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Review Article

Detection of common carotid artery calcifications on panoramic radiographs: prevalence and reliability

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Abstract: The aim of this study was to determine the prevalence of common carotid artery calcifications (CCAC) detected by panoramic radiographs (PR) in the population and main risk factors with review of the literature. Furthermore, the reliability of PR was verified to detect these calcifications. CCAC detected on PR was powerful markers for future cardiovascular or cerebrovascular events. We found that the prevalence of CCAC identified by PR may range from 0.43% to 9.4%, depending on the age and lifestyle of the population studied. In individuals with systemic diseases the prevalence was higher than in the general population, reaching up to 38.8%. The radiopaque masses compatible with CCAC identified by PR were more common in women and occurred unilaterally or both sides, without preference for one or the other. According to the literature reviewed PR had low sensitivity and acceptable accuracy for detecting CCAC. We conclude that calcified atheroma in the common carotid artery can be demonstrated in PR, and this is an important tool for early detection of CCAC. However, it is always necessary to refer the patient to a cardiology service to confirm the findings, determine the real extent of the disease and establish its corresponding treatment.

Keywords: Calcification, common carotid artery, panoramic radiography, atheroma

Introduction

Atherosclerosis is a disease of the arteries characterized by the deposition of fatty material on its wall, forming atheroma plaques, which are composed of lipids and inflammatory cells. These plaques become thick, may suffer calcification and project themselves into the vessel lumen, determining blood flow change [1]. The reduction or obstruction of the vessel lumen determines the decrease in the amount of blood and oxygen to a irrigated organ, affecting important functions and endangering the patient's life [1, 2].

Considering that atherosclerosis is a disease that delayeth its clinical manifestations and may even show no any clinical symptoms [1, 2], any diagnostic method that allows the detection of atherosclerotic plaques before the blood flow becomes too restricted is very important.

The panoramic radiograph is one of the most commonly used tests in dental routine, providing a wealth of information regarding oral and facial structures [3, 4]. It allows to observe the area of the first cervical vertebrae, becoming an important tool to help in the early diagnosis of calcified atheroma in common carotid artery.

Friedlander and Lande [5] were the first to describe the presence of calcifications in the region of common carotid artery by panoramic radiographs performed in the routine dental diagnosis. Friedlander and Baker [6] noted that by panoramic radiographs can be identified asymptomatic patients at risk for stroke.

Radiographically, the calcified atheroma plaques are presented as irregular, circular or heterogeneous radiopaque masses, unilateral or bilateral. These plaques have an aspect mostly circular when small and mostly linear or thin rectangular when enlarged [7-9]. They are usually located posterosuperiorly to the angle of mandible, approximately at the inferior margin of third cervical vertebra (between C3 and C4) near the hyoid bone [2, 10]; however its loca-

Table 1. Prevalence of CCAC identified by PR in the population and main risk factors

Authors	Sex	Age	Number of patients	Prevalence of CCAC	Unilateral	Bilateral	Right side	Left side	Diabetes	Smoker	Hyperlipidemia	Hypertension	Obesity
Friedlander and Lande [5]	M	50-75	1000	≈ 2%	-	-	-	-	-	-	-	-	-
Hubar [11]	F, M	14-77	700	0.43%**	-	-	-	-	-	-	-	-	-
Almong et al [12]	-	≥ 55	778	3.5%	-	-	-	-	-	-	-	-	-
Cohen et al [13]	M	≥ 55	2000	3.8%	-	-	-	-	22.5%	54.9%	36.6%	53.5%	21.1%
Ohba et al [14]	F, M	≥ 80	659	5%**	-	-	74%	26%	-	-	-	-	-
Tamura et al [15]	F, M	50-70	2568	4.13**	87.7%	12.3%	32.1%	80.2%	-	3.6%	14.5%	27.6%	15.8%
Bayram et al [16]	F, M	≥ 40	4106	2.1%**	79.5%	20.5%	43.2%	77.3%	4.34%	26.08%	56.5%	30.43%	-
Pornprasertsuk-Damrongsri and Thanakun [17]	F, M	≥ 50	1370	2.5%	73.5%	26.5%	58.8%	67.6%	29.4%	2.94%	14.7%	52.9%	-
Friedlander and Cohen [18]	M	≥ 55	1409	3.3%	-	-	-	-	20%	54%	39%	52%	22%
Kumagai et al [19]	1, 2	2-92	2374	4%**	-	-	-	-	9.4%	-	14%	8.1%	-
Sisman et al [20]	F, M	40-83	750	5.06%	68.4%	31.6%	62%	38%	18.4%	15.8%	31.58%	31.58%	
Brand et al [21]	F, M	68.2*	448	9.4%	10%	90%	-	-	-	-	-	-	-
Ariayi et al [22]	F, M	≥ 40	4007	3.6%**	-	-	-	-	-	-	-	-	-
Bayer et al [23]	F, M	≥ 30	2557	4.8**	-	-	-	-	-	-	-	-	-
Johansson et al [24]	F, M	18-74	1182	9.9%***	34.2%	65.8%	-	-	27.40%	17.9%	-	75.2%	-
Imanimoghaddam et al [25]	F, M	≥ 40	960	1.97**	33.4%	66.6%	73.4%	93.4%	-	-	-	-	-
Lee et al [26]	F, M	≥ 50	4078	6.2%	-	-	-	-	24.4%	71.9%	41.9%	-	-
Garay et al [27]	F, M	≥ 40	3028	2.76%**	-	-	-	-	-	-	-	-	-

