ORIGINAL ARTICLE

Use of digital panoramic radiography to detect cervical calcifications in obese individuals

Saulo Gonçalves de Abreu [1]
Natália Myrrha Simões [2]
Ana Paula Zanini [3]
Marcelo Gomes Girundi [4]
Amaro Ilidio Vespasiano Silva [5]
Flavio Ricardo Manzi [5]

[1] Department of Oral Diagnostic, School of Dentista (FEAD); Belo Horizonte - MG - Brazil
[2] Department of Dental Clinics, School of Dentista; Pontifical Catholic University, Belo Horizonte - Minas Gerais - Brazil
[3] Department of Endocrinology and metabolism; Medicine School, IPEMED, Belo Horizonte - MG - Brazil
[4] Department of Surgery, Medicine School, Faculdade de Ciências Médicas de Minas Gerais; Belo Horizonte - MG - Brazil
[5] Department of Oral Diagnosis, School of Dentistry; Pontifical Catholic University; Belo Horizonte - MG - Brazil

Correspondence to:
Natália Myrrha Simões.
E-mail: natimyrrha@hotmail.com

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Abstract:

Introduction: Cardiovascular diseases and stroke in particular are the leading causes of death worldwide. The most common reason for this interruption is a buildup of fatty deposits on the inner walls of blood vessels; upon calcification, these deposits are termed atheromas. **Objective:** The aim of this study was to identify calcified atherosclerotic plaque-like soft tissue calcifications in obese subjects using panoramic radiography. **Materials and Methods:** Sixty-three obese patients undergoing digital panoramic radiography in a radiology clinic in Belo Horizonte, Brazil, were selected and diagnosed with grade II obesity with comorbidities and grade III obesity according to the World Health Organization (WHO) body mass index (BMI) score table. The radiographs were examined by two trained oral and maxillofacial radiologists, and their evaluations were analyzed using the kappa test. Statistical analysis was performed using the X2 test, and the odds ratio was determined with a 95% confidence interval. A 5% significance level was used. **Results:** The weight and BMI ($p < 0.01$) differed significantly between individuals in the grade II with comorbidities and grade III groups, but no difference was observed for age and height. Of 63 radiographs, 45 (71.42%) showed calcifications in the cervical region, with no statistically significant difference between the grade II and grade III groups. Neither gender nor side was significantly correlated with the presence of soft tissue calcification. **Conclusion:** This study demonstrates the importance of panoramic radiography in identifying calcified atheromatous plaques. Such images may have critical diagnostic value for the early detection of carotid artery atheromas in obese subjects and thus may contribute to an increase in the length and quality of life of such individuals.

Keywords: Obesity; Carotid Artery Diseases; Radiography, Panoramic; Atherosclerosis.

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INTRODUCTION

Cardiovascular diseases and stroke in particular are the leading causes of death worldwide[1]. A high body mass index (BMI) is a major risk factor for cardiovascular disease, and obesity, hypertension, hyperlipidemia and increased glucose may partially mediate its effects[1] .Studies have investigated the mediating effects of BMI on coronary heart disease in conjunction with a combination of blood pressure, cholesterol and diabetes; however, few studies have been conducted on its effects on stroke.

A stroke is usually an acute event that is caused by the interruption of the blood supply to the brain. There are two forms of stroke: after the rupture of a blood vessel (hemorrhagic stroke) or after the blockage caused by a clot (ischemic stroke). These events interrupt the supply of oxygen and nutrients to the brain, causing damage to brain tissue.

The most common reason for this interruption is a buildup of fatty deposits on the inner walls of blood vessels; upon calcification, these deposits are termed atheromas. Heart attacks and strokes (which in 2012 were the leading cause of death) generally occur when multiple risk factors, such as tobacco use, unhealthy diet, physical inactivity, harmful alcohol use, hypertension, diabetes, hyperlipidemia, and obesity, are present[2].

Overweight and obesity are defined as abnormal or excessive accumulation of fat that presents a health risk. According to the World Health Organization (WHO), obesity has reached epidemic proportions in the world and is a major contributor to the global rate of chronic diseases and disability. BMI is calculated by dividing the weight (in kilograms) by the squared height (in meters). A person with a BMI of 30 or higher is generally considered obese. A person with a BMI of 25 or higher is considered overweight, and the risk of the associated noncommunicable systemic diseases increases proportionally to BMI[3].

Although the relationship between atheroma and obesity has not yet been clarified, several studies have shown that a higher BMI is a risk factor for ischemic stroke[4]. In a prospective study of 22,000 participants, Kurth *et al.*[5] concluded that overweight and obesity increase the risk of stroke. This risk seemed to be independent of potential biological factors, such as hypertension, diabetes, and cholesterol levels.

