Variations of Sulcus Arteria Vertebralis and Correlation with Clinical Symptoms

Sulkus Arteria Vertebralis Varyasyonları ve Klinik Bulgular ile Korelasyonu

Sulkus Arteria Vertebralis Varyasyonları / Variations of Sulcus Arteria Vertebralis

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Özet

Amaç: Pontikulus postikus olarak da bilinen Kimmerle anomalisi birinci servikal vertebranın(atlas) yaygın bir varyasyonudur. Vertebral arter ve C-1 spinal sinirin arka dalını içeren sulkus arteriovertebralis üzerinden geçen posterior atlanto-oksipital membranın kısmi veya tam kemikleşme ürünüdür. Çalışmamızda sulkus veretbralis ile ilgili varyasyonların Türk toplumunda sıklığının araştırılmasını amaçladık. Gereç ve Yöntem: Hastanemize baş ve boyun ağrısı, böş dönmesi, çınlama şikayetleri ile başvuran, 18- 99 yaş aralığında, 719 hastanın MDBT görüntüleri retrospektif olarak incelendi. Arkuat foramen varlığı ve tipi açısından görüntüler değerlendirildi. Bulgular: 106 vakada total foramen tespit edildi. Total foramen varlığı oranı % 14,74 olarak hesaplandı. Vakaların 48'inde(%6,67) bilateral total foramen tespit edildi. 21 vakada(%2,92) sağda tek taraflı, 37 vakada(%5,14) solda tek taraflı total foramen varlığı görüldü. Bilateral total forameni olan 30 hasta, tek taraflı total forameni olan 30 hasta ve total foramen görülmeyen 30 hastadan oluşan üç grup oluşturuldu. Gruplar arasında baş ağrısı, baş dönmesi, boyun ağrısı, kulak çınlaması gibi semptomlar açısından karşılaştırma yapıldı. Gruplar arasında semptomlar açısından istatistiki olarak anlamlı farklılık saptanmadı. Tartışma: Türk toplumunda arkuat foramen bulunma olasılığı yüksek bulunmuştur ve posterior yaklaşımlarda akılda tutulması gerekmektedir.

Anahtar Kelimeler

Sulkus Arteria Vertebralis; Arkuat Foramen; Pontikulus Postikus

Abstract

Aim: Kimmerle's anomaly (ponticulus posticus) is a common anatomical variation of the atlas, is the product of the complete or incomplete ossification of the posterior atlanto-occipital membrane over the vertebral groove, resulting in the formation of a foramen (arcuate foramen) containing vertebral artery and C1 nerve. We aimed to search the variations related to the sulcus arteriae vertebralis which is on the first cervical vertebrae in Turkish population. Material and Method: We retrospectively reviewed 719 3-D CT scanning digital images of consecutive patients between 18-99 years of age with complaints of headache, neck pain, vertigo, tinnitus, hearing loss in relation to the presence of complete or incomplete arcuate foramen. Results: Ponticulus posticus was found unilateral or bilateral in 106(14,7%) patients, bilateral in 48(6,6%), right side alone in 21(2,9%) patients and left side alone in 37(5,1%) patients. We found no statistical significiant difference in symptoms like headache, servical pain, vertigo, tinnitus between the patients with bilateral, unilateral and without arcuate foramen. Discussion: The probability of the presence of arcuate foramen in Turkish population is very high which has to be known in posterior approach.

Keywords

Sulcus Arteriae Vertebralis; Arcuate Foramen; Ponticulus Posticus

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Introduction

Sulcus Arteria Vertebralis is the name given to the groove which is found on C1 vertebra and where vertebral artery passes. As a result of the ossification of posterior atlanto-occipital membrane on the sulcus, arcuate foramen develops in which vertebral artery and the back branch of C1 spinal nerve passes through(Figure 1-2). Arcuate foramen can be one or two sides,