(-) Absence or no related; Female (F); Male (M); *mean age; **More prevalent in women; ***More prevalent in men.

Table 2. Prevalence of CCAC identified by PR in patients with systemic diseases

Authors	Sex	Age	Number of patients	Systemic Disease	Prevalence of CCAC	Prevalence of CCAC in control group
Friedlander et al [28]	M	51-78	19	Recent Stroke	37%	-
Friedlander et al [29]	M	60.4*	54	Obstructive sleep apnea	22.2%	3.7%
Friedlander and Maeder [30]	M	55-81	49	Type 2 Diabetes	20%	-
Friedlander et al [31]	F, M	62-77	46	Type 2 Diabetes insulin treated; Type 2 Diabetes	24%; 36%	-
Sung et al [32]	F, M	63.4*	27	Dilated cardiomyopathy	33.4%	3.7%
Kansu et al [33]	F, M	17-34	69	Renal disease	16%	-
Friedlander and Golub [34]	F, M	53-86	94	Occult metabolic syndrome	15%	6%
Ardakani et al [35]		30-89	128	Type 2 diabetes mellitus	43%	3.2%
Uthman and Al-Saffar [36]	F, M	40-80	157	Coronary heart disease, Hypertension, type 2 Diabetes, Hyperlipidemia	38.8%	11.6%
Pornprasertsuk-Damrongsri et al [37]	F, M	33-75	85	Metabolic syndrome	22.4%	-
Dolatabadi et al [38]	F, M	-	-	Type 1 diabetes; Type 2 diabetes	37.5%; 28.5%	-
Üstün et al [39]	F, M	44.5*	108	Renal Stones	16.6%	-
Guerreiro da Silva Junior et al [40]	F, M	40*	300	HIV-positive	8.2%	-

(-) no related; Female (F); Male (M); *mean age.

Table 3. Reliability of PR to detect CCAC

Authors	Number of patients	Gold Standard	Kappa	Accuracy	Sensitivity	Specificity	Conclusion
Romano-Sousa et al [2]	32	Color Doppler	0.78	-	-	-	Aids in detecting calcifications of the cervical region in patients susceptible to vascular diseases which predispose to myocardial infarction and stroke.
Khosropanah et al [41]	84	Doppler sonography	-	-	66.6	-	It is not an accurate method due its low sensitivity and PPV (45%).
Madden et al [42]	52	Ultrasonography	-	-	25%-31.1%	87.5%	The large number of false positives is an important limitation of the exam. Low NPV (42.5%).
Damaskos et al [43]	40	Digital subtraction angiography	-	-	60%	48%	Cannot be considered to be a useful screening tool for atheroma detection in the general dental population.
Ertas and Sisman [44]	70	Color Doppler ultrasound	-	80.5%	79.8%	81.1%	The findings of PR and ultrasound are consistent enough to warrant the referral the patients to medical evaluation.
Bastos et al [45]	42	Color Doppler	0.11	-	73.9%	36.8%	It is acceptable the PR sensitivity in detecting CCAC.
Yoon et al [46]	110	Computerized Tomography	-	62.3%	22.2%	90%	60.6% of PPV and 62.2% of NPV. Good accuracy, low sensibility.

