups based on morphology and location. These are seven (7) cervical vertebrae, twelve (12) thoracic vertebrae, five (5) lumbar vertebrae, five (5) sacral vertebrae and four (4) coccygeal vertebrae (Gupta *et al*., 2017). A characteristic cervical vertebrae consists of vertebral body, pedicle, lamina, transverse process, spinous process, and superior and inferior articular process (Drake *et al*., 2010). A foramen in transverse process is an important feature of the cervical vertebrae. It passes through vertebral artery, vertebral veins, and sympathetic nerves. Foramen transversarium may show the variation about shape, size, and be unilateral, bilateral, multiple or absent (Murlimanju *et al*., 2011; Gupta *et al*.). Furthermore, the existence of the accessory foramen transversarium may lead to vertebral artery compression. Vertebral vascular insufficiency may results in problems such as headache, migraine and fainting. Cervical vertebrae are entitled as typical (third, fourth, fifth and sixth) and atypical (first, second and seventh) cervical vertebrae (Gupta *et al*.).

Many studies of cervical vertebrae dimensions have been carried out until today. (Abuzayed *et al*., 2010; Bazaldúa Cruz *et al*., 2011; Murlimanju *et al*.; Gupta *et al*.; Kocabiyik *et al*., 2017). On the other hand, the morphometric measurements in vertebrae can change between the races (Abuzayed *et al*.; Bazaldúa Cruz *et al*.; Mahto & Omar, 2015; Desdicioglu *et al*., 2017; Prabavathy *et al*., 2017). Interestingly, the knowledge of cervical vertebrae morphology is significant for avoid damage to the vertebral artery, spinal medulla, or nerve roots during fixation process (Bazaldúa Cruz *et al*.). Rathke has defined the uncinate process (UP) as a bony protuberance in previous century. UP localization extends up to the third cervical vertebra,

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and down to the second thoracic vertebra, anteriorly and posteriorly respectively. They are mostly found between segments third cervical vertebrae and seventh cervical vertebrae. In addition, uncinate processes which are extended from lateral or posterolateral side of cervical vertebral body, are defined as bony protuberances, protuberentia, prominentia, etc. (Kocabiyik *et al*.). Although there have been made a large number of studies on cervical vertebrae in the literature, it has been noted that there are few studies including detailed morphometry of cervical vertebrae conducted in the Turkish population.

The current study was carried out to determine significance in terms of clinical of the anatomical structures of cervical vertebrae in Turkish population

MATERIAL AND METHOD

This study was based on observations of ninety six (96) cervical vertebrae. The data were collected from Anatomy Laboratory of Cukurova University Faculty of Medicine. The following parameters were measured on each cervical vertebrae with an electronic digital caliper accurate to 0.01 mm from C3 to C7 vertebrae. Measurements of the cervical vertebrae shown in Table I were as follows:

Vertebral body anteroposterior width: Distance between anterior and posterior surfaces of the body at the medial line (Bazaldúa Cruz *et al*.; Mahto & Omar).

Vertebral body transverse width: Distance between two lateral surfaces of the vertebral body (Bazaldúa Cruz *et al*.; Mahto & Omar).

Vertebral body height: Distance between superior and inferior margins of the vertebral body at the midline anteriorly (Bazaldúa Cruz *et al*.; Mahto & Omar).

Pedicle length: The distance between anterior margin of the superior articular facet and posterior margin of the vertebral body (Bazaldúa Cruz *et al*.; Devaraj *et al*., 2017).

Pedicle width: The distance between medial and lateral margins of pedicle (Bazaldúa Cruz *et al*.; Devaraj *et al*.).

Lamina height: The distance between superior and inferior margins (Bazaldúa Cruz *et al*.; Prabavathy *et al*.).

Lamina transverse length: The distance between anterior margin of the spinous process and lateral margin of the superior articular process (Bazaldúa Cruz *et al*.)

Superior articular process height: The distance from inferior margin to superior top of the process (Bazaldúa Cruz *et al*.).

Superior articular process transverse diameter: The transverse distance between two lateral margin of the process (Bazaldúa Cruz *et al*.).

