Original Article
An investigation into the frequency of carotid artery calcification on digital panoramic radiographs in individuals aged 60 and above

Sinem Coşkun

Department of Oral Diagnosis and Maxillofacial Radiology, Faculty of Dentistry, Lokman Hekim University, Ankara, Turkey

Abstract: The objective of this study is to determine the prevalence of carotid artery calcifications (CAC) in individuals aged 60 years or older, as incidentally detected on panoramic radiographs. A total of 566 patients, comprising 328 females and 238 males, aged between 60 and 101 years, were analyzed to identify the presence of CAC using panoramic images. The data were analyzed using IBM SPSS V23 (Chicago, USA). The presence of CAC was recorded, taking into account the individual's age and gender. The incidence of CAC was 9.5%, with 6.5% occurring unilaterally and 3% occurring bilaterally. Gender had no impact on the presence of CAC. Nevertheless, individuals aged 80 and above exhibit a higher tendency to have CAC. Conclusion: Panoramic radiography can incidentally identify CAC. Detecting asymptomatic CAC may have a beneficial impact on a patients' well-being.

Keywords: Atheroma plaques, atherosclerosis, maxillofacial radiology, panoramic imaging

Introduction

Peripheral artery disease is characterized by the constriction or blockage of the arteries located beyond the aortic arch [1]. Atherosclerosis is a chronic condition defined by the abnormal buildup of lipids in the walls of arteries. This condition can result in myocardial infarction, stroke, and sudden death [2, 3]. Hence, identifying both symptomatic and asymptomatic atheroma plaques will be advantageous in decreasing morbidity and mortality rates [4]. Angiography is often regarded as the most reliable diagnostic approach for arteriosclerotic disorders among all imaging techniques. Nevertheless, because of its invasive nature, it entails potential hazards [3].

Panoramic radiography is a frequently used technology in dentistry that allows for the visualization of the maxillary and mandibular arches, as well as their surrounding structures, on a single film [5, 6]. Panoramic imaging can also detect calcifications in soft tissues, including tonsilloliths, sialoliths, lymph node calcifications, and calcified atheroma plaques.

Nevertheless, unskilled physicians may overlook these findings [7]. The right and left carotid arteries ascend in the neck to the mid-cervical area, where they divide into the internal and external carotid arteries near the upper boundary of the thyroid cartilage. These bifurcation locations often display atheroma plaques. Calcified atheroma plaques can appear as unilateral or bilateral, irregular, round, or heterogeneous radiopaque masses when evaluated radiographically. When these plaques are small, they primarily appear circular; when they are larger, they primarily appear linear or thinly rectangular [8, 9].

Usually found posterosuperior to the mandibular angle, they are situated close to the hyoid bone at the inferior edge of the third cervical vertebra (between C3 and C4) [3, 10].

Due to their precise positioning, panoramic radiographs can clearly display the lesions [11]. This imaging technique makes the region of the first cervical vertebra visible, making it a valuable tool for the early detection of calcified atheroma in the common carotid artery [12].

Panoramic radiographs, one of the most frequently requested imaging exams in dentistry today, can reveal the presence of atheromatous plaques, even in cases with partial calcifications caused by the deposition of calcium salts. About 2.5 cm posterior and inferior to the mandibular angle, near the space between vertebrae C3 and C4, the atheromas can be seen unilaterally or bilaterally as one or more irregular radiopacities, which may be accompanied by vertical-linear radiolucent areas with one or more lesions of varying sizes [13-15].

Following the research conducted by Friedlander and Lande [11], other researchers have investigated the frequency of carotid artery calcification (CAC) on panoramic radiographs across various ethnic groups [4, 16-21]. However, these studies included a wide range of age groups with varied risk factors, and there is a scarcity of studies specifically targeting older individuals [22, 23].

The objective of this study is to ascertain the prevalence of incidentally observed CAC on panoramic radiographs among individuals aged 60 and above who have visited our faculty.

Materials and methods

Study design and setting

This study was conducted using panoramic radiographs to assess the prevalence of carotid artery calcification (CAC) among individuals aged 60 and above. The images were obtained from the computer database of our faculty, with data collected between January 2023 and December 2023.

Ethical considerations

Approval for the research was granted by the ethics committee of the Scientific Research Ethics Board at Lokman Hekim University under protocol number 2024/133. The study was conducted in accordance with the principles outlined in the Declaration of Helsinki.

