

RADIOGRAPHIC INCIDENCE OF COMPLETE ARCUATE FORAMEN IN TURKISH POPULATION

Türk toplumunda foramen arcuatum'un radyografik sıklığı

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Abstract:

To detect the radiographic incidence, dimensions and side predilection of arcuate foramen, a radiographic and fluoroscopic survey was employed in 351 patients. Eighteen patients (5.1%) had arcuate foramen. Age and sex did not appear to be related to the frequency of the occurrence of foramina ($P>0.05$), which was right-sided in 8 cases (2.3%), left-sided in 7 cases (2%), and bilateral in 3 cases (0.9%). The mean superior-inferior, anteroposterior diameters and ponticle thickness were 5.7mm (3.7-8.5 mm), 8.1mm (5.7-10.0mm) and 2.2mm (1.0-3.5mm), respectively.

Key Words: Atlas vertebra, Spine, Variation

One of the variations displayed by the first cervical vertebra (atlas) is the ossified ligamentous border of posterior atlanto-occipital membrane (ponticulus) over the vertebral artery groove to form arcuate foramen (1, 2, 3). The posterior atlanto-occipital membrane connects the posterior margin of the foramen magnum to the upper border of the posterior atlantal arc. This ligament is a broad but thin membranous sheet intimately blending with dura. It arches over the grooves of the vertebral arteries (retro-condylar groove), completing openings for entrance of the arteries, and exit of venous plexuses and the first cervical spinal nerves (2). The ligamentous border (free margin of oblique part of posterior atlanto-occipital membrane) can ossify completely or

*VI. Ulusal Anatomi Kongresi, 3-7 Eylül 2001, Edirne
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Geliş tarihi: 3 Haziran 2003

Özet:

Foramen arcuatum'un radyografik insidansını, boyutlarını ve sağ- sol dağılımını tespit etmek amacıyla 351 hastada radyografik ve floroskopik inceleme gerçekleştirildi. Vakaların 18'inde (%5.1) foramen arcuatum tespit edildi. Bunların 8'i (%2.3) sağda, 7'si (%2) solda ve 3'ü (%0.9) bilateral yerleşimli idi. Foramen arcuatum'un oluşumunda yaş ve cinsiyetin etkili olmadığı tespit edildi ($P>0.05$). Foramen arcuatum'un üst-alt çapı 3.7-8.5 mm (ortalama 5.7 mm), ön-arka çapı 5.7-10.0 mm (ortalama 8.1 mm) ve pontikulus kalınlığı 1.0-3.5 mm (ortalama 2.2 mm) olarak ölçüldü.

Anahtar Kelimeler: Atlas, Varyasyon, Omurga

incompletely. Complete ossification leads to arcuate foramen, which may cause external pressure on the vertebral artery, especially during extreme rotatory movements of the head (3, 4, 5).

In this study, we aimed to detect the radiographic incidence, dimensions and side predilection of complete arcuate foramen (CAF) in the Turkish population.

MATERIALS AND METHODS

Lateral cervical spine radiographs of 351 patients (243 females and 108 males; age range, 20-82 years; mean, 42.6±13.2years) with clinical complaints such as vertigo, neck pain or discopathy were reviewed in the Radiology Department of the University Hospital over a 3 month period. Only the radiographs of patients with clearly visible skull base and no history of craniocervical operation or trauma were included in the study. The radiographs were obtained by conventional X-ray equipment

using screen films and movable focused grid (grid ratio: 1/8). X-ray exposure parameters were 300 mA, 55 kV, and 0.10-0.15 sec. Films were processed automatically by Multiloader 700 Plus Room light processor (Eastman Kodak Company, Rochester, NY). Patients with radiographic evidence of complete arcuate foramina (CAF) underwent a second examination with MultiDiagnost 3 C-armed fluoroscopy instrument (Philips Medical Systems, Best, Netherlands) in order to detect the side of appearance of CAF. Prior to fluoroscopic examination, verbal consent was obtained from all patients. The study was approved by the Hospital Ethic Committee. Fluoroscopic examination included review of the images in right or left posterior oblique position (maximum scopy time, 30 seconds), plus digital acquisition of a final radiography in a slightly oblique position to reveal the maximum dimensions of the complete foramen. Hardcopy of the final image was obtained on laser imaging films using X-Omat 2000 automatic film processor and Ektascan 1120 laser printer (Eastman Kodak Company, Rochester, NY). Exposure parameters for the final image were 70 kV, 230 mA and 20-30 msec. A radioopaque ruler was included in the final image with maximum attention to place the ruler in the same coronal plane as the arcuate foramen.

Maximum dimensions of the superoinferior (SI) and anteroposterior (AP) diameters of the foramen, and the thickness of the ponticle (Fig. 1) were estimated on the hardcopy of the radiographs with a micrometer. AP diameter was measured parallel to the upper border of posterior elements of atlas, with SI diameter perpendicular to it. The ponticle thickness was determined along the SI diameter, i.e. the thinnest distance at the dome. Due to the magnification factor on the hardcopy, each measurement was corrected by that of the radioopaque ruler. For statistical description of various factors (age, sex, side of appearance) the results were analysed by unpaired t test.

RESULTS

Radiographic appearances of complete arcuate foramina (CAF) were round to oval in shape (Fig. 2). There were numerous variations with respect to thickness and configuration of the ponticuli.

