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Radiologic Investigation of the Presence of Accessory Transverse Foramen in Individuals Aged 21-60 Years Living in the Western Black Sea Region

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ABSTRACT

Aim: The aim of this study was to radiologically evaluate the occurrence of more than one for. transversarium, called accessory foramen transversarium (ATF), in individuals aged 21-60 years living in the Western Black Sea Region.

Material and Methods: Personal information (name, last name and age) of the patients who participated in the study were not shared and confidentiality was taken as a basis. In the study, cervical vertebrae of 200 healthy individuals, 100 females and 100 males aged 21-60 years, were obtained retrospectively by Computed Tomography (CT) through the Hospital Imaging Archiving System (PACS). The for. transversarium of all cervical vertebrae from C1 to C7 were examined on coronal and sagittal plane images brought to orthogonal plane. The presence or absence of variation was examined. The vertebrae with ATF were noted. It was noted whether the ATF was unilateral or bilateral in the vertebra where it was found. If it was unilateral, which side it was on was noted. After all CT images were examined, the data obtained were entered into the Microsoft Excel program. It was analyzed with SPSS 24.0 program.

Results: The according to the analysis results, ATF was observed in a total of 95 individuals, 49 males (49%) and 46 females (46%). 18 individuals (18.9%) had right-sided ATF, 46 individuals (48.4%) had left-sided ATF and 31 individuals (32.6%) had bilateral ATF. There was no statistically significant difference between gender and ATF ($p>0.05$). ATF was observed in a total of 121 vertebrae out of 1400 vertebrae examined. C6 was the most common vertebra with ATF in both sexes.

Conclusion: We believe that our study will provide guidance for clinicians and radiologists in predicting changes in the structures passing through the foramen (for.) transversarium, interpreting X-ray and CT scans, and determining the more appropriate intervention when surgical intervention is considered.

Keywords: Cervical vertebra; transvers foramen; accessory transverse foramen; computed tomography.

Batı Karadeniz Bölgesinde Yaşayan 21-60 Yaş Arasındaki Bireylerde Aksesuar Foramen Transversarium Varlığının Radyolojik İncelenmesi

ÖZ

Amaç: Bu çalışmanın amacı Batı Karadeniz Bölgesinde yaşayan 21-60 yaş aralığındaki bireylerde aksesuar foramen transversarium (ATF) olarak adlandırılan birden fazla for. transversarium görülme durumunu radyolojik olarak değerlendirmektir.

Gereç ve Yöntemler: Çalışmaya katılacak olan hastaların kişisel bilgileri (ad-soyad ve yaş) paylaşılmayarak gizlilik esas alındı. Çalışmada 21-60 yaş arasındaki 100 kadın ve 100 erkek toplam 200 sağlıklı bireyin servikal vertebraları Bilgisayarlı Tomografi (BT) ile Hastane Görüntüleme Arşivleme Sistemi (PACS) üzerinden geriye dönük elde edildi. Ortogonal plana getirilen coronal ve sagittal düzlem görüntüleri üzerinde C1'den C7'ye kadar bütün servikal vertebraların for. Transversarium'larına bakıldı. Varyasyonun bulunup bulunmadığı incelendi. ATF görülen vertebralar not edildi. ATF'nin bulunduğu vertebrada unilateral mi bilateral mi olduğu kaydedildi. Unilateral ise hangi tarafta olduğu not edildi. Bütün BT görüntüleri incelendikten sonra elde edilen veriler Microsoft Excel programına girildi. SPSS 24.0 programı ile analiz edildi.

Bulgular: Analiz sonuçlarına göre 49 erkek (%49), 46 kadın (%46) toplam 95 bireyde ATF gözlendi. 18 birey (%18,9) sağ, 46 birey (%48,4) sol ve 31 bireyde de (%32,6) çift taraflı ATF gözlendi. Cinsiyet ile ATF arasında istatistiksel olarak anlamlı bir fark bulunmadı ($p>0,05$). İncelenen 1400 vertebra içerisinde de toplam 121 vertebra'da ATF gözlendi. İki cinsiyette de en sık ATF görülen vertebra C6 olarak belirlendi.