Image acquisition

Digital panoramic radiographs were obtained using the New Tom Giano HR (QR SRL Company, Verona, Italy) X-ray device. The device was set to standard shooting mode with parameters of 6 mA, 16 seconds, and a peak tube potential of 66 kV, adjusted according to the subject's jaw size. Patients were positioned in the ski position, with edentulous patients resting their chin and dentulous patients biting a sterile bite piece with the incisal surfaces of their upper and lower incisors. Guide laser lights were used to ensure symmetrical positioning, with the Frankfurt horizontal plane parallel to the ground, the midline of the incisive teeth aligned with the sagittal plane, and the midline of the upper canine teeth aligned with the coronal plane.

Inclusion and exclusion criteria

A total of 566 images (238 males, 328 females) showing the cervical vertebrae C3-C5 and of diagnostic quality were included in the study. Images with artifacts, positioning errors, or those not allowing for bilateral evaluation of the vertebrae were excluded.

Inclusion Criteria: 1. Diagnostic Quality: Only digital panoramic radiographs of diagnostic quality were included. These images must clearly show the cervical vertebrae C3-C5. 2. Age Requirement: Participants must be 60 years of age or older. 3. Image Coverage: The radiographs must include the cervical vertebrae C3-C5 to ensure accurate assessment of carotid artery calcification (CAC).

Exclusion Criteria: 1. Artifacts: Images with visible artifacts that could obscure or distort the view of the cervical vertebrae were excluded. 2. Positioning Errors: Radiographs where positioning errors made accurate assessment impossible were excluded. This includes images where the cervical vertebrae are not properly aligned or are outside the field of view. 3. Incomplete Bilateral Evaluation: Images that did not allow for the bilateral evaluation of the cervical vertebrae, meaning they did not show both sides adequately, were excluded.

Data interpretation

The collected radiographs were interpreted by an oral and maxillofacial radiologist (SC). The images were evaluated for the presence of nodular calcification foci or two radiopaque vertical lines near or just below the intervertebral space between C3 and C4, as described by Roldán-Chicano and others [10]. Findings of CAC were documented as unilateral or bilateral, with

Figure 1. 68-year-old male patient with calcifications in both carotid arteries.

Results Presentation: Prevalence rates of CAC were categorized by side (right, left, bilateral) and compared across different age groups and genders. The analysis also explored the relationship between age and the extent of CAC.

Results

Distribution of participants

Out of all the participants, 42% are male and 58% are female. A total of 54.6% of the participants are aged 60 to 69 years, 40.8% are aged 70 to 79 years, and 7.6% are 80 years of age or older.

The prevalence of carotid artery calcification

The prevalence of carotid artery calcification (CAC) on the right side is 6.2%, while the prevalence on the left side is 6.4%. The prevalence of bilateral CAC is 3% (**Figure 1**). The prevalence of individuals without CAC is 90.5%, with unilateral CAC at 6.5% and bilateral CAC at 3% (**Table 1**).
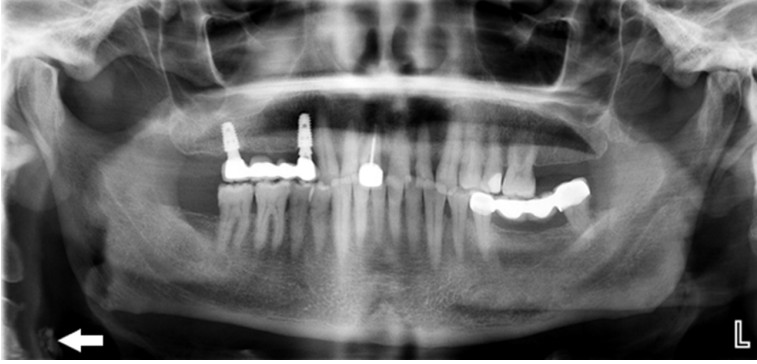
The relation between gender and the occurrence Of CAC

The presence of CAC is not influenced by gender (P = 0.302). The prevalence of unilateral CAC is found to be 78.3%, while the rate of bilateral CAC is 21.7% among males with CAC (**Figure 2**). The prevalence of unilateral CAC is found to be 61.3% among females with CAC, while the rate of bilateral CAC, which is higher than in males, is 38.7% (**Table 2**). A total of 78% of CACs in men are unilateral.