Eighteen patients (13 females, 5 males) had CAF (5.3 % of 243 females and 4.6% of 108 males, 5.1% of all cases) (table I). The mean patient ages were 44.8 ± 12.0 years for CAF, and 42.5 ± 13.3 years for absent foramen. Age and sex do not appear to be related to the frequency of occurrence of complete foramina (unpaired t test, $P > 0.05$). The side of appearance was right in 8 cases (2.3%), 7 in seven cases (2%), and bilateral (Fig. 2) in 3 cases (0.9%). When viewed as a group, the side of involvement was right in 44.4%, left in 38.8%, and bilateral in 16.6%. The mean SI and AP diameters were 5.7 mm (3.7-8.5 mm) and 8.1 mm (5.7-10.0 mm),



Figure 1. Measurement of CAF (SI: Superoinferior diameter, AP: Anteroposterior diameter, PT: Ponticle thickness). See text for details of measurement.



Figure 2. Bilateral complete arcuate foramina (a)

Table I. Incidence of complete arcuate foramen according to sex and age in Turkish population.

	n	age	CAF	
			n	%
Males	108	43.7±13.3	5	5.3
Females	243	42.2±13.0	15	4.6
Total	351	42.6±13.2	18	5.1

respectively. The mean ponticle thickness was 2.2 mm (1.0-3-5mm).

DISCUSSION

Arcuate foramen has been studied extensively in skeletal bones (3, 6-9) or radiographs (1, 10-12) in different populations. In the studies performed on skeletal bones, retroarticular canal of atlas vertebra is classified in 3 groups. Class I represents retroarticular impression on the posterior arch of atlas vertebra, Class II is defined retroarticular sulcus, and Class III represents complete bony ring

Table II: Incidence of Complete Arcuate Foramen as Reported in the Literature

Study	Material	Incidence (%)
Pyo, 1959	Radiographs	12.6
Romanus, 1964	Radiographs	14.3
Lamberty, 1973	Osteologic specimens	15
	Radiographs	7.5
Basaloglu, 1983	Osteologic specimens	9.5
Stubbs, 1991	Radiographs	13
Cankur, 1995	Osteologic specimens	14.2
Mitchell, 1998	Osteologic specimens	9.8
Malas, 1998	Radiographs	2,6
Hasan, 2001	Osteologic specimens	3.4
Present Study	Radiographs	5.1

(6). A less detailed description is given in radiologic studies, in which arcuate foramen is classified as complete or incomplete (1,3,11). Depending on the method of study, reported incidence changes between 9.5-15% in skeletal bone studies, and between 2.6-14.3% in studies carried out on radiographs (Table II). In a study involving both the skeletal bones and radiographs of 60 European spines, the reported incidences are 15% and 7.5%, respectively (3). In general, the radiographic incidence for partial or CAF seems to be lower than that of skeletal bone studies (3 and 11), however, variations in different populations and races should also be considered.

According to Pyo and Lowman (1) and Nathan (13), the ossification of free margin of atlanto-occipital membrane is a late process, which occurs with increasing age. However, many authors have stated that ponticle formation is a regressive and disappearing morphological phenomenon (3 and

14). Furthermore, this anatomical variation is not related to an increase in degenerative changes synonymous with ageing (6). Thus, the development of ossification centres in the atlanto-occipital membrane appears to be spontaneous, and may have a genetic basis because of the reported familial occurrence (15 and 16). These characteristics not only serve as anthropological data, but may also help in identifying the impact of CAF on the signs and symptoms of vertebrobasilar insufficiency.

In general, the incidence of arcuate foramen is not related with sex, although Stubbs (11) has reported that CAF is more common in males. In our study, age and sex do not appear to be related to the frequency of occurrence of complete foramina, confirming the findings in early literature.

There are few data in the literature about measurements and side of appearance of arcuate foramina. Mitchell (6), in his skeletal study of 1354 atlas vertebrae of African white and black adults, reported that SI diameters of complete arcuate foramina range between 4.9-5.7 mm, whereas AP diameters range between 5.9-6.7 mm. Pyo and Lowman (1) reported that the CAF has a mean diameter of 8.3 mm in females and 8.5 mm in males, with a range of 6-12 mm in American whites, however, this report does not mention the plane of measurement. Assuming that it is the AP diameter which is of concern, our findings on the AP diameter (8.2 mm in right and 8.0 mm in left) confirm the findings of Pyo and Lowman (1), and do not substantiate those by Mitchell (6). In the study by Mitchell (6), the incidence of complete retroarticular canal was 9.8%, of which 17% were on the right, 36.1% were on the left, and 46.6% were bilateral. The figures in our study (44.4%, 38.8% and 16.6%, respectively) greatly outnumber these figures in case of unilateral appearance. To our knowledge, there is no study to compare our results of the ponticle thickness.

Aside from the characteristics of the population, the discrepancy between the various studies may be related to the instrumentation, which, improperly

selected, may be a limiting factor in radiographic detection of CAF. The term image clarity is used to describe the visibility of a diagnostically important detail in the radiograph (17). There are many factors determining the visibility of foramen in radiographic images such as use of grids, photographic characteristics of X-ray film, film processing (development) and proper selection of kVp and mAs. Unfortunately, radiological studies concerning the incidence of arcuate foramen do not mention about factors determining image clarity. Image clarity is determined by contrast and image quality. Image quality is influenced by radiographic noise, image sharpness and resolution. Both sharpness and resolution depend on the geometry of the object, which may lead to difficulty in detecting a fine thread of ossification (i.e. ponticle) in posterior atlantooccipital membrane ligament. However, the effect of these factors in the radiographic detection of CAF needs to be proven by large-scale cadaver studies.

In conclusion, the data obtained from our study reflects one of the morphologic characteristics of atlas in the Turkish population. The contribution of the presence of CAF to the clinical findings of vertebrobasilar insufficiency must be evaluated by further studies.

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