Sonuç: Çalışmamızın foramen (for.) transversarium içerisinden geçen yapılardaki değişikliklerin tahmin edilmesinde, klinisyenler ve radyologlar için röntgen ve BT taramalarının yorumlanmasında ve cerrahi müdahale düşünüldüğünde daha uygun girişimin belirlenebilmesi için yol gösterici olacağını düşünüyoruz.

Anahtar Kelimeler: Cervical vertebra; foramen transversarium; aksesuar foramen transversarium; bilgisayarlı tomografi.

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INTRODUCTION

The human vertebral column is classified as cervical, thoracal, lumbar, sacral and coccygeal. This classification is based on the characteristics of the vertebrae in each group. One of the most important features that distinguishes cervical vertebrae from other vertebrae is the presence of transverse foramen in their transverse process. The vertebral artery and vein and the surrounding sympathetic plexus pass through the transverse foramen. The vertebral artery ascends through the transverse foramen of the sixth cervical vertebra. Only the vertebral vein is present in the transverse foramen of the seventh cervical vertebra (1,2). The transverse foramen may vary in shape and size. Sometimes there may be many of them and sometimes there may be none (3,4). Changes in the course of the vertebral artery are thought to cause variations in the transverse foramen (5,6). In cases of these variations, the course of the vertebral artery may be disrupted. Variations in the number and size of the transverse foramen can lead to pathologic conditions and clinical symptoms such as headache, migraine, and fainting attacks on the vessels and nerves (5,3-8). The variation of the transverse foramen is called accessory transverse foramen (ATF). ATF is the presence of one or more transverse foramen next to the transverse foramen. This condition is not common in the literature and there is no detailed information on the subject (5,9). Depending on the course of the vertebral artery. ATF can be seen unilaterally or bilaterally in any of the cervical vertebrae or in more than one vertebra (5,10). In the literature, studies on this subject were mostly performed on dry bones (3,8,11-14).

The aim of our study is to investigate the ATF variations in Turkish population and to emphasize their importance in terms of clinical surgery in the light of literature information.

MATERIAL AND METHODS

Written permissions were obtained from Düzce University Clinical Research Ethics Committee and the Chief Physician's Office of Düzce University Research Hospital, where the study was conducted (No: 2023/152, Date: 02.10.2023). Ethical principles were adhered to in accordance with the Declaration of Helsinki (2013). Our study was performed retrospectively on CT images obtained from a total of 200 healthy individuals (100 females and 100 males) admitted to Düzce University Research and Application Hospital between 01.10.2023 and 01.10.2024. The images obtained using a Siemens (model Somatom Definition AS) 128-slice CT device were accessed and analyzed through the Hospital Imaging Archiving System (PACS).

Statistical Analysis

The for. transversarium of all cervical vertebrae from C1 to C7 were examined on the coronal and sagittal plane images brought to the orthogonal plane. The vertebrae with ATF were noted. It was noted whether the ATF was unilateral or bilateral (Figure 1). If it was unilateral, the side on which it was located was noted. After examining the CT images, the data obtained were entered into the Microsoft Excel program. Data were analyzed with SPSS 26.0. The kurtosis and skewness coefficients were analyzed to determine the conformity of the measurements to normal distribution. The kurtosis and skewness values obtained from the measurements between +3 and -3 are considered sufficient for normal distribution. Chi-square and independent t-test were used in the analyses. The relationship between categorical variables was analyzed by Chi-square test.

