Original Article

HEALTH SCIENCES
MEDICINE

DOI: 10.32322/jhsm.1769306
J Health Sci Med. 2025;8(6):1006-1010

Evaluation of carotid artery calcification on panoramic radiographies

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Cite this article as: Altındağ A, Altındağ Ö. Evaluation of carotid artery calcification on panoramic radiographies. *J Health Sci Med.* 2025;8(6):1006-1010.

Received: 20.08.2025 ◆ **Accepted**: 18.09.2025 ◆ **Published**: 25.10.2025

ABSTRACT

Aims: The aim of this study was to evaluate the prevalence of carotid artery calcification (CAC) on panoramic radiographs and to investigate its relationship with age, sex, and systemic diseases.

Methods: Panoramic radiographs obtained from 599 patients who referred to our clinic were retrospectively analyzed. Irregular, heterogeneous radiopaque masses located at the C3-C4 cervical vertebral level were considered indicative of CAC, with differential diagnosis performed against other calcified anatomical or pathological structures. Data on patient age, sex, and systemic conditions (cardiovascular disease, diabetes) were recorded. Information on smoking status, lipid profiles, medication use, and history of cardiovascular surgery was not recorded. Chi-square tests and logistic regression analyses were used to assess associations between CAC and clinical variables.

Results: CAC was detected in 19 patients, corresponding to a prevalence of 3.2%. The prevalence increased with age: 0.9% in the 18-35 age group, 6.3% in the 36-60 age group, and 4.9% in patients aged ≥61 years. Logistic regression analysis identified age as an independent risk factor for CAC ($p<0.05$). No significant differences were observed with respect to sex or systemic diseases; however, the prevalence of CAC was relatively higher in patients with cardiovascular disease (7.7%), whereas no cases were observed among diabetics.

Conclusion: The prevalence of CAC detected incidentally on panoramic radiographs was within the range reported in previous studies. Age was confirmed as an independent risk factor, while sex and systemic comorbidities showed no significant associations. Panoramic radiographs may serve as a useful tool for the incidental detection of CAC in routine dental practice.

Keywords: Atherosclerosis, carotid arteries, diagnostic imaging, panoramic radiography

INTRODUCTION

Calcification is defined as the abnormal deposition of calcium salts in tissues and organs.[1] When this deposition results in an organized structure within soft tissues, it is termed heterotopic ossification; when the deposition occurs without organization, it is referred to as heterotopic calcification. Soft tissue calcifications are rare in children but are more frequently observed in individuals over the age of 40. In the head and neck region, calcifications are commonly seen in the laryngeal cartilages, vertebrae, arteries, and thyroid gland.[2,3]

Calcification and plaque formation in the carotid arteries may lead to carotid artery calcification (CAC). Atherosclerosis-related calcifications are most often observed in the internal carotid artery.[4,5] Hypertension, elevated serum cholesterol and carbohydrate levels, and systemic disorders that may impair endothelial integrity are among the main etiological factors of CAC.[6]

Atherosclerosis is a progressive inflammatory disease and represents a major cause of morbidity and mortality in developed countries. It has been reported to lead to peripheral arterial disease, coronary artery disease, and stroke.[7,8] The most commonly affected site is the internal carotid artery, and approximately 40% of cerebrovascular events caused by atherosclerotic plaques are reported in this region.[9] According to global data, cerebrovascular events such as stroke constitute a leading cause of death and disability worldwide; specifically, stroke ranks as the second leading cause of death and the third leading cause of death and disability combined (DALYs) globally and across regions including North America, Europe, and Asia.[10,11]

In dentistry, panoramic radiographs are widely used along with intraoral radiographs for diagnosis, treatment planning, and post-treatment evaluation.[3,12,13] The main advantage of panoramic radiographs is their ability to visualize the teeth, alveolar bones, and anatomical structures of the head and neck with a lower radiation dose compared to other imaging modalities.[14,15] Since early detection of risk factors is crucial

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for reducing morbidity and mortality, imaging plays an important role in preventive strategies.[16]

The use of panoramic radiographs for the detection of CAC was first highlighted by Friedlander and Lande in 1981.[17] They reported that CAC, which can be observed at the C3-C4 vertebral level and is a major cause of stroke, may be identified on panoramic radiographs.[17] On panoramic films, these lesions typically appear at the C3-C4 level as irregularly bordered, heterogeneous radiopaque formations (**Figure**).[3,17,18] Thus, panoramic radiography not only provides a rapid and cost-effective evaluation of dental and maxillofacial structures but also enables the incidental detection of CAC.[19]

Figure. Bilateral carotid artery calcifications at the C3-C4 vertebral level on panoramic radiograph (indicated by red arrows)

The present study aimed to determine the prevalence of carotid artery calcifications incidentally detected on panoramic radiographs, which may occasionally be overlooked, and to evaluate their distribution according to age, sex, and systemic disease status.