Superior articular process anteroposterior width: The distance between anterior and posterior margins of the process (Bazaldúa Cruz *et al*.).

Inferior articular process height: The distance from superior margin to the inferior top of the process (Bazaldúa Cruz *et al*.).

Inferior articular process transverse diameter: The transverse distance between two margins of the process (Bazaldúa Cruz *et al*.).

Inferior articular process anteroposterior width: The distance between anterior and posterior margins of the process (Bazaldúa Cruz *et al*.).

Spinous process length: The distance from the superior margin to the tip of the spinous process (Bazaldúa Cruz *et al*.).

The uncinate process width: The distance between lateral and medial margins of the cervical uncinate process at process base (Bozbug˘a *et al*., 1999; Lee *et al*., 2012; Kocabiyik *et al*.).

The uncinate process length: The length between anterior and posterior parts of the uncinate process (Bozbug˘a *et al*.; Lee *et al*., 2012; Kocabiyik *et al*.).

The uncinate process height: Distance between the tip of the uncinate process and the base of the uncinate process (Bozbuga *et al*.; Lee *et al*., 2012; Kocabiyik *et al*.).

The distance of the apex of the uncinate process to intervertebral foramen were measured (Kocabiyik *et al*.).

The distance of the apex of the uncinate process to foramen transversarium were measured (Kocabiyik *et al*.).

Vertebral foramen anteroposterior width: The maximum anteroposterior length of vertebral canal or foramen vertebrae at the midline (Sengül & Kadıoglu, 2006; Gosavi & Vatsalaswamy, 2012).

Vertebral foramen transverse diameter: The maximum

distance between two lateral limits of vertebral foramen at the medial line (Sengül & Kadıoglu; Gosavi & Vatsalaswamy).

Foramen transversarium anteroposterior width: The maximum anteroposterior diameter of foramen transversarium (Gosavi & Vatsalaswamy; Yesender *et al*., 2017; Molinet Guerra *et al*., 2017).

Foramen transversarium transverse diameter: The maximum transverse diameter of foramen transversarium or distance between two lateral margins (Gosavi & Vatsalaswamy; Yesender *et al*.; Molinet Guerra *et al*.).

The SPSS 21.0 program was used for statistical analysis of the measurement results. From these measurements, means, standard deviations (SD), and minimum (min.) and maximum (max.) values were calculated. Also, Paired Samples T test were used to determine whether there was a significance difference or not in comparison of measurements in right and left sides. $p<0.05$ was considered as statistically significant.

RESULTS

The minimum (min.), maximum (max.), mean and standard deviations (SD) values of the measurements from cervical vertebrae (C3-C7) were shown in Table I respectively. The following means of parameters relevant cervical vertebrae were observed; vertebral body anteroposterior width (14.03 mm), vertebral body transverse width (24.45 mm); vertebral body height (10.64 mm); pedicle length (R:5.65±1.91 mm, L:5.65±1.76 mm); pedicle width (R:3.72 mm, L:3.61 mm); lamina height (R:9.87 mm, L:9.86 mm); lamina transverse length (R:13.41 mm, L:13.49 mm); superior articular process anteroposterior width (R:7.26 mm, L:7.46 mm); superior articular process transverse diameter (R: 9.87 mm, L:9.58 mm); superior articular process height (R:16.41 mm, L:16.08 mm); inferior articular process anteroposterior width (R: 7.67 mm, L:7.44 mm); inferior articular process transverse diameter (R: 10.32 mm, L:10.09 mm); inferior articular process height (R:12.72 mm, L:12.67 mm); spinous process length (17.91 mm); uncinate process width (R:4.37 mm, L:3.78 mm); uncinate process height (R:4.58 mm, L:3.93 mm); uncinate process length (R:9.28 mm, L:9.12 mm); vertebral foramen anteroposterior width (13.85 mm); vertebral foramen transverse diameter (20.88 mm); foramen transversarium anteroposterior width (R:4.23 mm, L:4.28 mm); foramen transversarium transverse diameter (R:4.78 mm, L:4.95 mm); the distance of the apex of the uncinate process to foramen transversarium (R:2.91 mm, L:2.70 mm), and the distance of the apex of the uncinate process to intervertebral foramen (R: 5.77 mm, L:5.66 mm). However, in assessment of the cervical vertebrae (from C3 to C7) measurements in both sides, there were no found significant difference in some values such as pedicle length ($p=1.000$), pedicle width ($p=0.340$), superior articular process anteroposterior width ($p=0.207$), superior articular process transverse width ($p=0.144$), superior articular process height ($p=0.162$), inferior articular process anteroposterior width ($p=0.254$), inferior articular process transverse width ($p=0.361$), inferior articular process height ($p=0.782$), lamina height ($p=0.930$), lamina length ($p=0.578$), uncinate process length ($p=0.265$), foramen transversarium anteroposterior ($p=0.719$) and transverse width ($p=0.225$), bilateral foramen transversarium anteroposterior ($p=0.843$) and transverse width ($p=0.453$), and distance between uncinate process and intervertebral foramen ($p=0.454$). There were significant difference values of uncinate process width and height, and distance between uncinate process and foramen transversarium ($p<0.05$).