Obesity prevention should help decrease the risk of stroke. The presence of an atheromatous plaque in the carotid artery of clinically asymptomatic patients is often associated with the subsequent development of clinically evident cerebrovascular disease, stroke, coronary artery disease (angina and myocardial infarction), and death[6].

Atherosclerosis is a progressive process, and early diagnosis is crucial. Unfortunately, the first clinical manifestation of carotid artery atheroma (CAC) typically occurs after the stroke, when treatment is too late. However, CACs can be detected early. Panoramic radiography, which is performed during dental checkups, is a potential method for early detection. CAC detection could provide information that saves lives.

A further diagnostic examination should be recommended whenever CACs are detected in a panoramic radiograph. Early CAC detection is also economically relevant. The cost of treatment for atherosclerosis is lower than the cost to treat the subsequent effects[7].Studies indicate that a panoramic radiograph can be highly suggestive of the presence of a carotid atheromatous plaque, which is an especially important finding for asymptomatic patients[8].

Patients with an atheroma that is detectable in a panoramic radiograph (PR) are more likely to suffer cerebrovascular events. Therefore, patients with calcified carotid plaques that are detectable on PRs should consult their physician for a more in-depth evaluation[8].

The discovery of atherosclerotic calcifications in the internal carotid artery has important implications because atherosclerosis is a progressive process and can lead to transient ischemic attacks or stroke[9]. The objective of this study was therefore to verify the presence of calcified carotid plaque-like soft tissue calcifications using a digital panoramic radiograph (DPR) in patients with either grade II obesity with comorbidities or grade III obesity to identify asymptomatic individuals who are at risk of stroke.

MATERIALS AND METHODS

This study was approved by the Ethics Committee of the Pontifical Catholic University of Minas Gerais (Pontifícia Universidade Católica de Minas Gerais). This prevalence, prospective and cross-sectional study was conducted to evaluate the presence of atheroma-like radiopacity in obese patients. The Table 1 and Table 2 were made using Microsoft Excel version 2013 15.0.4805.1003.

Subjects

The subjects were 63 obese patients, who were classified according to the WHO BMI classification table[3] (normal patients - BMI from 18.5 to 24.9; overweight patients - BMI from 25.0 to 29.9; patients with grade I obesity - BMI 30.0 to 34.9; patients with grade II obesity - BMI 35.0 to 39.9; and patients with grade III obesity - BMI greater than 40).

The subjects were patients of both genders who visited a dental radiology clinic in Belo Horizonte, Brazil, to undergo routine panoramic radiography, as indicated by a dentist. These patients completed a general health questionnaire. Information from this questionnaire, such as gender, age, weight, height, BMI and comorbidities (e.g., cardiovascular disease, diabetes, hepatitis B and C, hypertension) was placed in a Microsoft Excel worksheet. Patients who were classified with grade II obesity with comorbidities or grade III obesity were thereby selected to take part of the study.

The inclusion criteria were morbid or severe obesity with comorbidities, a dental evaluation, an age between 16 and 60 years, a mass corresponding to being at least 45 kg overweight, a BMI of 40 or higher (grade III) or a BMI from 35 to 39.9 (grade II) but with obesity-related health problems (comorbidities), and the signing of an informed consent form.

Patients who did not consent to participate in the study or refused to complete the questionnaire, those with destructive lesions in the jaw, those who had undergone previous surgery of the jaw or evaluated regions, those who had a previous fracture in the evaluated region, and those with prior reports of stroke were excluded from the study.

Acquisition and analysis of digital panoramic radiographs

Digital panoramic radiographs (DPRs) of all patients were obtained using a KODAK 9000C 3D® device (Eastman Kodak Company, Rochester, New York, USA) at 140 kHz, 60-90 kV, 2-15 mA. All evaluated panoramic radiographs had to show the soft tissue region of the neck, including the C3 and C4 vertebrae.

The Friedlander and Friedlander criteria were used[10] to diagnose the likely presence of atheroma, which was defined as the appearance of radiopaque masses adjacent to the cervical vertebrae at or below the intervertebral space between C3 and C4 on the panoramic radiograph (Figure 1).

Figure 1. Panoramic radiograph showing a circumscribed radiopaque image of the soft tissue region of the left side of the neck adjacent to the C3 and C4 intervertebral space (indicated by the arrow).

The radiographs were examined by two oral and maxillofacial radiologists who were trained on these criteria, and their evaluations were analyzed using the kappa test. Each observer initially interpreted each panoramic radiograph individually, and after a discussion of each radiograph, the two observers agreed on a diagnosis. For each patient, a separate evaluation was conducted on each side, i.e., the cervical region was evaluated on the right and left sides. Patients who had results indicative of CAC were contacted by telephone for subsequent referral to a neurologist or angiologist.

Statistical analyses

Statistical analysis was performed using the X^2 test, and the odds ratio was determined with a 95% confidence interval. A 5% significance level was used.