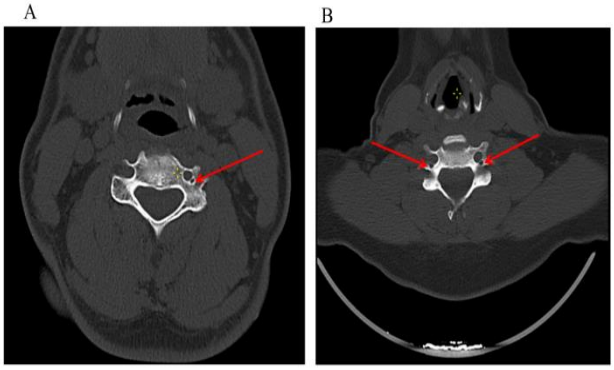

Figure 1. A) C5 cervical vertebra example showing unilateral ATF, B) C4 cervical vertebra example showing bilateral ATF

RESULTS

A total of 1400 cervical vertebrae of 200 individuals were analyzed. Of these, ATF was observed in 95 individuals (47.5%), 49 males (49%) and 46 females (46%) (Table 1). Of these, 18 (18.9%) right, 46 (48.4%) left and 31 (32.6%) bilateral ATF's were observed (Table 2).

Table 1. Unilateral and bilateral findings of ATF by gender

		Gender			X2	p
		Male	Female	Total		
		n (%)	n (%)	n (%)		
Do you have ATF?	None	51(51)	54(54)	105(52.5)	0.180	0.671
	Yes	49(49)	46(46)	95(47.5)		

Chi-square test.

Table 2. Illustration of the comparison of ATF by side and gender

		Gender			X2	p
		Male	Female	Total		
		n (%)	n (%)	n (%)		
Side of the vertebra	Left	25 (51)	21 (45.7)	46 (48.4)	6.428	**0.040**
	Right	13 (26.5)	5 (10.9)	18 (18ç9)		
	Double	11 (22.4)	20 (43.5)	31 (32.6)		

Chi-square test.

In our study, ATF was detected in 121 vertebrae, 64 of which were in C6 (Table 3). The vertebra with the highest incidence of ATF was C6 (52.5%). ATF was not detected in the atlas, axis and C3 cervical vertebrae (Table 3).

Table 3. Number of ATF's at cervical vertebral levels by gender

		Gender				
		Male	Female	Total	X2	p
		n (%)	n (%)	n (%)		
ATF seen in vertebral level	C1	0(%0)	0(%0)	0(%0)	2,296	0,513
	C2	0(%0)	0(%0)	0(%0)		
	C3	0(%0)	0(%0)	0(%0)		
	C4	11(%16,6)	6(%10,9)	17(%14,2)		
	C5	18(%27,2)	18(%32,8)	36(%29,7)		
	C6	35(%53)	29(%52,7)	64(%52,8)		
	C7	2(%3,02)	2(%3,6)	4(%3,3)		

Chi-square test.

DISCUSSION

The vertebral artery is a factor that shapes the formation of transverse foramen. Hadley, Hyyppa et al. stated that changes in the course of the vertebral artery can lead to various variations in the transverse foramen (5,6,15,16). There is a direct proportion between the dimensions of the transverse foramen and the dimensions of the vertebral artery. Changes in this ratio also affect the blood flow in the vertebral artery. Transverse foramen variations can cause changes in the course of the vertebral artery, as well as transverse foramen variations due to changes in the vertebral artery. Sanelli et al. investigated the relationship between vertebral artery and transverse foramen dimensions and reported that changes in the diameter of the transverse foramen showed a significant change in the diameter of the vertebral artery and that the vertebral artery filled 8-85% of the transverse foramen (5).

After passing through the foramen magnum, the a. vertebralis joins to form the a. basilaris. The a. basilaris gives off branches that supply the brain stem, inner ear and cerebellum. Movements of the head affect the amount of blood flowing through the a. vertebralis and therefore the amount of blood flowing through the a. basilaris. In addition, symptoms such as diplopia, dizziness, blurred vision, and sudden falls may be observed with the addition of stimulation of the sympathetic plexus around the arteries due to ATF-related stenosis (5).

Absence of the transverse foramen may indicate the absence of vertebral artery or the presence of arteries traveling along the transverse process but not passing through the transverse foramen. A narrowing of the transverse foramen may also cause narrowing of the vessels passing through it. In addition, a duplication of the transverse foramen may cause duplication of the vertebral artery (5,6,12).