DISCUSSION

Although the basic characteristics of the vertebrae were similiar, the features of the vertebrae vary in size and different due to region, race, genetic and gender parameters (Mahto & Omar; Desdicioglu *et al*.; Prabavathy *et al*.). Also, the success in cervical vertebrae surgery involves the detailed anatomical knowledge for selection and installment of proper screw, plate or surgical instruments (Mahto & Omar; Rao *et al*., 2016). The present study provides detailed morphometric information of dry typical cervical vertebrae in Turkish population.

Uncinate process (UP) lies from vertebral body posterior part and it is defined as important bony protuberance in head and neck motions. Also, the variations of UP provide the surgeon to be more effective in treating the pathological lesion and complications. It is known that UP are commonly located at C3 and C7 and this structure is one of the characteristic of cervical vertebrae (Bozbuga *et al*.; Kocabiyik *et al*.). The connection or relation of the UP to inferior side of vertebrae constitudes the uncovertebral joints. Uncovertebral joints plays an important role in cervical spine stability. If degeneration develops in uncovertebral joints, the compressive effect of uncinate osteophytes may arise and end up with nerve root compression in intervertebral foramen, or vertebral artery compression, or cervical spondylotic radiculopathy. Therefore, some symptoms including pain, paraesthesia, muscle weakness, reflex decay or vertebral and basilar failures are seen. UP or uncovertebral

Table I. Cervical vertebrae measurements.

Cervical vertebrae (C3-C7) Measurements (mm)	N	Min	Max.
Vertebral body transverse width	96	17.30	32.00
Vertebral body anteroposterior width	96	10.50	20.00
Vertebral body height	96	3.50	20.00
Pedicle length	R (96)	1.50	11.00
	L (96)	2.00	10.50
Pedicle width	R (96)	1.50	8.50
	L (96)	1.00	9.50
Superior articular process anteroposterior width	R (96)	2.50	13.50
	L (96)	3.50	12.00
Superior articular process transverse diameter	R (96)	5.50	15.00
	L (96)	5.00	15.00
Superior articular process height	R (96)	7.50	23.50
	L (96)	8.00	23.00
Inferior articular process anteroposterior width	R (96)	3.50	13.00
	L (96)	3.50	16.00
Inferior articular process transverse width	R (96)	5.50	17.00
	L (96)	6.00	17.00
Inferior articular process height	R (96)	5.00	21.00
	L (96)	6.20	21.00
Spinous process length	96	5.00	37.00
Lamina height	R (96)	5.00	21.00
	L (96)	4.00	20.00
Lamina transverse length	R (96)	3.50	20.00
	L (96)	3.00	20.00
Uncinate process length	R (96)	5.00	16.50
	L (96)	4.10	16.50
Uncinate process height	R (96)	2.00	16.00
	L (96)	1.00	13.50
Uncinate process width	R (96)	1.00	14.00
	L (96)	0.50	11.00
Vertebral foramen anteroposterior width	96	9.00	19.50
Vertebral foramen transverse diameter	96	15.00	29.00
Foramen transversarium anteroposterior width	96	1.00	7.00
	96	1.50	8.00
Foramen transversarium transverse diameter	96	1.90	9.00
	96	2.00	9.00
Distance between uncinate process and foramen transversarium	96	1.00	6.50
	96	1.00	7.50
Distance between uncinate process and intervertebral foramen	96	1.50	11.00
	96	1.50	9.00
Unilateral accessory transverse foramina anteroposterior width	R (7)	0.50	1.00
Unilateral accessory transverse foramina transverse diameter	R (7)	1.00	2.00
Bilateral accessory transverse foramina anteroposterior width	R (3)	0.50	1.50
Bilateral accessory transverse foramina transverse diameter	L (3)	1.50	4.00
Bilateral or unilateral accessory transverse foramina presence (-)	86 (-)		
Presence of osteophytes	16 (+)	-	-
	80 (-)		