RESULTS

Of the 63 obese patients who participated in this study, 42 (66.67%) were female, and 21 (33.33%) were male. Thirty-three patients (52.38%) were classified with grade II with comorbidities, and 30 (47.62%) were classified with grade III. The weight and BMI ($p < 0.01$) differed significantly between individuals in the grade II with comorbidities group and the grade III group, but no difference was observed for age and height (Table 1). The kappa test was used to analyze inter- and intra-examiner variations in diagnosing the likely presence of atheroma, with results of k=0.92 and k=0.88, respectively, demonstrating a significant level of agreement. The patients's demographics as such age, gender, weight, height and BMI are present in Table 1.

Table 1. Subject characteristics.

Obesity diagnosis based on WHO classification	Grade II with comorbidities	Grade III	TOTAL
Subject characteristics Total individuals	n=33 (52.38%)	n=30 (47.62%)	63 (100%)
Female	n=24 (38.10%)	n=18 (28.57%)	42 (66.67%)
Male	n=9 (14.29%)	n=12 (19.04%)	21 (33.33%)
Age (years)	45 (±8.65)	41.75 (±10.37)	43.55 (±9.31)
Weight (kg)*	97.28 (±5.79)	126.42 (±11.00)	111.16 (±17.13)
Height (cm)	161.72 (±6.25)	159.6 (±21.38)	160.71 (±15.05)
BMI*	37.26 (±1.66)	45.58 (±5.51)	41.22 (±5.76)

Number of subjects (n) with the percentage (%) and mean values with the standard deviation.
* indicates a statistically significant difference between evaluated groups according to the t-test (p<0.01).

Of the 63 radiographs taken, 45 showed calcifications in the cervical region (71.42%), with 19 occurring bilaterally (30.15%). There was also a rather even distribution between the right and left sides. Neither gender nor side showed a significant correlation with the presence of soft tissue calcifications (Table 2).

Table 2. Statistical evaluation of the correlation of gender and side with the presence of cervical region calcifications in obese individuals

	Presence of cervical region calcifications				
Variable	Yes n (%)	No n (%)	Total n (%)	OR (95% CI)	P
Gender					
Male	13 (28.89%)	8 (44.44%)	21 (33.33%)	0.50	p=0.37*
Female	32 (71.11%)	10 (55.56%)	42 (66.67%)	0.16 – 1.57	
Side					
Unilateral	28 (59.57%)	35 (44.30%)	63 (50%)	1.85	p=0.14*
Bilateral	19 (40.43%)	44 (55.70%)	63 (50%)	0.89 – 3.85	
Right	33 (52.38%)	30 (47.62%)	63 (50%)	1.21	p=0.72*
Left	30 (47.62%)	33 (52.38%)	63 (50%)	0.60 – 2.42	

* Chi-squared test
OR - Odds ratio; 95% CI - confidence interval of 95%; NA - Not applicable

The likelihood of finding cervical region calcifications in a panoramic radiograph was the same for both genders (odds ratio [OR], 0.50; 95% confidence interval [CI], 0.16 to 1.57, p=0.37), and the likelihood of finding cervical region calcifications in a panoramic radiograph was the same for the unilateral and bilateral presentations (OR, 1.85; 95% CI, 0.89 to 3.55; p=0.14) and for the right and left sides (OR, 1.21; 95% CI, 0.60 to 2.42; p=0.14).

Comparison between the two groups of obese individuals (according to the WHO BMI classification) regarding the presence of cervical region calcifications revealed that the incidence of these calcifications was higher in the grade II with comorbidities group. However, there was no statistically significant difference between this group and the grade III group ($p > 0.05$, Table 3). The likelihood of finding cervical region calcifications using panoramic radiography was the same for both groups (OR, 1.46; 95% CI, 0.72-2.96; p=0.37).

Table 3. Statistical evaluation of the BMI variable (WHO group classification) with the presence of cervical region calcifications in obese individuals

	Presence of cervical region calcifications				
Variable	Yes n (%)	No n (%)	Total sides (%)	OR (95%)	P
WHO Classification					
Grade II + Comorbidities	36 (57.14%)	30 (47.62%)	66 (52.38%)	1.46	p=0.37*
Grade III	27 (42.86%)	33 (52.38%)	60 (47.62%)	0.72 - 2.96	

*Not significant

DISCUSSION

In this prospective cross-sectional study, higher grades of obesity were associated with CAC-like soft tissue calcifications, which were observed using DPR. CACs are the third leading cause of death worldwide[11]. Previous studies reported that carotid artery calcifications are a marker of advanced atherosclerotic disease and a predictor of adverse cardiovascular events. Dentists are in a unique position because they can perform a non-invasive test, such as DPR, and may thereby contribute to the reduction of mortality from stroke.