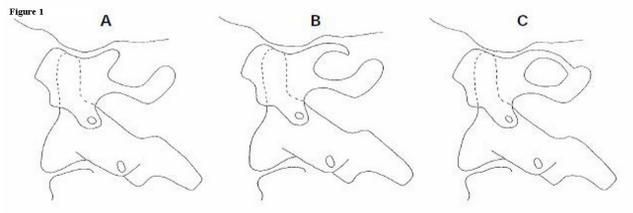


Figure 1. The forms of vertebral sulcus A: Normal sulcus vertebralis B: Partial arcuate foramen C: Total arcuate foramen



Figure 2. A)Total arcuate foramen, B: Partial arcuate foramen on lateral cervical radiograph

partial or complete. The presence of foramen can lead to external mechanic pressure to artery in the extension and rotation movements of the head. These variations of vertebrobasilar disorder symptoms are associated with several types of headaches and acute hearing loss [6].

The purpose of this study is to determine the frequency of these variations in normal population, compare the rates of the symptoms such as headache, dizziness, neck pain, hearing loss and tinnitus in variation and normal cases and determine the potential connection between variation and clinic symptoms.

Material and Method

719 patients who were examined and applied with preliminary diagnoses to Suleyman Demirel University Faculty of Medicine Department of Radiology between May 2010 and October 2013 were taken to the study. The examinations of the patients were examined retrospectively. 54 of the examinations were carotid CT angioradiography, 246 of them were cervical vertebra CT, 154 of them were neck CT, 265 of them were paranasal sinus CT. All examinations fully contained C1 vertebra. Carotid CTA and neck CT analyses were made by non- ionic IV contrast substances, cervical and paranasal sinus CT was made without contrast substance. CT analyses were made by 128-section CT device (Definition AS, Siemens Medical Solutions, Forchheim, Germany). The images were taken by 1 mm section thickness. All of the images were re-evaluated in PACS (picture archiving and communication system). Axial images were analyzed in bone window. In each case, multiplanar (MPR) and volume rendering (VRT) reconstructions were made. The images were carefully analyzed in terms of the presence of arcuate foramen in both sides if there was a foramen, either partial or total (Figure 3).



Figure 3. Three-dimension VRT images of sulcus vertebralis A: Normal sulcus vertebralis on the both sides, B:total arcuate foramen on the left.

18 of the 48 cases with bilateral complete foramen were excluded from the study due to chronic diseases (such as malignity, diabetes), chronic sinusitis diagnosis or hypertension disease which can lead to headache, injury on the head and neck as a result of trauma and common degenerative osteophyte changes on the neck. The remainder 30 patients constituted our first group. The second group of patients was selected from those with one side complete foramen. 20 of total 61 patients with one side foramen were excluded from the study due to the above mentioned reasons. Among 41 patients, 30 patients were selected from the group with the age and sex similar to those in the first group. The third group was constituted randomly from the patients similar in terms of age and sex to the first group among the patients without arcuate foramen. The groups were queried in terms of symptoms such as headache, neck pain, dizziness, tinnitus, syncope attacks, hearing loss, and epilepsy. The patients who had headache complaints were queried and were classified as migraine and other headaches. The differences in terms of clinical findings were assessed between the groups. Statistical assessment was made in the computer environment by Mann-Whitney U test by using SPSS for Windows (version 15.0). When p value is less than 0.05, the difference was accepted as statistically significant. The distribution of the cases according to the gender and foramen type was drown as a graph (Figure 5).

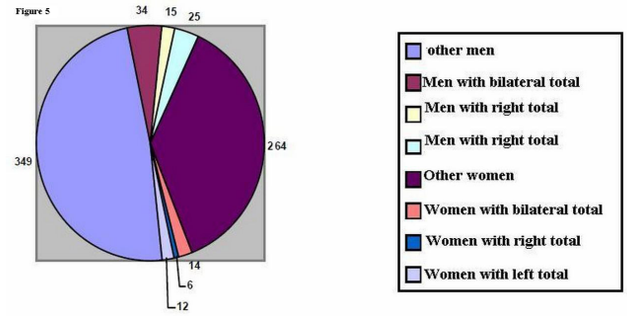


Figure 5. The distribution of the cases according to the gender and foramen type

Results

From total 719 cases, 296 were women (41.2%), 423 were men (58.8%). The age average of the cases was 46.5 (18-99). Bilateral complete foramen was diagnosed in 48 of the cases. 21 cases had one side complete foramen on the right, 37 cases had one side complete foramen on the left. Complete foramen was seen on the right in total 69 cases, and on the left in 85 cases. Complete foramen on the right was determined 1.2 times more. Complete foramen was found in total 106 cases. The presence of complete foramen was calculated as 14.7%.