joints are the point of the injury in head and neck trauma. So, the knowledge of the UP is essential for safe removal of the uncovertebral joint without damaging the spinal cord, nerve roots or vertebral artery (Bozbuga *et al*.; Kocabiyik *et al*.). Some studies was reported the average width of the UP should be 4-6 mm for UP's safely resection (Lu *et al*., 1998; Bozbuga *et al*.; Park *et al*., 2015). Kocabiyik *et al*. declared that the means of the uncinate process width, height and length at the C3-C7 levels ranged from 4.25 mm to 5.50 mm; from 6.11 mm to 7.54 mm; and from 8.50 mm to 11.46 mm, respectively (Kocabiyik *et al*.). Moreover, Bozbug˘a *et al*. measured UP width (R:4.5 mm and 6.1 mm), (L:4.8 mm and 6.2 mm); the UP height (R:5.1 mm and 6.1 mm), (L:5.2 mm and 6.2 mm); and the UP length (R:11.9 mm and 12.5 mm), (L:11.8 mm and 12.4 mm) (Bozbug˘a *et al*.). In Koreans, the width, height and length of the UP were found between 5.5 mm and 6.3 mm; 5.1 mm and 5.9 mm; and 13.0 mm and 13.7 mm in males, respectively. The corresponding values were measured between 5.5 mm and 6.3 mm; 4.2 mm and 6.0 mm; and 11.0 mm and 12.2 mm in females, respectively between C3 - C7 segments (Lee *et al*., 2012; Park *et al*.). In a study of Tubbs *et al*. (2012) UP height (ranged from 4.8 mm to 5.1 mm); and UP length (ranged from 6 mm to 8.1 mm) were measured. In a study of Americans, the UP height ranged from 5.0 mm to 6.3 mm in males, whereas the same value of females were between 4.8 mm and 5.8 mm, respectively. The UP width and length values of males were found between 5.0 mm and 6.5 mm; 11.7 mm and 12.5 mm, respectively whereas the corresponding values of females ranged from 4.6 mm and 6.1 mm; 11.3 mm and 12.4 mm, respectively at C3-C7 levels (Lu *et al*.). Our UP width and height results were lower than above studies'findings. However, the width of the UP was close to the ideal value reported by Bozbug˘a and Lu *et al*.'s studies. There was a few studies about the distance from UP to FT, and the distance from UP to IVF in literature. The distance from UP to FT is important for decompression of

artery during cervical spine anterior approach and may provide the useful knowledge to neurosurgeons and other clinicians. In Indian population, the distance from UP to FT was found as 4.14 mm in right side, 4.42 mm in left side, respectively (Yesender *et al*.). In a study consisting of American population the corresponding value was 5.00 mm in both sides (Sangari *et al*., 2015). In Turkish population, the same value was reported between 1.38 mm and 3.16 mm at C3-C7 levels (Kocabiyik *et al*.). The corresponding value was found as 2.91 mm (right) and 2.70 mm (left) in present study. Moreover, the distance from UP to IVF was reported between 5.56 mm and 6.56 mm at C3-C7 levels (Kocabiyik *et al*.). The same dimension was found as 5.77 mm and 5.66 mm in right and left sides in this paper.

