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RESEARCH ARTICLE

DETERMINATION OF THE PREVALENCE OF CAROTID ARTERY CALCIFICATIONS BY EARLY DIAGNOSIS OF ATHEROSCLEROSIS USING PANORAMIC RADIOGRAPHY

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Abstract

Background and aim: Panoramic radiographs are routinely performed in dentistry and are a standard component of the initial dental examination. These radiographs often show carotid arteries (CAT) opacities, which are often the result of calcification in the internal carotid artery (ICA) or external carotid artery (ECA). The aim of this study was to determine the prevalence of carotid artery (CA) calcifications, using panoramic radiographs, and determine factors associated with carotid artery calcifications.

Materials and Methods: The study was based on 1823 digital panoramic radiographs retrieved consecutively from archival records. All radiographs were taken between 2022 and 2024 from our clinics at the Faculty of Dentistry, Sana'a University, Sana'a City, Yemen and private clinics in Sana'a city. The digital radiographs of 1823 patients with dental problems were originally taken for routine examination and not for investigation of dental diseases. All panoramic radiographs were then interpreted by both observers. Each observer interpreted each panoramic image individually, followed by discussion of each film between the observers. The diagnosis of carotid calcifications was made when the two observers agreed.

Results: There were 639 males and 1184 women in the trial, and all of the patients were older than 34.The prevalence of carotid artery calcification was 6.4% for total in males was 9.2% and 4.8% in females, with a significant association between male sex and the presence of calcification (OR=2.03, $p<0.0001$). Older age groups <65 years and those 55-64 years had a 3.2 and 2.5 times higher odds ratio of carotid calcification respectively, while younger age groups had no association. The study found that 42.2% of patients had plaque in the ICA bulb, 39.7% in bifurcations, and 18.1% in distal location. Mixed iso and hypodense plaque were prevalent, with low grade stenosis being the most common.

Conclusion: Based on the information provided here, we believe it is critical to look more thoroughly at the calcification in the (CAT) carotid arteries of the many panoramic radiographs that are obtained every day in Yemen before sending any patients who may be impacted to a specialist for additional diagnosis.

Keywords: Atherosclerosis, carotid calcifications, early diagnosis, panoramic radiographs, stenosis, Yemen.

INTRODUCTION

In developed nations, strokes and other cerebrovascular events rank as the third leading cause of mortality. The development of calcium-rich fatty plaques on artery walls and their ramifications, which can be localized or diffuse and contribute to the hardening and narrowing of the arteries, along with the buildup of fat in the

artery walls, known as atheroma, is the pathology known as atherosclerosis, which is associated with strokes[1]. Both sexes are affected, and they are often detected radiographically in people over 50[2]. Because carotid artery disease is directly linked to the narrowing or blockage of the arteries in the neck (carotid arteries), which transport blood from the aorta to the brain, it can result in cerebrovascular and encephalic accidents, sometimes referred to as strokes or cerebral ischemia[3]. Traditional risk factors including high blood pressure, diabetes, high cholesterol, smoking, and obesity are often linked to the condition, which only manifests symptoms when blood arteries are nearly totally clogged[4].

X-rays are an important tool in the diagnosis of infection[5,6]. Panoramic radiography has evolved from this. It is a panoramic dental x-ray of the maxilla and mandible. It shows a two-dimensional view of a semicircle from ear to ear. Panoramic radiography is a form of focal plane computed tomography; therefore, images are taken from multiple planes to form a composite panoramic image, with the maxilla and mandible in the focal pelvis and the superficial and deep pelvic structures obscured. Healthcare professionals use orthodontic panoramic radiographs (OPTs) to provide information on the diagnosis of impacted wisdom teeth[7,8], estimation of dental age[9], dental caries[10], root caries[11], and treatment planning. The most common uses are to determine the condition of wisdom teeth and jaw trauma[12], bone loss and periodontal fractures, assessment of dental implant placement, and orthodontic evaluation[13]. Pre- and post-operatively[14], diagnosis of developmental anomalies such as kyphoscoliosis, cranio-clavicular dysplasia[9,10, 15,16], cancer related to the jaws[17-19] and diagnosis, pre- and post-operative evaluation of oral and maxillofacial trauma, e.g., alveolar fractures and mandibular fractures[12].

Panoramic radiographs are taken as standard radiographs during initial dental examinations. Every year, approximately 200,000–300,000 of these panoramic radiographs are taken in Yemen. Given the high expense of patient rehabilitation, atherosclerosis is a major public health concern due to its chronic inflammatory features, which can result in mortality and disability[20]. Angiography is regarded as the "gold standard" among the several techniques for diagnosing atherosclerotic disease[21]. But since 1981, certain radiopaque pictures from panoramic dental X-rays have been identified as an indication that calcified carotid atheroma plaques are present[22]. Using an extra-oral approach in which the X-ray equipment revolves around the subject to get a virtual picture, panoramic radiography produces images of the middle third of the face[23].