METHODS

Ethical Approval

This study was approved by the Necmettin Erbakan University Dentistry Non-drug and Non-medical Device Researches Ethics Committee (Date: 31.03.2022, Decision No: 2022/16-120), and conducted in accordance with the principles of the Declaration of Helsinki.

Study Design

Panoramic radiographs of patients who presented to the Department of Oral and Maxillofacial Radiology, Faculty of Dentistry, Necmettin Erbakan University, for various reasons between January 2020 and October 2021 were retrospectively reviewed and randomly selected. All panoramic radiographs were obtained using a Morita Veraviewepocs 2D panoramic unit (J. Morita MFG Corp., Kyoto, Japan) at 60-70 kVp, 5-7 mA, and 6-8 s exposure time, according to the manufacturer's recommendations.

Inclusion criteria:

- Individuals aged 18 years and older
- Patients with complete demographic and clinical records
- Panoramic radiographs of diagnostically acceptable image quality

Exclusion criteria:

- Patients with a history of head and neck surgery
- Radiographs with artifacts, positioning errors, or pathologies reducing diagnostic quality
- Patients with incomplete demographic data

Data on patient age, sex, and systemic conditions were collected from clinical records. Systemic diseases included cardiovascular disorders (e.g., hypertension, ischemic heart disease, arrhythmia, congenital heart disease) and diabetes mellitus. Data regarding patients' smoking habits, lipid profiles (LDL cholesterol and triglycerides), and medication use (e.g., antihypertensives, anticoagulants, antiplatelet agents, lipid-lowering drugs) were not recorded. Information about previous cardiovascular interventions (e.g., bypass surgery, angioplasty, stenting) was also not recorded.

Of the 750 radiographs screened, 599 were included in the study.

A priori power analysis was performed to determine the minimum required sample size for detecting differences in the prevalence of carotid artery calcification (CAC) between age groups. Using a two-tailed comparison of two independent proportions with $\alpha=0.05$ and power=0.80, the required total sample size was estimated to be 312. In addition, when the age groups were analyzed together in a 3×2 contingency table (18-35, 36-60, ≥61 years vs. presence/absence of CAC), the effect size (Cohen's w) was 0.15, and the minimum required total sample size was approximately 443 to achieve 80% power at $\alpha=0.05$. As our study included 599 individuals, the achieved power was sufficient for the planned analyses.

At the cervical C3-C4 level, irregular, heterogeneous, vertically linear, or nodular radiopaque masses were recorded as CAC. In the differential diagnosis, anatomical structures such as thyroid cartilage, hyoid bone, calcified stylohyoid ligament, and epiglottis, as well as calcified lymph nodes, phleboliths, submandibular salivary gland stones, and tonsilloliths were considered.[20]

Statistical Analysis

Data were analyzed using SPSS software (Version 21.0; IBM Corp., Armonk, NY, USA). Descriptive statistics (mean±SD, median, frequency, and percentage) were calculated. Associations between categorical variables were assessed using the chi-square test. For non-normally distributed age data, the Mann-Whitney U test was applied.

To identify independent risk factors for CAC, logistic regression analysis was performed. All results were evaluated at a 95% confidence interval with a significance level set at $p<0.05$.

To assess intraobserver reliability, 100 randomly selected radiographs were re-evaluated by the same examiner after 20 days, and Cohen's kappa coefficient was calculated.

RESULTS

Intraobserver agreement was excellent, with a Cohen's kappa coefficient of 0.97, indicating high reliability in the detection of CAC.

A total of 599 individuals were included in this study. The mean age of the participants was 36.1±13.8 years (range: 18-84), with a median age of 33 years. Of the participants, 74.5% were female (n=446) and 25.5% were male (n=153). A total of 18.4% (n=110) reported a systemic disease, including cardiovascular disease (n=26, 4.3%) and diabetes mellitus (n=20, 3.3%). The cardiovascular disease group comprised heterogeneous conditions, predominantly hypertension, ischemic heart disease, and arrhythmias. Carotid artery calcification (CAC) was detected in 3.2% (n=19) of all participants.

When stratified by age groups, CAC was detected in 3 of 335 patients (0.9%) in the 18-35 age group, 14 of 223 patients (6.3%) in the 36-60 age group, and 2 of 41 patients (4.9%) in those aged 61 years and older. The difference between age groups was statistically significant (p=0.001). No significant association was observed between CAC and sex (female: 3.4% vs. male: 2.6%, p=0.379). Similarly, the presence of systemic disease (p=0.226), cardiovascular disease (p=0.440), or diabetes mellitus (p=0.862) did not show a statistically significant relationship with CAC (Table 1). However, given the limited number of participants with cardiovascular disease (n=26), these findings should be interpreted with caution.