The foramen transversarium which is unique to the cervical vertebrae is found on the transverse process. Plexus sympaticus, vertebral artery and vein passes inside (Aydınlıogˇlu *et al*., 2001; Murlimanju *et al*.; Gujar *et al*., 2015; Molinet Guerra *et al*.). FT narrowing is a sign of the vertebrobasilar inadequacy and the formation of trombosus which occurs during head rotation (Yesender *et al*.). The variations of FT may be occurred due to many reasons such as penetrating injuries, trauma, or vascular compression developped secondary to fractures or luxations and width and path of the vascular elements (Dalgic *et al*., 2009; Murlimanju *et al*; Molinet Guerra *et al*.) and these deformations or variations of FT lead to pathologic conditions or clinical findings by affecting significant arteries and veins during course (Aydınlıogˇlu *et al*.). Moreover, some health problems such as headache, migraine, and fainting attacks or compression of vertebral artery are possible reasons for the foramina transversaria number and size variations (Murlimanju *et al*.; Molinet Guerra *et al*.). Also, an absence of foramen transversarium refer absence of the vertebral artery. Additionaly, a narrowing of the foramina shows narrowness of the vessels (Murlimanju *et al*.). So, to know these variations are beneficial for estimate differences in the pattern of the vertebral artery and vein, or nerves passed inside FT (Aydinlıoglu *et al*., 2001). These variations are significant for physicians, neurosurgeans, and radiologist in the outcome monitoring like computed tomogram or magnetic resonance image scanes (Murlimanju *et al*.; Molinet Guerra *et al*.). Because, vertebral and basilar arteries which makes a significant contribution to blood supply for brain and inner ear. Compression or spasm of the vertebral artery may be cause both neurological symptoms and hearing problems (Murlimanju *et al*.). In studies about foramen transversarium, the means of the anteroposterior and transverse width vary in populations (Murlimanju *et al*.; Molinet Guerra *et al*.; Yesender *et al*.; Ananthi *et al*., 2019). In studies consisting of Indians, the means of FT transverse diameter and FT anteroposterior width were reported between 5.20 mm and 6.72 mm in right, and 5.05 mm and 6.66 mm in left; 4.08 mm and 5.45 mm in right, and 3.75 mm and 5.56 mm in left side, respectively (Yesender *et al*.; Ananthi *et al*.). The same values were found 5.69 mm and 5.87 mm; and 5.17 mm and 5.13 mm in right and left side, respectively in Americans (Sangari *et al*.). In Chilean population, the FT diameter ranged from 4.47 mm to 6.11 mm in right side; 4.43 mm to 5.42 mm in left side (Molinet Guerra *et al*.). In our study, the FT transverse diameter (R:4.78 mm, L:4.95 mm) were found lower than Indians and Americans, whereas that dimension was obtained similar to Molinet Guerra *et al*.'s study. The FT anteroposterior width (R:4.23 mm, L:4.28 mm) in this study was lower than American population.