The relation between age and the occurrence of CAC

The extent of CAC is influenced by age (P = 0.007). The prevalence of unilateral CAC is 73.7% among individuals aged 60 to 69 years, 80.8% among those aged 70 to 79 years, and 22.2% among individuals aged 80 and above. The prevalence of bilateral CAC is 26.3% in people aged 60 to 69 years, 19.2% among individuals aged 70 to 79 years, and 77.8% among individuals aged 80 and above. The prevalence of CAC in individuals aged 80 and above differs

Table 1. Frequency distributions of variables

	Frequency	Percentage
Gender		
Male	238	42
Female	328	58
Age range		
60-69	292	51.6
70-79	231	40.8
80+	43	7.6
Right-sided CAC		
Absent	531	93.8
Present	35	6.2
Left-sided CAC		
Absent	530	93.6
Present	36	6.4
Bilateral CAC		
Absent	549	97
Present	17	3
Side		
Absent	512	90.5
Present	54	9.5
Unilateral	37	6.5
Bilateral	17	3

details recorded along with age and gender data.

Statistical analysis

Data were analyzed using IBM SPSS V23 (Chicago, USA). Categorical data were analyzed using the Yates correction and Fisher-Freeman-Halton test. Multiple comparisons were conducted using the Bonferroni-corrected Z test. Results were presented as frequencies (percentages), and statistical significance was set at P<0.05.

Figure 2. 75-year-old male patient with unilateral carotid artery calcification.

Table 2. The analysis of the relation between gender and the occurrence of CAC

		Gender		Test Statistics	p*
		Male	Female		
Side	Unilateral	18 (78.3)	19 (61.3)	1.064	0.302
	Bilateral	5 (21.7)	12 (38.7)		

*Yates correction.

Table 3. An examination of the relationship between age and the occurrence of CAC

		Age category			Test statistics	p*
		60-69	70-79	80+		
Side	Unilateral	14 (73.7)[a]	21 (80.8)[a]	2 (22.2)[b]	9.872	0.007
	Bilateral	5 (26.3)	5 (19.2)	7 (77.8)		

*Fisher Freeman Halton Test; a, b: Groups with the same letter are indistinguishable.

significantly compared to other age groups (**Table 3**).

Discussion

Early detection is crucial since atherosclerosis is a progressive condition. One potential tool for early detection is panoramic radiography, which is often taken during initial dental examinations [24].

The aim of this study is to determine the prevalence of incidentally detected CAC on panoramic imaging in individuals aged 60 years or older. Calcification of the carotid artery, particularly near the carotid bifurcation, can lead to significant vessel blockage, potentially resulting in a stroke [19]. Atherosclerosis is a primary cause of cerebrovascular accidents (CVA). Panoramic radiography, commonly used in dental offices, can help identify patients at higher risk for CVA [25].

Panoramic radiography is a frequently employed diagnostic tool in dental practice, providing a comprehensive view of oral and facial anatomical features. It also allows for the examination of the cervical vertebrae region, making it a valuable instrument for the early detection of CAC [12].

However, it is essential to differentiate CAC from other anatomical structures (such as the hyoid bone, calcified lymph nodes, and the styloid process and ligaments) and pathological entities (such as sialoliths, phleboliths, and portions of the larynx) that may also be present in this area [24].

Scientific investigations have demonstrated the efficacy of panoramic radiography in detecting carotid artery calcification (CAC) [24, 26-28]. The calcified atheromatous plaque located at the carotid bifurcation is typically distinguishable on panoramic images due to its distinct position and appearance compared to other radiopacities in the surrounding region. Panoramic radiographs can detect atherosclerotic lesions in the cervical carotid artery, which may appear as a solid, dense mass or as two vertical lines below the angle of the jaw, between the back edge of the lower jawbone and the C3-C4 vertebrae [29]. Given the widespread use of panoramic dental radiographs in general dentistry, CAC is frequently encountered by dentists [17].

An analysis of the relevant literature reveals considerable variability in the prevalence of CAC. Friedlander and Lande [11] conducted pioneering research on CAC in panoramic images, analyzing 1000 patients aged 50 to 75, and found a prevalence of 2%. Tamura and others [18] examined panoramic radiographs of a large cohort of Japanese adults aged 50 to 70

and reported a prevalence of CAC of 4.13%, highlighting its clinical significance, particularly in female patients. Ağaçayak and others [23] studied a cohort of Turkish patients and found a prevalence of 8.8%, noting that neither age nor gender significantly influenced the prevalence of CAC. This is consistent with findings from other studies. However, our research revealed a substantial correlation between CAC and individuals aged 80 and older, with a p-value of 0.007. The increased sample size and broader age range in our study may account for the observed differences. Sisman and others [20] studied another group of Turkish individuals and found a prevalence of CAC at 5.06%. In their study, 68.4% of cases had unilateral calcifications, while 31.6% had bilateral calcifications.

Although the frequency of incidence is not as high as in this study, the distribution of unilateral and bilateral calcifications is similar, with 68.5% and 31.4%, respectively.