This approach permits assessment of both dental arches and the adjacent structures in a single X-ray. Together with the clinical examination, they are regarded as the preferred diagnostic test due to their usefulness and thoroughness[24]. On a panoramic radiograph, atheros-clerosis of the carotid artery (ACA) can be seen as a diffuse bilateral radiopaque picture that extends from the area of the ramus and angle of the mandible to the base of the neck in asymptomatic persons who are at risk of stroke[20]. For this reason, this test is crucial to the early identification of ACA[25]. The right expert can begin treating atherosclerosis when ACA is detected. The goal is to repair or mitigate acute or chronic ischemic lesions in order to prevent major symptoms and maintain the patient's quality of life[26]. Using panoramic radiography, Friedlander evaluated 94 individuals (mean age 65.6 years) in 2006 for the existence of atheromatous plaques; in 50% of these individuals, atheromatous plaques were discovered in the carotid arteries[27]. The hidden metabolic syndrome, which includes atheroma plaques, high blood pressure, insulin resistance, decreased HDL levels, raised triglycerides, and abdominal obesity, was present in this subgroup[27].

After ascending through the mid-cervical region, the common carotid artery splits into the external and internal carotid arteries[28]. This bifurcation varies slightly in location and can occasionally occur so far below the typical level that a panoramic radiograph can no longer show it[29]. Therefore, if this kind of imaging test is used on such individuals, a stroke risk may go unnoticed. However, by carefully observing and differentiating structures in the area between cervical vertebrae C3 and C4, it is possible to use panoramic radiographs to identify atherosclerosis in the carotid arteries, allowing for treatment anticipation and a reduction in patient morbidity and mortality[30]. Only calcifications seen on panoramic radiographs in the central coronary artery region were included among the structures examined in this study. In order to ascertain whether carotid artery calcifications could be identified as a secondary finding on panoramic radiographs and whether the suspicion of such calcifications could be verified by ultrasound evaluation of the neck vessels.

MATERIALS AND METHODS

Population: The study was based on 1823 digital panoramic radiographs retrieved consecutively from archival records. All radiographs were taken between 2022 and 2024 from our clinics at the Faculty of Dentistry, Sana'a University, Sana'a City, Yemen and private clinics in Sana'a city. The digital radiographs of 1823 patients with dental problems were originally taken for routine examination and not for investigation of dental diseases.

Exclusion criteria: Radiographs with questionable errors in the hyoid bone complex, errors in positioning and magnification, and with superimposed normal anatomical structures were excluded from the study.

Inclusion criteria: The selected X-rays were of patients over 34 years of age. To obtain the percentages of different age groups, the subjects were divided into subgroups 35-44, 45-54, 55-64, and ≥ 65 years.

Presence of carotid artery calcification: All panoramic radiographs were taken using a Proline XC (Planmeca Oy, Helsinki, Finland) with a digital sensor. The radiographs were then examined by two radiologists for the presence of carotid calcifications as heterogeneous radiographic opacities in a linear vertical direction adjacent to the hyoid bone, epiglottis

and cervical vertebrae either above or below the C3-C4 inter space. All panoramic radiographs were then interpreted by both observers. Each observer interpreted each panoramic image individually, followed by discussion of each film between the observers. The diagnosis of carotid calcifications was made when the two observers agreed.

Data analysis: Data were described using appropriate descriptive statistics. Data analysis was performed using EPI-Info version 7. Data were described in numbers and percentages. The significance threshold was fixed at 5% level. When *p*-value ≤ 0.05, results were considered significant. The association of carotid calcifications for different sexes and age groups was calculated by determining the odds ratio (OR).

Ethical approval: Ethical approval was obtained from the Medical Ethics Committee of the Faculty of Dentistry, Sana'a University, reference number 24/2024, dated June 21, 2024, and all data, including the patient's identity, were kept confidential.

RESULTS

Table 1 shows the demographics of Yemenis by age and gender that underwent screening for carotid calcifications in Sana'a City, Yemen. There are just 639 (35.1%) men and 1184 (64.9%) women. Every patient was an adult above the age of thirty-four. 588 (32.3%) of the population was in the 35–45 age group, followed by 621 (34.1%) in the 45–54 age group, 463 (25.4%) in the 55–64 age group, and 151 (8.3%) in the > 65 age group. The crude prevalence of carotid artery calcifications as heterogeneous radiographic opacities was 6.4%; males 9.2% and females 4.8%. There was a significant association between male sex and the presence of carotid artery calcifications with an odds ratio (*OR*) of 2.03, with a 95% confidence interval (*CI*) of 1.4–2.9, with a significant X^2 value of 14.1, *p*-value of 0.0001. In females, there was no association with the presence of carotid artery calcifications (*OR*=0.4, CI=0.3–0.71, X^2=14.1, *p*-value of 0.0001). When looking at age, there was a significant association between older age groups <65 years and the presence of carotid calcifications with an *OR* of 3.2 times, with a 95% *CI* of 2.0–5.3, with a significant X^2 of 25.1 and a *p*-value of <0.0001.