Among 106 patients with bilateral and one side total arcuate foramen, 74 of them were men (69.8%), 32 of them were women (30.1%). Complete foramen was determined at the rate of 17.4% in men, and 10.8% in women(Table 1). Complete foramen in men was statistically found significantly higher (p<0,02). 68.9% of the patients with one side total arcuate foramen and 70.8% of the patients with bilateral arcuate foramen were men. No statistically significant difference was found in terms of sex in the patients with one side and two side complete foramen (p<0,05).

Table 1. The distribution of total arcuate foramen according to the gender

	Bilateral	Right	Left	Sum
Women	14	6	12	32
Men	34	15	25	74
Sum	48	21	37	106

The presence of bilateral complete foramen corresponded 6.67% of all cases, 2.92% of the cases with one side foramen on the right, and 5.14% of the cases with one side complete foramen on the left. Higher arcuate foramen on the left was statistically found significant (p<0,05). Among 296 women, 14 had bilateral complete foramen, 6 had one side complete foramen on the right, and 12 had one side complete foramen on the left. Among all women, the presence of bilateral complete foramen was found as 4.7%, the presence of one side foramen on the left was found as 2,1%, and the presence of one side foramen on the left was found as 4.1%. Among 423 men, 34 had bilateral, 15 had one side on the right, and 25 had one side complete foramen on the left. Among all men, the presence of bilateral complete foramen was found as 8.1%, the presence one side foramen on the right was found 3.5%, the presence of one side foramen on the left was found as 5.9% .

The average age of all patients was 46.5, the average age of 106 patients with complete foramen on the right and on the left was 46.9, and the average age of the patients with bilateral foramen was 46.9. It was accepted that the prevalence of total arcuate foramen did not show significant difference with the age.

The number of cases with partial foramen on both sides was found as 39 (25 men, 14 women). These numbers corresponded 5.9% of men and 4.7% of women. 88 patients had partial foramen on the right while 91 patients had partial foramen on the left (Figure 4).

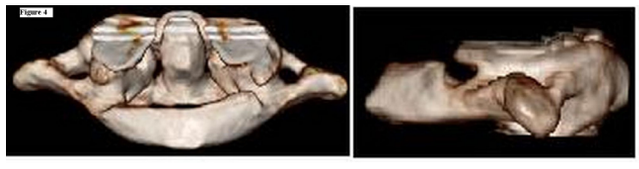


Figure 4. Three-dimension VRT images of partial arcuate foramen. A: Normal sulcus vertebralis on the right, partial arcuate foramen on the left. B: Lateral VRT image of partial arcuate foramen.

19 of the patients with partial foramen on the right (11 men, 8 women), also had complete foramen on the left; 12 of the patients with partial foramen on the left (8 men, 4 women) had complete foramen on the right. 30 (15 men, 15 women) cases, only had partial foramen on the right, 40 (25 men, 15 women) cases only had partial foramen on the left. Total 140 patients had partial foramen (19.5%). 18.9% of women, 19.8% of men had partial foramen. The prevalence of partial foramen did not show any difference with sex. There was no significant difference between the right and the left, either (Table 2).

Table 2. The distribution of partial arcuate foramen according to the gender

	Bilateral	Only right partial	Right partial and left total	Only left partial	Left partial and right total	Sum
Women	14	15	8	15	4	56
Men	25	15	11	25	8	84
Sum	39	30	19	40	12	140

There was no difference in terms of age and sex among the three groups which were created to be analyzed in terms of clinical symptoms. The age average of the first group was calculated as 34.1, the age average of the second group was calculated as 34.1 and the age average of the third group was calculated as 34.4. Each of the three groups involved 10 women, 20 men patients. The age average of these groups was quite lower when compared to the age average of 719 patients. This was because the cases which were excluded from the study due to chronic diseases were older.