There are many studies on the vertebral body morphometry in literature (Yılmazlar *et al*., 2003; Abuzayed *et al*.; Bazaldúa Cruz *et al*.; Mahto & Omar; Prabavathy *et al*.). The vertebral body development may be affected some factors including genetic, race, postural or occupational lesions (Mahto & Omar; Prabavathy *et al*.). The vertebral body morphometry provides important knowledge for surgeons performing anterior cervical reconstructions or diagnose many clinicinal problems such as stenosis, degenerative disorders (Abuzayed *et al*.; Bazaldúa Cruz *et al*.; Prabavathy *et al*.). Also, the vertebral body anteroposterior diameter was a useful parameter for the anterior fixation of bicortical screws (Bazaldúa Cruz *et al*.). Researches in different populations, anteroposterior (AP) diameter of vertebral body was declared between 14.02 mm and 15.79 mm (Yilmazlar *et al*., 2003); 14.68 mm and 17.47 mm (Bazaldúa Cruz *et al*.); 14.4 mm and 16.1 mm in females; 16.00 mm and 17.80 mm in males (Lee *et al*., 2012); 14.70 mm and 15.6 mm in females; 16.70 mm and 17.30 mm in males (Kwon *et al*., 2004); and 13.60 mm and 15.80 mm (Mahto & Omar). We found differences in the mean values of AP diameter of vertebral body of the studies given above but American and Koreans having greater values than us. According to data, our result (14.03 mm) was similar to Indian and Mexico populations. Moreover, transverse width of the vertebral body was measured in between 22.6 mm and 28.6 mm in American males, and in American females, whereas the same measurement was between 20.9 mm and 26.9 mm respectively ranged from C3 to C7 levels (Kwon *et al*.). The corresponding value was 22.7 mm and 30.4 mm in Korean males whereas this dimension was found as 20.8 mm and 27.3 mm in Korean females at C3-C7 segments (Lee *et al*., 2012). Additionally, the corresponding value of Mexican population was between 19.17 mm and 23.44 mm, respectively (Bazaldúa Cruz *et al*.). In Indians the vertebral body transverse diameter was reported from 22.8 mm to 26.4 mm (Mahto & Omar). A study in Turkish population the vertebral body transverse diameter was reported between

16.49 mm and 20.51 mm (Yilmazlar *et al*.,2003). In present study, the vertebral body transverse diameter was found as 24.45 mm. The vertebral body height reported by Lee *et al*. was measured between 12.6 mm and 14.6 mm in Korean females, whereas the same value was found from 13.3 mm to 15.2 mm in Korean males. In a study of Mahto & Omar, this height was found between 8.1 mm and 11.3 mm (Mahto & Omar). It can be said that the differences between our findings and the studies given above may be caused by race, genetic and regional factors.

The morphometry of the cervical vertebrae pedicle is used in surgery of the transpedicular fixation to determine the size (length or diameter) of screw. The lamina dimensions which contribute to cervical spine stability, provide important knowledge in cervical laminoplasty for resection of tumors and in ossification of the posterior longitudinal ligament (Bazaldúa Cruz *et al*.; Prabavathy *et al*.). In Mexican population, pedicle length and width values of cervical vertebrae were found between 3.80 mm and 5.27 mm; and 4.47 mm and 5.14 mm, respectively (Bazaldúa Cruz *et al*.). In a study of Prabavathy *et al*'s the pedicle length and width was ranged from 4.46 mm to 6.96 mm; from 4.40 mm and 5.80 mm in Indian population (Prabavathy *et al*.). Also, lamina height and width dimensions of cervical vertebrae were between 11.27 and 14.31 mm; and 13.92 mm and 15.59 mm in Mexico population, respectively (Bazaldúa Cruz *et al*.). In Indians, the lamina heigth was found between 8.20 mm and 13.52 mm (Prabavathy *et al*.). We found some different findings compared to the above studies in pedicle length (R:5.65±1.91 mm, L:5.65±1.76 mm), pedicle width (R:3.72 mm, L:3.61 mm), lamina height (R:9.87 mm, L:9.86 mm) and lamina width (R:13.41 mm, L:13.49 mm) measurements.

The spinous process play a role in screw placement in traumatic and degenerative lesions (Rao *et al*.). Articular process transmits the compressive forces on the cervical vertebrae. One of the cervical stabilization methods is transpedicular fixation and the other is the transfacet fixation. Transfacet fixation has a minimal risk of nerve root injury. So, it is prefered an alternative method to transpedicular fixation. Moreover, the size adaptation of the superior-inferior articular facets is important due to articular luxation (Bazaldúa Cruz *et al*.). Also, during wiring or screw the variations of measurement in both side is critical point. Rao *et al*. reported that there were no significant difference in measurements of the superior articular process and inferior articular process in right and left sides. In contrary, we found bilateral symmetry as well as Indians. Congenital or degenerative narrowing of cervical canal is an significant risk factor for spinal canal stenosis, myelopathy, spinal cord injury. Therefore, the many factors play a important role in morphometry of vertebral foramen as similarly the other sections of the cervical vertebrae. Also, transverse diameter was found larger than anteroposterior diameter similiar to our data (Karakaş *et al*., 2007; Desdicioglu *et al*.).