Table 1. Distribution of carotid artery calcification according to age groups, sex, and systemic disease subgroups

Parameter	n (%)	CAC present n (%)	CAC absent n (%)	p-value
Sex				
Female	446 (74.5)	15 (78.9)	431 (74.3)	0.379
Male	153 (25.5)	4 (21.1)	149 (25.7)	
Age groups				
18-35	335 (55.9)	3 (15.8)	332 (57.2)	0.001
36-60	223 (37.2)	14 (73.7)	209 (36.0)	
≥61	41 (6.8)	2 (10.5)	39 (6.7)	
Systemic disease				
Absent	489 (81.6)	13 (68.4)	476 (82.1)	0.226
Present	110 (18.4)	6 (31.6)	104 (17.9)	
Cardiovascular disease				
Absent	573 (95.7)	17 (89.5)	556 (95.9)	0.440
Present	26 (4.3)	2 (10.5)	24 (4.1)	
Diabetes mellitus				
Absent	579 (96.7)	19 (100.0)	560 (96.6)	0.862
Present	20 (3.3)	0 (0.0)	20 (3.4)	

Values are presented as numbers and percentages. Statistical comparisons were performed using the Chi-square test. A p-value of <0.05 was considered statistically significant. CAC: Carotid artery calcification

In logistic regression analysis, age was identified as the only independent risk factor for CAC. Each one-year increase in age was associated with approximately a 4% increase in the likelihood of developing CAC (OR=1.04; 95% CI: 1.01-1.08; p=0.014). Sex (OR=1.53; p=0.402), systemic disease (OR=1.30; p=0.684), cardiovascular disease (OR=1.12; p=0.900), and diabetes (OR=0.00; p=0.993) were not significant independent predictors (Table 2).

Table 2. Logistic regression analysis of risk factors associated with carotid artery calcification

Variable	OR	95% CI (lower-upper)	p-value
Age (years)	1.04	1.01-1.08	0.014**
Sex (male)	1.53	0.56-4.18	0.402
Systemic disease	1.30	0.36-4.67	0.684
Cardiovascular disease	1.12	0.18-7.11	0.900
Diabetes mellitus	0.00	0.00-∞	0.993

Values are presented as OR with 95% CI. Logistic regression analysis was applied to evaluate independent associations between variables and CAC. A p-value of <0.05 was considered statistically significant. Odds ratio, CI: Confidence interval, CAC: Carotid artery calcification

Subgroup analyses revealed that, among participants with systemic disease, the prevalence of CAC was highest in the 36-60 age group (6.7%), but the differences across age groups were not statistically significant (p=0.61). When sex and age were evaluated together, a significant difference in CAC prevalence was observed (p=0.012), with the highest rate detected in men aged ≥61 years (9.1%) compared to women in the same age group (3.3%). In participants with cardiovascular disease, the prevalence of CAC was higher (7.7%) than in those without (3.0%), although the difference was not statistically significant (p=0.440). No cases of CAC were observed among participants with diabetes mellitus (0/20).

Overall, the prevalence of CAC in this population was 3.2%, with age emerging as the strongest independent risk factor. Other variables, including sex, systemic disease, cardiovascular disease, and diabetes, were not significantly associated with CAC.

DISCUSSION

Atherosclerotic cardiovascular diseases encompass a group of conditions that include fatal and nonfatal coronary artery diseases (such as myocardial infarction and angina), ischemic cerebrovascular diseases (stroke), and peripheral arterial diseases. Panoramic radiographs, which are routinely obtained during dental treatment, may be useful in detecting CAC, a known risk factor for stroke.[21] Dentists are able to distinguish CAC from anatomical and pathological structures in the differential diagnosis.[22] Considering the health benefits of early diagnosis and treatment, the prevalence of CAC was evaluated on panoramic radiographs of patients who presented to our clinic for various dental reasons. The early detection of CAC by dentists is regarded as an important step toward reducing the risk of stroke.

In this study, the prevalence of carotid artery calcification (CAC) incidentally detected on panoramic radiographs was 3.2%. Previous studies have reported that the prevalence of CAC varies across populations depending on sample characteristics and diagnostic criteria, but it is generally within the range of 2% to 5%. Higher rates have been observed particularly in older individuals and in those with systemic comorbidities.[23,24] Our findings therefore fall within this expected range, supporting the notion that panoramic radiography can reveal clinically relevant incidental findings and are in agreement with prior studies conducted in dental and general populations.