Headache complaint was determined in 12 patients (6 women, 6 men) in the first group; 7 patients (4 women, 3 men) in the second group, 8 patients (4 women, 4 men) in the third group. No statistically significant difference was found among the groups although headache complaint was higher in number in the first group (p=0,329).

Among the patients with headache complaint, migraine was diagnosed in 4 patients (2 women, 2 men) patients in the first group, 2 patients (2 women) in the second group, 3 patients (2 women, 1 men) in the third group. The number of patients in whom migraine was diagnosed was also higher when compared to the others in the first group but it was not statistically found significant (p>0,69).

Neck pain was found in 3 men patients in the first group, 1 women patient in the second group, 3 men patients in the third group. No statistically significant difference was found among the groups (p>0,538). The number of the patients with dizziness complaint was 5 (3 men, 2 women) in the first group, 2 (2 men) in the second group, 2 (2 women) in the third group. Dizziness complaint in the group with bilateral foramen was numerically higher when compared to the two groups. However, no statistically significant difference was found (p>0,329). There were 2 (1 women, 1 men) in the first group, 2 (2 men) in the second group, 1 women patient in the third group who occasionally had syncope attacks. There was no significant difference in this group, either (p>0,809).

There was 1 women patient with hearing loss in the first group, and 2 men patients in the second group. None of the patients complained hearing loss in the third group. 2 men patients in the first group, and only one men patient in the third group had tinnitus. No statistically significant difference was found in terms of these symptoms. None of the patients described epileptic attack in three groups.

Discussion

Arcuate foramen is a variation which is randomly found in radiologic examinations made for several clinic conditions, which is not so rare. Patients are usually asymptomatic. The clinic importance of this anatomic variation has not been clearly determined yet and there are a few studies in literature which state that the presence of arcuate foramen can be connected with clinical symptoms such as headaches and neck aches, vertigo, nausea, vomiting, loss of balance, sight, swallowing, and hearing problems.

In literature, there are many different results in relation to arcuate foramen incidence and prevalence in women and men from different countries (Table 3).

Table 3. The incidence of total arcuate foramen on various materials and studies

Study	Materials	Incidence
Pyo, 1959[10]	Radyografi	12.6
Romanus, 1964	Radyografi	14.3
Lamberty, 1973[7]	Kemik spesmenler	15
Lamberty, 1973[7]	Radyografi	7.5
Başoğlu, 1983	Kemik spesmenler	9.5
David M. 1991	Radyografi	13.5
Mitchell, 1998	Kemik spesmenler	9.8
Malas, 1998[8]	Radyografi	2.6
Hasan, 2001	Kemik spesmenler	3.4
Kavaklı,2004[5]	Kemik spesmenler	12.8
Krishnamurthy, 2007	Kemik spesmenler	8.33
Yong Jae Cho, 2009[2]	3D BT	15.5

In our study, we determined complete foramen (right, left and bilateral) at the rate of 14.7%. This result was higher when compared to many studies as in the study by M.A. Malas et al. that the complete foramen was found at the rate of 2.6% while 1000 lateral cervical radiographs were evaluated. According to this study, complete foramen was significantly higher in men, partial foramen was significantly higher in women [8]. Likewise, it was determined in another study which was done in our country by E. Unur et al., complete foramen rate was found as 5.1% in cervical radiographs [13].

The reason why the incidence was lower in these studies when compared to our study was because the studies were done by cervical radiographs. In an autopsy study which was performed in Kenya, this rate was calculated as 14.7%. According to this study, the prevalence of foramen was higher on the right when compared to the left and in women when compared to men [4]. In the study by Kavaklı et al. with bone specimens, total arcuate foramen incidence was found as 12% [5]. Likewise, this rate was 15% in a study in England which was again done with bone specimens. This rate was found only 7.58% in the part of the same study which was done with lateral cervical radiographies [7]. In another study which was done in Greece, the rate of incidence of arcuate foramen was reported as 10.2% in bone specimens [9]. The rate of incidence of arcuate foramen was higher in our study when compared to some studies because it was primarily done with CT. Monitoring the atlanto-occipital region in lateral cervical radiographs can be superimposed by the mastoid bone or malpositioning. Stronger incidence of arcuate foramen in the studies which are done by cervical radiographs can lead to such low results. And, the similar results in the studies which were done by autopsy and bone specimens with our studies show that CT is a more effective method in the assessment of this variation. Hence, in a study which was done by analysing 3-D CT images of 200 patients in Korea, arcuate foramen incidence was found as 15.5% as similar to our study [15].