NPV - negative predictive value; PPV - Positive predictive value.

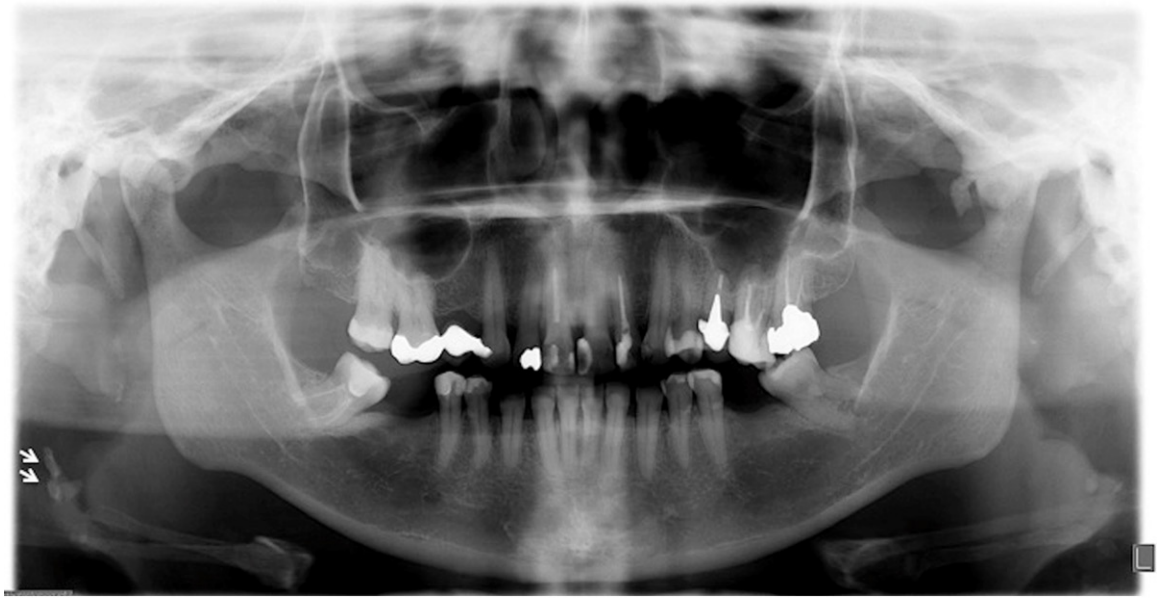

Figure 1. Panoramic radiography image suggesting the presence of common carotid artery calcifications (arrows).

tion is not limited to the hyoid bone or thyroid cartilage [9].

The goal of this study was to review the literature to determine the prevalence of common carotid artery calcifications (CCAC) detected on panoramic radiographs (PR) in the population and main risk factors. Furthermore, verify the reliability of PR to detect these calcifications.

Materials and methods

We analyzed studies published in the medical literature, after review in Pub-Med/MEDLINE, SCOPUS, ISI Web of Knowledge, SciELO and LILACS. Articles were searched using the keywords: Carotid artery calcification, Panoramic Radiograph, Atheroma, Reliability, Accuracy. Original articles, systematic reviews were included, longitudinal prospective studies and retrospective studies, which were published between 1981 and 2014. We excluded articles without abstract available and case reports.

Results

A total of 253 articles were found, being 27 in Pub-Med/MEDLINE, 97 in SCOPUS, 47 in ISI Web of Knowledge, 26 in Scielo and 19 in LILACS. A total of 31 articles were selected and based on these selected articles, 35.110 PR to analyze the prevalence and 7 articles to analyze the reliability of PR were included. **Table 1** shows the prevalence of CCAC identified by PR in the population and main risk factors; **Table 2** shows the prevalence of CCAC identified by PR in patients with systemic diseases; and the **Table 3** shows the reliability of PR to detect CCAC. **Figure 1** shows a suggestive image of common carotid artery atheroma.

Discussion

The common carotid artery has an ascending trajectory in the neck, emitting two terminal branches on both sides, the external and internal carotid arteries at level of superior margin of thyroid cartilage of the larynx. The external carotid artery irrigates mainly extracranial structures; the internal carotid artery penetrates into the skull irrigating large part of the anterior portion of the brain [4, 47]. The atheroma plaques may accumulate in the common carotid artery producing a narrowing and consequent decrease in cerebral blood flow.