Table 1: Gender and age distributions of Yemenis screened for carotid artery calcifications.

Variables	N (%)
Sex	
Male	639 (35.1)
Female	1184 (64.9)
Age groups	
35-44 years	588 (32.3)
45-54 years	621 (34.1)
55-64 years	463 (25.4)
≥ 65 years	151 (8.3)
Total	1823 (100)

Also, there was a significant association between age group 55–64 years and the presence of carotid calcifications with an *OR* of 2.5 times, with a 95% *CI* of 1.7–3.6, with a significant X^2 of 22.5 and a *p*-value of <0.0001 (Table 2). However, there was no association between younger age groups and the presence of carotid calcifications (Table 2). Table 3 shows the location, morphology, and degree of stenosis among Yemeni patients with carotid artery calcifications in Sana'a city, Yemen. Considering the location of the plaque, 42.2% of patients had plaque in the internal carotid artery bulb (ICA bulb), followed by bifurcations at 39.7%, while distal location constituted only 18.1% of the total. Considering the morphology of the plaque, 53.4% of patients had mixed dense plaque, followed by hyper-dense plaque (28.4%), while hypo-dense plaque constituted only 18.1% of the total. Considering the degree of stenosis, low grade was the most common at 59.5%, followed by intermediate (24.1%), while high grade of stenosis constituted only 6.4% of the total.

Table 2: Prevalence and association of carotid artery calcifications in different genders and age groups.

Variables	Positive CC N (%)	OR	95% CI	X^2	*p*
Sex					
Male n=639	59 (9.2)	2.03	1.4-2.9	14.1	0.0001
Female n=1184	57(4.8)	0.4	0.3-0.71	14.1	0.0001
Age groups					
35-44 years n=588	6 (1.02)	0.1	0.04-0.24	41.5	<0.0001
45-54 years n=621	35 (5.6)	0.8	0.5-1.2	0.8	0.36
55-64 years n=463	51 (11.0)	2.5	1.7-3.6	22.5	<0.0001
< 65 years n=151	24 (15.9)	3.2	2.0-5.3	25.1	<0.0001
Total, n=1823	116 (6.4)				

DISCUSSION

In the current study the crude prevalence of carotid artery calcifications (atherosclerosis) was 6.4%; males 9.2% and females 4.8%. Atherosclerosis is one of the primary causes of death in Yemen and worldwide[31]. Atherosclerosis is is a chronic inflammatory illness of multifactorial origin, in which there is deposition of fat, cholesterol, and other substances on the artery walls, reducing blood flow and causing many different health issues[32]. Factors that lead to the onset of artery disease include: excessive cholesterol, diabetes, obesity, smoking, family history of heart disease, physical inactivity, chronic kidney disease, and others[33]. The development of atherosclerosis is characterized by large accumulations of fatty and fibrous tissue, calcium deposits, blood, blood products, and other substances in the arteries[34]. After endothelial injury and tissue

healing, plaque development can occur[35] by generating endothelial dysfunction and facilitating the entry of monocytes, and altered proteins such as oxidized LDL, which may increase endothelial risk factors, leading to the formation of foam cells[36,] and the process may be prolonged and plaques are formed by the release of inflammatory mediators[37]. Cerebrovascular accidents (stroke), are a leading cause of death and disability worldwide[38,39]. They are characterized by blood leakage into brain tissue[40], which results in interruption of blood flow, and also lead to functional and structural changes in the affected area, creating a complex "ischemic cascade", the ultimate result of which is neuronal death[41]. The diagnosis of the disease is based on the patient's clinical condition in conjunction with the neurological examination[42].

Table 3: Plaque location, morphology, and degree of carotid artery stenosis in Yemeni patients with carotid artery calcifications.