The presence of complete foramen in our study was statistically found significantly higher in men. The presence of complete foramen was found higher in men in many studies [8, 11, 12]. In another study, it was reported higher in women [4]. And no significant difference was found in terms of age in some studies [13,10, 8].

The association of the presence of partial foramen with gender was not found statistically significant in our study. However, the presence of partial foramen was reported as significantly higher in women in a study in literature [12].

The prevalence of partial foramen is in a quite wide interval in literature. In our study, we found this rate as 19.5%. In a study in Chile which was performed with cervical radiographies which contained asymptomatic cases, partial foramen incidence was reported as 10.1% [11]. And, in the study with cervical lateral radiographs by Çakmak et al.., partial foramen was observed at the rate of 6.2% [6].

In the study by Kavaklı et al. which was done with bone specimens, this rate was 9.3% [5]. In the study by Lamberty and Zivanovic which was also done with bone specimens, partial foramen rate was found as 21.6% [7]. In a study in Greece which was done with bone specimens, this rate was reported as 24.4% [9]. Wright et al. reported an important correlation between arcuate foramen and non-aura migraine. The purpose of this study is to research the prevalence of arcuate foramen in persons with migraine and cervicogenic headache and compare it with the group without headache. The study involved the patients who applied to the chiropractic clinic for the first time and whose cervical radiographs; the patients were divided into categories which are namely those with aura migraine, non-aura migraine, cervicogenic headache and only headache complaint. As a result, although arcuate foramen incidence was found numerically higher in patients with aura migraine and non-aura migraine and patients with cervicogenic headache, this difference was statistically found higher only in patients with non-aura migraine [13].

In our study, most of the symptoms (headache, syncope, vertigo) were particularly found numerically higher in patients with bilateral complete foramen, this difference was not statistically found significant. This result may have been because our study group involved a few patients. This difference can be statistically found significant in the studies which will be done with more patients within a long time.

Total arcuate foramen was found in 5 of the 8 epileptic patients which were randomly included in the study by Wright et al. which were done with the patients who applied to chiropractic clinic. This incidental result was interpreted as there might be a connection between arcuate foramen and epilepsy. However, there were no patients who described epilepsy in our study groups.

The age average of our patient group decreased because the

patients who were excluded due to chronic diseases were elder. Having younger patients might also have led to significant difference in the complaints of the patients with and without arcuate foramen. Degenerative skeleton changes and atherosclerosis which emerge upon ageing might increase the symptoms which are caused by arcuate foramen.

In the study by Wright et al. in which arcuate foramen incidence was reported as significantly higher in non-aura migraine patients, the age average of the patient group was found as 46 [14]. In this study, the higher age average of the patients when compared to our study might have increased the incidence of clinical symptoms.

A similar study by Çakmak et al. scrutinized the association between the presence of arcuate foramen and clinical symptoms such as headache, dizziness, lacrimation, shoulder, arm and neck pain. In this study, the patients with complete foramen were compared to the patients with partial foramen. All symptoms excluding lacrimation were found significantly higher in patients with complete foramen [6]. This study involved patients between 29 and 79 years old and the age average was reported as 49.5. The higher age average of the patients in this study when compared to our study might also have increased the incidence of clinical symptoms.

Neither study by Wright et al. nor the study by Çakmak et al. included any information indicating that the patients with degenerative – osteophyte changes in the cervical area were excluded from the study. The exclusion of these patients from our study group can also explain the reason why the symptoms were lower when compared to these studies. In a study which was done in Chile and researched arcuate foramen incidence in asymptomatic patients, the age average was reported as 18.4 [11]. Total arcuate foramen incidence was found as 9.2%, partial arcuate foramen incidence was found as 10.1% in these patients. That this patient group consists of younger patients can also support the fact that the incidence of arcuate foramen related symptoms increased along with the changes that emerge upon ageing.