In summary, when comparing our findings with the literature, we found that some differences between American, Indian, Korean and Turkish population's data. We consider that these discrepancies could be a result of such factors like race, genetic factors, cervical vertebrae pathologies, and regional variations. Knowledge of cervical vertebrae anatomy will provide crucial information for neurosurgeons, radiologist or clinicians and will help surgeons to achieve greater success in cervical operations and they can be used as reference values for evaluating pathologic changes and determine the significance of the anatomic structures in cervical region. Therefore, the observations presented in this study have defined anatomic parameters that need to be taken into consideration for evaluate cervical vertebrae problems and guidelines for determine the reference values.

POLAT, S.; GÖKER, P.; YÜCEL, A. H. & BOZKIR, M. G. Estudio morfométrico de vértebras cervicales secas. *Int. J. Morphol., 37(3)*:845-851, 2019.

RESUMEN: El objetivo de este estudio fue enfatizar la importancia clínica de la morfometría y los parámetros quirúrgicos de las vértebras cervicales. El presente estudio se realizó en noventa y seis vértebras cervicales secas adultas (C3-C7) de sexo desconocido de la población turca. Las diversas dimensiones de las vértebras cervicales (C3 a C7) se midieron utilizando un calibrador digital con una precisión de 0,01 mm. Se determinaron parámetros lineales incluyendo ancho anteroposterior del cuerpo vertebral (14,03 mm), ancho transversal del cuerpo vertebral (24,45 mm); altura del cuerpo vertebral (10,64 mm); longitud del pedículo (R: 5.65 ± 1,91 mm, L: 5.65 ± 1,76 mm); ancho del pedículo (R: 3,72 mm, L: 3,61 mm); altura de la lámina (R: 9,87 mm, L: 9,86 mm); longitud transversal de la lámina (R: 13,41 mm, L: 13,49 mm); Diámetro anteroposterior del proceso articular superior (R: 7,26 mm, L: 7,46 mm); Diámetro transversal del proceso articular superior (R: 9,87 mm, L: 9,58 mm); Altura articular superior del proceso (R: 16,41 mm, L: 16,08 mm); Diámetro anteroposterior del proceso articular inferior (R: 7,67 mm, L: 7,44 mm); Diámetro transversal del proceso articular inferior (R: 10,32 mm, L: 10,09 mm); Altura del proceso articular inferior (R: 12,72 mm, L: 12,67 mm); longitud del proceso espinoso (17,91 mm); ancho del proceso uncinado (R: 4,37 mm, L: 3,78 mm); altura de proceso uncinado (R: 4,58 mm, L: 3,93 mm); longitud del proceso uncinado (R: 9,28 mm, L: 9,12 mm); Ancho anteroposterior del foramen vertebral (13,85 mm); Diámetro transverso del foramen vertebral (20,88 mm); Ancho anteroposterior del foramen transverso (R: 4,23 mm, L: 4,28 mm); Diámetro transverso del foramen transverso (R: 4,78 mm, L: 4,95 mm). Además, la distancia del vértice del proceso uncinado al foramen transverso (R: 2,91 mm, L: 2,70 mm) y la

distancia del vértice del proceso uncinado al foramen intervertebral (R: 5,77 mm, L: 5,66 mm) Se encontraron diferencias significativas entre los dos lados, en el ancho y la altura del proceso uncinado, y la distancia entre el proceso uncinado y el foramen transverso. Las mediciones actuales sugieren que los parámetros relevantes de las vértebras cervicales se pueden usar como referencia y punto de referencia anatómicos para evaluar los cambios patológicos y minimizar las complicaciones en la columna cervical.

PALABRAS CLAVE: Vértebras cervicales; Vértebras de huesos secos; Antropometría.

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Received: 19-11-2018
Accepted: 01-02-2019