A study conducted on a Thai population of 1,370 individuals aged between 50 and 87 years found that only 34 patients (2.5%) had CAC [19]. Similarly, a separate study of 2,374 individuals from Japan reported a lower incidence of CAC at 4.0% [17]. Despite the larger sample size in the Japanese study, the prevalence of CAC was notably lower compared to other studies. Another study conducted in Lebanon reported a CAC prevalence of 6.8% [16].

Additionally, the prevalence of CAC varies with age. Alzoman and others [30] found a prevalence rate of 5% in the Saudi Arabian population. Abreu and others [31] reported a prevalence rate of 2.9% in Brazil. Maia and others [22] conducted a study on elderly adults in Brazil and found that CAC was the most common type of calcification, with a prevalence rate of 12.5%. In our study, the prevalence of CAC was 9.5%. We observed no correlation with gender but did find a significant correlation with age. There was no substantial difference in the location of CAC between males and females.

Clearly, there is significant variation in CAC prevalence across different studies. Factors such as ethnicity, dietary patterns, lifestyle, sample size, and sample characteristics may contribute to these differences. While some studies suggest no association between age and CAC [23, 32], several investigations have shown a relationship between different age groups and CAC. Research conducted by Nasseh and Aoun [16] found a 6.8% prevalence of CAC, with age influencing this prevalence. Similarly, a study involving dental patients from Poland revealed a positive correlation between age and the occurrence of bilateral CAC in both sexes. However, a significant association with unilateral CAC was observed exclusively in men [32]. Maia and others [22] reported a higher prevalence of CAC in women as they aged, and Vengalath and others [33] found that elderly women had a greater prevalence of CAC compared to younger women. In contrast, no significant disparity was observed in CAC prevalence among men. Our study found a similar association between age and CAC, consistent with previous research.

The relationship between gender and CAC remains mixed in the literature. Some studies suggest a favorable association between CAC and gender [18, 32], while others report no significant relationship [16, 20, 23]. In this study, no statistically significant association was found between gender and the prevalence of CAC.

Additionally, panoramic radiographic exams performed on diabetic patients revealed a prevalence of carotid artery calcifications in 24% of those treated without insulin and 36% of those treated with insulin. These findings highlight the elevated risk of stroke in diabetic patients, regardless of the treatment modality [34].

Due to the comprehensive diagnostic information they provide, computed tomography and Doppler ultrasonography are often recommended for identifying atheromas. However, panoramic radiographs, despite their extensive use primarily in dentistry, offer valuable diagnostic insights for detecting carotid artery atheromas. Given the frequent use of panoramic radiography in dental practices, dentists are well-positioned to identify potential atheromas and should be considered key healthcare providers for this evaluation [14, 15].

Several limitations were noted in this study. Since it was designed retrospectively, clinical findings and systemic disease histories of the

patients could not be obtained. The cross-sectional nature of the study restricts the ability to infer causality or observe changes over time. Longitudinal studies are needed to assess the progression of CAC and its relationship with other health outcomes. The study is based on a specific population of individuals who visited our faculty for dental examinations, which may not be representative of the general population. This could introduce selection bias and limit the generalizability of the findings. The focus on individuals aged 60 and above is relevant for assessing CAC, but the results may not be applicable to younger populations or those with different risk profiles. Additionally, CAC interpretation was performed by a single radiologist. Despite efforts to standardize evaluation criteria, interobserver variability could affect the consistency of findings if multiple radiologists had been involved.

Conclusion

Panoramic radiographs enable the assessment of teeth and jaws, as well as the incidental detection of soft tissue calcifications. The likelihood of identifying carotid artery calcification (CAC) on panoramic radiographs is notably greater in patients aged 60 and above. Since individuals with no symptoms may have CAC, detecting CAC through panoramic dental radiography has the potential to reveal a serious health issue. In such cases, physicians should recommend that patients undergo further evaluation and therapy. It is advisable to conduct longitudinal studies to monitor the progression of CAC over time and its impact on cardiovascular health outcomes. This would aid in understanding the development and progression of CAC and its clinical significance. Additionally, implementing multidisciplinary prospective clinical studies that integrate cardiovascular disease and dentistry, taking into account medical history and using advanced imaging techniques, are recommended.

Disclosure of conflıct of ınterest

None.

Address correspondence to: Sinem Coşkun, Department of Oral Diagnosis and Maxillofacial Radiology, Faculty of Dentistry, Lokman Hekim University, Söğütözü Mh. 2179 Cd. St No: 6, 06510 Çankaya/Ankara, Turkey. E-mail: sinem.coskun@lokmanhekim.edu.tr

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