Moreover, retrospective study and the impossibility of face-to-face interview with the patients also limited our study. As a result, arcuate foramen is a variation whose incidence is reported at varying rates in literature, which is associated with many different symptoms and is not rare.

Conclusions

The association of this variation with clinical symptoms has not been clearly set before. The possible association between the clinical symptoms and the variation should be researched more comprehensively. Even though its association with the symptoms has not been proven indeed, it is obvious that the presence of this variation should be known at the phase of planning the operations concerning craniovertebral junction.

In the posterior approach for craniovertebral junction, knowing the presence of foramen in advance during lateral dissection and C1 laminectomy or other stabilization procedures such as screwing of the lateral mass of the atlas will reduce the risk of vertebral artery injury.

Competing interests

The authors declare that they have no competing interests.

References

1. Cakmak O, Gurdal E, Ekinci G, Yildiz E, Cavdar S. Arcuate foramen and its clinical significance. Saudi Med J 2005;26:1409-13.
2. Cho YJ. Radiological analysis of ponticulus posticus in Koreans. Yonsei Med J 2009;50:45-9.
3. Cushing KE, Ramesh V, Gardner-Medwin D, Todd NV, Gholkar A, Baxter P, Griffiths PD. Tethering of the vertebral artery in the congenital arcuate foramen of the atlas vertebra: a possible cause of vertebral artery dissection in children. Dev Med Child Neurol 2001;43:491-6.
4. Karau PB, Ogengo JA, Hassanali J, Odula P. Anatomy and prevalence of atlas vertebrae bridges in a Kenyan population: An osteological study. Clin Anat 2010;23:649-53.
5. Kavakli A, Aydinlioglu A, Yesilyurt H, Kus I, Diyarbakirli S, Erdem S, Anlar O. Variants and deformities of atlas vertebrae in Eastern Anatolian people. Saudi Med J 2004;25:322-5.
6. Koutsouraki E, Avdelidi E, Michmizos D, Kapsali SE, Costa V, Baloyannis S. Kimmerle's anomaly as a possible causative factor of chronic tension-type headaches and neurosensory hearing loss: case report and literature review. Int J Neurosci 2010;120:236-9.
7. Lamberty BG, Zivanović S. The retro-articular vertebral artery ring of the atlas and its significance. Acta Anat (Basel) 1973;85:113-22.
8. Malas M.A, Çetin M, Salbacak A. Sulcus arteriae vertebralis variations on atlas. Türkiye Klinikleri Journal Medical Research 1998;16:98-102.
9. Paraskevas G, Papaziogas B, Tsonidis C, Kapetanos G. Gross morphology of the bridges over the vertebral artery groove on the atlas. Surg Radiol Anat 2005;27:129-36.
10. Pyo J, Lowman RM: The ponticulus posticus of the first cervical vertebra. Radiology 72:850-4, 1959.
11. Schilling J, Schilling A, Galdames IS. Ponticulus posticus on the Posterior Arch of Atlas, Prevalence Analysis in Asymptomatic Patients. Int J Morphol 2010;28:317-22.
12. Stubbs DM. The arcuate foramen. Variability in distribution related to race and sex. Spine 1992;17:1502-4.
13. Unur E, Erdoğan N,Ulger H, Ekinci N, Oztürk O. Radioradiographic incidence of complete arcuate foramen in Turkish population. Erciyes Tıp Dergisi 2004;26:50-4.
14. Wight S, Osborne N, Breen AC. Incidence of ponticulus posterior of the atlas in migraine and cervicogenic headache. J Manipulative Physiol Ther 1999;22:15-20.
15. Young JP, Young PH, Ackermann MJ, Anderson PA, Riew KD. The ponticulus posticus: implications for screw insertion into the first cervical lateral mass. J Bone Joint Surg Am 2005;87:2495-8.

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