Radiographically, carotid artery atheromatous plaques may be classified as calcified and non-calcified carotid plaques. The former can be observed on a panoramic radiograph, ultrasound scan and CT scan, whereas the latter cannot be detected by panoramic radiography[12]. Obesity may make it difficult to obtain ultrasound images of carotid artery calcifications, especially in distal portions and at the carotid bifurcation[13]. Thus, further investigations to differentiate calcified carotid plaques from non-calcified carotid plaques in ultrasound exams and DPR are important.

The results show no statistically significant difference in the distribution of height, gender and age, indicating homogeneity for these parameters. In a study of 2,568 subjects with a mean age of 62.2 years, Tamura *et al.*[14] found a significant difference between genders, with a 3:1 ratio of women to men. They also found that 80.2% of calcifications were observed on the left side. These findings may suggest methodological differences regarding the observed side, or the type of the patient, i.e., as the obesity grade increases, gender may no longer be a determining factor. There was a significant difference ($p<0.01$) regarding weight and BMI, which can be explained by the fact that the only inclusion criteria were appropriate WHO BMI classification levels[3].

This study found that the DPRs captured a high prevalence of CAC-like calcifications. A likely reason for this finding was the type of patient included in the study, i.e., obese patients. Several studies have demonstrated that obesity is one of the most important risk factors for atherosclerotic plaque formation[4,6,7,10,15,16].

There are several risk factors for the development of atheroma: advanced age, which is associated with the loss of endothelial integrity caused by aging-related physiological changes (loss of repair ability); male gender; high cholesterol levels; high blood pressure; obesity; diabetes mellitus; smoking; history of transient ischemia or stroke; high level of triglycerides; alcohol abuse; and a sedentary life style[4,6,8,10,12,15,17,18].

Some authors have suggested that at least five risk factors are needed for the development of atheroma and that obesity is almost always present[10,16].

The radiographic appearance of CACs can be similar to that of other soft tissue calcifications near the C3 and C4 vertebrae. In this case, some radiopaque anatomical structures, such as the hyoid bone, epiglottis, and stylomandibular and stylohyoid ligaments, and soft tissue calcifications, such as calcified thyroid cartilage, sialoliths, tonsilloliths, and phleboliths, are easily identified; however, calcified triticeous cartilage and calcified lymph nodes may be mistakenly diagnosed as CACs[7,17,19].

This obstacle can be overcome using the modified Towne AP radiographic technique as a method to help differentiate between those conditions. Some authors state that positive findings for calcifications in the C3 and C4 region are highly suggestive of carotid artery atherosclerotic occlusive disease, despite the low sensitivity and specificity[8,20].

In a prospective cohort study of 21,414 subjects who were monitored by U.S. physicians for 12.5 years, there was a significant increase in the relative risk of total stroke and its major subtypes (ischemic and hemorrhagic) irrespective of potential biological factors, such as hypertension, diabetes, and cholesterol[5]. Despite the satisfactory sample size, that study had limitations with regard to gender and race (only physicians who were male and predominantly white were selected), and obesity data were collected using self-reports and medical records.

Another noteworthy finding of this study is that although there was a higher incidence of calcifications in the grade II with comorbidities group than in the grade III group, the difference was not statistically significant. The comorbidities presented by the grade II individuals are co-factors for predicting future stroke events.

However, recent reports have highlighted the "obesity paradox", which is the observation that patients with a high BMI tend to have better cardiovascular conditions than patients with low BMIs, with obesity functioning more as a protective factor than as a risk factor[21-24]. Hypotheses for this paradox are being evaluated. Pacchioni *et al.*[23] found a significant relationship between BMI and the qualitative characteristics of atherosclerotic plaques, leading to speculation that BMI can affect the balance between pro- and anti-inflammatory activities, which are directly involved in the stability of plaques. Another study suggested that obese patients are treated sooner and suffer strokes at younger ages, making age a beneficial factor[25]. Finally, Morse *et al.*[22] reported that obese patients have many TNF-α receptors in their fat deposits, which may cause a reduction in circulation, thereby reducing atherogenic activity in vascular diseases.

Previous studies have shown that patients with CACs should undergo ultrasound screening to detect carotid artery stenosis. Johansson *et al.*[26] suggested a risk factor evaluation for patients with CACs, who many unknowingly have other coadjuvant factors. The incidental finding of carotid artery calcifications on panoramic radiographs is a powerful marker for future cerebrovascular and cardiovascular events and death[5]. Because BMI is a modifiable risk factor, stroke prevention may be another benefit associated with the prevention of obesity.

CONCLUSIONS

In conclusion, this study demonstrates the importance of panoramic radiography in identifying calcified atheromatous plaques. Such images may have critical diagnostic value in the early detection of CACs in obese subjects and thus might contribute to an increase in the length and quality of life of such individuals.

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