In a study by Hubar et al.,[25] which evaluated 700 patients, the prevalence of CAC was reported as 0.43%. However, the individuals included in that study were between 14 and 77 years of age, whereas in the present study the age range was 18 to 84 years. The discrepancy between the two studies may be attributed to differences in age distribution and racial background.[25] In a prevalence study conducted among Japanese individuals over the age of 80, the rate of CAC was found to be 5%.[26] Furthermore, when comparing smokers by sex, men were reported to have a higher risk of stroke and to be at greater risk compared to non-smokers.[27] The lack of assessment of lifestyle factors such as smoking and diet in our study should therefore be considered among its limitations.

According to the findings of our study, logistic regression analysis identified age as an independent risk factor for CAC. The increase in CAC prevalence with advancing age has been consistently emphasized in large-sample studies and systematic reviews.[24,28] In particular, individuals over the age of 50 have been reported to demonstrate a markedly higher risk.

In terms of sex, no significant difference was observed in our study. The literature, however, presents conflicting results: some investigations have reported a higher prevalence of CAC in men, while others have highlighted an increased risk among postmenopausal women. For instance, Almog et al.[20] found higher rates in men, although the difference did not reach statistical significance. Conversely, other series have suggested that male sex may act as an independent risk factor.[29] These discrepancies imply that the influence of sex on CAC may vary according to population characteristics and age distribution. Our findings therefore appear to be more consistent with studies that did not identify sex as an independent determinant of CAC.

With respect to systemic conditions, no statistically significant association was found between the presence of CAC and either cardiovascular disease or diabetes. Nevertheless, the prevalence of CAC was relatively higher among patients with cardiovascular disease (7.7%), whereas no cases were identified among diabetic individuals. The literature also presents divergent findings on this issue: while some studies have reported significant associations between CAC and cerebrovascular events, coronary artery disease, diabetes, and hypertension,[30,31] others have failed to confirm such relationships.[31] The absence of significant associations in our study may, at least in part, be attributed to the small sample size within these subgroups. Future studies with larger cohorts and a more balanced distribution of systemic comorbidities are warranted to clarify these relationships.

From a diagnostic perspective, panoramic radiographs, in addition to their widespread use in dentistry, provide the opportunity to incidentally detect clinically significant findings such as CAC. Friedlander and Lande[17] were the first to describe the presence of CAC on panoramic radiographs and suggested that this method could be useful in identifying individuals at increased risk of stroke.[10] Subsequent studies have confirmed that panoramic radiographs possess a certain diagnostic value in detecting CAC, although confirmation by complementary methods-particularly Doppler ultrasonography and, when indicated, cone-beam computed tomography (CBCT)-has been recommended.[32-34] Therefore, when radiographic findings consistent with CAC are observed on panoramic images, referral of patients to the appropriate medical units is of critical importance. This further underscores the potential role of dentists in interdisciplinary prevention strategies aimed at reducing stroke risk.

Limitations

The limitations of this study include its single-center and cross-sectional design, the use of a single observer for image evaluation, and the small number of cases within certain systemic disease subgroups. Additionally, data regarding patients' smoking habits, lipid profiles (LDL, triglycerides), and medication use (e.g., antihypertensives, anticoagulants, and antiplatelet agents) were not recorded. Furthermore, the cardiovascular disease group was heterogeneous, consisting of different conditions such as hypertension, ischemic heart disease, and arrhythmias, which may have influenced the results. These factors, which may influence the presence of CAC, should be addressed in future studies. Another important limitation is the absence of confirmation with Doppler ultrasonography, which is considered the gold standard for CAC assessment. Larger, multicenter, and prospective studies are therefore needed to more reliably elucidate the relationship between CAC detected on panoramic radiographs and clinical outcomes.

CONCLUSION

In this retrospective study, CAC was identified in 3.2% of panoramic radiographs, with prevalence increasing significantly with age. Logistic regression confirmed age as an independent risk factor for CAC, consistent with findings from previous epidemiological studies. Although no statistically significant associations were found with sex or systemic comorbidities, a higher prevalence was observed in patients with cardiovascular disease. Panoramic radiographs, while primarily used for dental purposes, may thus provide valuable information regarding systemic vascular health. The incidental detection of CAC highlights the important role of dentists in interdisciplinary prevention strategies and supports the referral of suspected cases for further medical evaluation to reduce stroke risk.

ETHICAL DECLARATIONS

Ethics Committee Approval

The study was carried out with the permission of the Necmettin Erbakan University Dentistry Non-drug and Non-medical Device Researches Ethics Committee (Date: 31.03.2022, Decision No: 2022/16-120).

Informed Consent

Because the study was designed retrospectively, no written informed consent form was obtained from patients.

Referee Evaluation Process

Externally peer-reviewed.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

Financial Disclosure

The authors declared that this study has received no financial support.

Author Contributions

All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

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