Pretty Rathnakar et al. (2013) examined 140 dried cervical vertebrae of unknown sex and age and found 8 ATF's (5.7%) (12). Akhtar et al (2015) reported 25 (14.36%) ATF's among 174 cervical vertebrae of unknown sex and age in their study to investigate the incidence of ATF's in dried cervical vertebrae in Indian population (20). Degirmenci et al. investigated for. transversarium variations by CT imaging in 127 patients (63 females and 64 males) and observed ATF in 117 (13%) vertebrae out of a total of 889 vertebrae (17). In our study, ATF was detected in 121 (8.64%) vertebrae among 1400 cervical vertebrae of 200 individuals.

Tellioğlu et al. (2018) examined the size and variations of the for. transversarium and the anatomical variations of the a. vertebralis passing through it. They imaged a total of 987 cervical vertebrae of 141 patients aged 18-79 years, 90 males and 51 females. As a result of the study, they found 43 completed and 63 incomplete ATF's (22).

Aydınoğlu et al. (2001) examined 222 dry bones and observed ATF in 47 vertebrae. Of these, 25 were bilateral, 10 on the right side and 12 on the left side. They did not find ATF in atlas (C1) and axis (C2) (9). As a result of the analyses performed in our study, we did not find ATF's in the atlas and axis. This is similar to the study conducted by Aydınoğlu et al.

Çırpan at al.(2018) examined 81 dry cervical vertebrae of unknown age and sex and reported the presence of ATF in 10 cervical vertebrae (12.34%). They reported that 2 of these were bilateral (2.47%) and 8 were unilateral (9.87%). In the literature, the unilateral incidence of ATF is higher than the bilateral incidence (5). In our study, unilateral ATF was found in 76 vertebrae (5.4%) and bilateral ATF in 45 vertebrae (3.2%). This result was consistent with the study of Çırpan et al. and the literature.

Guerra et al. (2017) macroscopically examined for. transversarium mutually on 121 vertebrae and found 21 (17.35%) ATF's. Of these, 14 (66.6%) were unilateral, 8 (54.14%) on the right side and 6 (45.86%) on the left side (18). As a result of the study, they found that the incidence of ATF on the right side was higher than on the left side. In our study, the incidence of ATF was calculated as 46 (48.40%) on the left side and 18 (18.9%) on the right side. Contrary to the study of Guerra et al. we found a higher incidence of ATF on the left side compared to the right side.

Katikireddi et al. (2014) found 3 (3%) ATF's in their study on 100 dried cervical vertebrae. Of these, 2 (2%) were unilateral and 1 (1%) was bilateral (19). This study is insufficient to examine the incidence of ATF.

Chaudhari et al. (2013) macroscopically examined 133 dried cervical vertebrae and observed ATF in 22 vertebrae (23.15%). Of these, 14 (14.73%) were unilateral and 8 (8.42%) were bilateral ATF's. They reported that ATF's were more common in the lower cervical vertebrae (C5 to C7), especially in the 7th cervical vertebra (11). Sharma et al (2010) found unilateral or bilateral ATF's in 16 vertebrae (8%) in a study of 200 dry cervical vertebrae. It was observed that 8 (4%) of these vertebrae were in C6 (21). In our study, the vertebra with the highest incidence of ATF was C6 (52.5%). In contrast to Chaudhari et al. our study was similar to Sharma et al.

In our study, unilateral ATF's were found in 76 vertebrae (5.4%) and bilateral ATF's in 45 vertebrae (3.2%) among 1400 vertebrae of 200 individuals. As a result of the analysis performed in our study, ATF was not found in the atlas and axis. In the literature, the frequency of unilateral ATF is higher than the frequency of bilateral ATF (5). Our study was consistent with the literature.

CONCLUSION

In conclusion, we think that the presence of ATF may be helpful in diagnosis and treatment due to the involvement of the vessels and sympathetic nerves passing through the

transverse foramen and may also guide radiologists and surgical clinicians in selecting the appropriate intervention when surgical intervention is deemed necessary.

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