The common carotid atheromas are associated with greater severity of coronary artery disease and also stroke, which is an important cause of death in patients older than 50 years [2].

Friedlander and Cohen [18] reported that 26% of men (mean age 66 years) with CCAC diagnosed by PR showed some adverse vascular event (myocardial infarction, stroke, revascularization, transient ischemic attack, angina).

These authors suggest that the accidental finding of CCAC predicts a significant risk of future vascular event. The results obtained by Griniatsos et al [48] corroborate those reported by Friedlander and Cohen [18], when indicate that patients with carotid calcified plaque detectable by PR are more likely to have suffered a stroke.

Ertas and Sisman [44] report that the increased risk of CCAC is associated with an increase in the length of time smoking, a finding also reported in other studies [19, 26]. Other authors associate CCAC with other diseases, such as diabetes [17, 24, 30, 31, 36, 38, 49], hypertension [17, 24, 49, 50] and hyperlipidemia [17, 19, 49]. However, Ohba et al [14] report that found no difference in blood pressure, cholesterol and blood sugar in patients with CCAC and patients without CCAC. Ertas and Sisman [44] also found no association between diabetes and CCAC.

Kumagai et al [19], Ardakani et al [35] and Madden et al [42] associate increasing age with the highest prevalence of CCAC. In men over 50 years the prevalence was between 2% and 3.8% [5, 13, 18]. In samples from individuals of both sexes, aged ≥ 30 years, the prevalence varied among 2.1%-6.2% [12, 14, 15-17, 19, 22, 25-27]. Brand et al [21] and Johansson et al [24], who also worked with individuals of both sexes, reported the prevalence of 9.4% and 9.9%, respectively, very expressive values when we consider the general population. Hubar [11] in a study with black Americans noted that the presence of CCAC on PR is extremely rare, 0.43%, the lowest prevalence found in the literature. The prevalence found in Asian patients varied among 2.5%-6.2% [14, 15, 17, 19, 26]. Lee et al [26] claim that the high prevalence of CCAC in Korean population is due to the current lifestyle of this population.

In the literature review we found that CCAC are more frequent in women than men [11, 14-16, 22, 23, 25, 27]; are usually unilateral [15-17, 20], but can occur on both sides, without predilection for one or the other.

The prevalence of CCAC when associated with systemic disease, such as dilated cardiomyopathy [32], obstructive sleep apnea [29], diabetes [30, 31, 35, 36, 38], metabolic syndrome [34, 37], recent stroke [28], kidney stones [39]; HIV-positive [40] has shown higher than in general population, varying from 8.2% to 38.8%. In post-menopausal women is also observed higher prevalence, being able to reach 31% [16, 50].

In diagnosis is important to differentiate CCAC from other radiopacities which can cause deception, such as anatomical radiopacities (**Table 4**) and pathological radiopacities (**Table 5**). The triticeal cartilage can lead errors in radiographic interpretation, suggesting a foreign body in the soft tissues of the region [47], a fact also noted by Kamikawa et al [58]. The differentiation between calcified carotid atheroma and calcified triticeal cartilage is possible due to the shape and contour of the calcifications. The calcified carotid atheromas are mostly circular when they are small and linear or thin rectangular when they have larger size, whereas calcified triticeal cartilage is mostly oval with smooth margins [9]. The hyoid bone is a structure that causes errors in identifying CCAC due its location [56]. The thyroid cartilage on panoramic radiograph is located medial to the image of C4, which can sometimes lead to confusion [17]. Besides these structures, there are others which can also cause errors in radiographic interpretation, such us styloid process, styloid ligament, stylomandibular ligament and epiglottis. Calcified lymph node, salivary glands sialoliths, tonsilloliths and phleboliths can generate similar images from CCAC on PR.

The differential diagnosis of calcified atheroma from anatomic structures located in the cervical region is of paramount importance, however the general dentist not always has the experience necessary to do it. Thus, cardiology inter consultation must be routine conduct when there is a suspicion of CCAC. Cardiology inter consultation for patients with suggestive images of CCAC detected on PR, provides benefits to the health of patients. Furthermore, is very important to consider that early diagnosis of this disease propitiates early initiation of cardiovascular therapy and therefore the prevention of events that can endanger the patient's life.