Variables	N (%)
Location of the plaque	
Distal	21(18.1)
Bifurcation	46 (39.7)
Internal carotid artery bulb (ICA bulb)	49 (42.2)
***Morphology (type of plaque)**	
Hyper-dense	33 (28.4)
Hypo-dense	21 (18.1)
Mixed dense	62 (53.4)
Degree of stenosis	
Low grade	69 (59.5)
Intermidiate	38 (24.1)
High grade	9 (7.8)
Total, n=1823	116 (6.4)

*colors on image

In the present study, there was a significant association between older age groups <65 years and the presence of carotid calcifications with an *OR* of 3.2 times, with a 95% *CI* of 2.0–5.3, with a significant X^2 of 25.1 and a *p*-value of <0.0001. Also, there was a significant association between age group 55–64 years and the presence of carotid calcifications with an *OR* of 2.5 times, with a 95% *CI* of 1.7–3.6, with a significant X^2 of 22.5 and a *p*-value of <0.0001. However, there was no association between younger age groups and the presence of carotid calcifications (Table 2). The current findings are consistent with those that have been published previously, where the oldest patient groups were those with stenoses[43,44]. Additionally, Almog *et al.*[45], discovered that older patients (those over 55) had greater percentages of CA calcifications. According to Mahler *et al.*[46], the prevalence of carotid stenoses rises with age.

In the current study the crude prevalence of carotid artery calcifications as heterogeneous radiographic opacities was 6.4%; with higher males prevalence (9.2%) comparing to females lower rate (4.8%). Also, there was a highly significant association between male sex and the presence of carotid artery calcifications with an odds ratio (*OR*) of 2.03, with a 95% confidence interval (*CI*) of 1.4–2.9. In females, there was no association with the presence of carotid artery calcifications (*OR*=0.4, *CI*=0.3–0.71, X^2=14.1, *p*-value of 0.0001. Our findings are comparable to those published by Baumann-BhallaIn *et al.*[44], in Switzerland and Borba *et al.*[47], in Brazil. Nonetheless, Fatahzadeh *et al.*, highlighted risks that cannot be changed, including advanced age, male gender, ethnicity, and genetic susceptibility to carotid artery calcifications[48].

In current study, panoramic X-rays was used to diagnose CA, and some errors may occur. Therefore, CA calcifications detected on panoramic X-rays should be distinguished from other radiological opacities which, due to their topographic proximity to the CA, can also be prominent in this region of the X-ray. Kamikawa *et al.*[49], found that in a significant proportion of patients, tricuspid cartilage calcification was incorrectly identified as carotid CA calcification. Likewise, Pornprasertsuk-Damrongsri & Thanakun[50] also drew attention to the confusion between calcified tricuspid cartilage, thyroid cartilage, hyoid bone, and calcified lymph nodes and CA calcifications. In 18 of the recalled patients, suspected CA calcification was not confirmed on the new panoramic radiograph. Either the calcification could no longer be detected radiographically on the second image or it could be differentially excluded diagnostically based on its location or shape. One of the advantages of digital X-rays is that after they are taken, they can be manipulated and the contrast improved. This capability greatly facilitates the recognition of potential calcifications, because areas of interest can be better visualized. In particular, the lateral areas of panoramic CT X-rays, which are often very dark, can be modified on the screen.

When it comes to the early and symptomatic identification of carotid atherosclerosis, panoramic radiographs are crucial. The dental surgeon's responsibility is to identify atherosclerosis in panoramic radiographs, counsel patients to confirm the condition with additional testing techniques, and recommend them to the right medical specialist for the right care. This is to guarantee the patients' well-being and quality of life. It is projected that Yemen's stroke death rate would double by 2030 as a result of the country's increasing elderly population. Preventing cerebrovascular accidents is therefore becoming more and more crucial. Finding cost-effective strategies that can help lower stroke-related morbidity and death in

Yemen both now and in the future is crucial for both medical and financial reasons.

Limitation of the study

The information contained in this study did not address the extent to which dentists are familiar with and capable of reading panoramic dental and jaw radiographs, nor whether they are aware of or interested in assessing the patient's general condition. Therefore, this should have been included in this study.

CONCLUSIONS

Based on the information provided here, we believe it is critical to look more thoroughly at the calcification in the CAT of the many panoramic radiographs that are obtained every day in Yemen before sending any patients who may be impacted to a specialist for additional diagnosis. In addition to examining the teeth and jaws, dentists should focus more on the lateral regions of panoramic radiographs, particularly in patients who are older than 34 or who have risk factors. Early detection of calcifications in the panoramic radiograph can help avoid cerebrovascular accidents in this way.

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AUTHOR'S CONTRIBUTIONS

Al-Mutahar AMY: writing the original draft, methodology. **Al-Shamahy HA:** methodology, investigation. **Al-Moyed KA:** conceptualization**,** writing, review. **AL-Haddad KA:** editing. **Al-Shamahi EH:** conceptualization**,** writing. **Al-Hababi NM:** writing review and editing. **Al-Abdaly GM:** conceptualization**,** writing. **Al-dossary OAI:** review, editing. Final manuscript was checked and approved by all authors.

DATA AVAILABILITY

The accompanying author can provide the empirical data that were utilized to support the study's conclusions upon request.

CONFLICT OF INTEREST

There are no conflicts of interest in regard to this project.

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