CCAC detected on PR are powerful markers for future cardiovascular or cerebrovascular events [2, 13, 15, 18]. Some authors report that the PR has good accuracy [44, 46] and

Table 4. Anatomical radiopacities which can cause deception in the differential diagnosis of common carotid artery calcifications detected on panoramic radiographs

Anatomical Radiopacities	Brief description of the structure/Location	References
Triticeal cartilage	Circular or ovate, with well-marked and smooth margin, located between the greater horn of the hyoid bone and superior horn of the thyroid cartilage. Prevalence 12% in females and 5% in males.	[8, 9, 47]
Superior horn of thyroid cartilage	Thyroid cartilage is constituted by two laminae which are joined anteriorly in "v". The superior margin of each lamina projects superiorly as superior horn, which may calcify. Located medial to the fourth cervical vertebra (C4).	[8, 47]
Styloid process	The elongation of styloid process appears as a thin and elongated bony projection. It can be observed between the ramus of mandible and the mastoid process.	[47]
Stylohyoid ligament	It extends from the styloid process to the lesser horn of the hyoid bone. When calcified it is noted as a radiopacity posterior to the mandible.	[12, 47]
Hyoid bone	Median bone, which has no direct connection with other bones. Located in the cervical region, between the sternum and the base of mandible.	[47]
Stylomandibular ligament	It extends from the styloid process to the angle of mandible. It is located above the angle of mandible.	[47, 51]
Epiglottis	Median cartilage, located posteriorly to the root of tongue and the thyroid cartilage. Usually seen bilaterally on panoramic radiograph, above the greater horn of the hyoid bone.	[12, 47]

Table 5. Pathological radiopacities which can cause deception in the differential diagnosis of common carotid artery calcifications detected on panoramic radiographs

Pathological Radiopacities	Radiographic appearance/Location on PR	References
Lymph node (calcified)	When calcified, have unilateral images single, multiple or ordered in rows, according to the cervical chain. They have an irregular contour and indefinite internal aspect. The most affected are the submandibular and cervical lymph nodes. Prevalence 1%.	[47, 52, 53]
Major salivary glands (sialoliths)	The sialoliths are crystallized minerals located above the carotid artery calcifications. They have irregular or diffuse calcifications appearance and are usually unilateral. 92% of the stones are located in the submandibular gland. Prevalence 0.01-1.0%	[31, 49, 54]
Palatine tonsil (Tonsilloliths)	Chronic inflammation of the palatine tonsils can lead to the formation of calcifications, called tosilloliths. Are rare, unique or multiple, round or irregular, unilateral or bilateral and superimposed on the ramus of mandible. Prevalence 2%-16%.	[55]
Veins or sinusoidal vessels of hemangiomas (Phleboliths)	Phleboliths are calcified thrombi. Are manifold, they look circular or oval, with a feature of peripheral radiopaque halo and radiolucent in the center.	[49, 56, 57]

good agreement with the gold standard method [2], however for Bastos et al [45], despite the low correlation between PR and gold standard test the sensitivity of PR in detecting CCAC is considered acceptable. Other authors suggest that PR has low sensitivity for detecting CCAC [42, 43, 46] and produce large numbers of false positives, hence presents a significant limitation for the detection of CCAC [42], becomes an inaccurate method [41]. Almong et al [12] do not suggest the use of PR as a screening tool for CCAC, neither indicate the use of PR exclusively for detection of the disease. However, they caution that patients with visible calcifications on both sides of PR have significant rates of carotid artery stenosis, and us the PR provides important information with no additional cost, whether this finding is ignored, the opportunity to prevent a potential stroke is lost.

In conclusion, the prevalence of CCAC identified by PR may range from 0.43% to 9.4%, depending on the age and lifestyle of the population studied. In individuals with systemic diseases the prevalence is higher than in the general population, reaching up to 38.8%. The radiopaque masses compatible with CCAC identified by PR are more common in women and can occur unilaterally or both sides, without preference for one or the other. Furthermore, we conclude that calcified atheroma in the common carotid artery can be demonstrated in PR, and this is an important tool for early detection of CCAC. However, it is always necessary to refer the patient to a cardiology service to confirm the findings, determine the real extent of the disease and establish its corresponding treatment.

Disclosure of conflict of interest

None.

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