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Interobserver agreement on the diagnosis of carotid artery calcifications on panoramic radiographs

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ABSTRACT

Purpose: This study was performed to investigate the interobserver agreement on the detection of carotid artery calcifications on panoramic radiographs.
Materials and Methods: This study consisted of panoramic radiographs acquired from 634 male patients of the age of 50 years or older. Having excluded carotids of no diagnostic quality, 1008 carotids from the panoramic radiographs of the patients were interpreted by two oral and maxillofacial radiologists independently for the presence of carotid artery calcifications. Statistical analysis was used to calculate the interobserver agreement.
Results: Interobserver agreement was obtained for 932 carotids (92.4%). Inconsistent interpretation of 76 carotids (7.5%) between the two observers was found. Cohen's kappa value was 0.688 ($p < 0.001$).
Conclusion: The probability of a match between the two observers was substantially high. (***Imaging Sci Dent 2014; 44: 137-41***)

KEY WORDS: Atherosclerosis; Radiography, Panoramic; Diagnosis

Introduction

The blood supply of the brain is derived from bilateral internal carotid arteries and vertebral arteries. The internal carotid artery supplies most of the ipsilateral cerebral hemisphere, eye, and accessory organs. Atherosclerotic plaques are particularly prominent at the bifurcation of the common carotid artery into external and internal branches. The occlusion or stenosis of internal carotid arteries may cause transient ischemia or stroke. Since Friedlander and Lande[1] first reported the detection of soft-tissue calcification in the carotid artery region identified on panoramic radiographs, several studies have shown that the carotid artery calcification (CAC) detected on panoramic radiographs can identify stroke-prone patients.[2-4] CACs are more prevalent in certain patients with stroke risk factors such as old age, hypertension, type 2 diabetes, heart disease, metabolic syndrome, and obesity. In ultrasound studies, all of the sides of the neck with a radiographically identified atheroma had stenosis in the internal carotid artery and 21% of the patients had clinically significant stenosis (stenosis of 50% or more).[5,6]

The American Dental Association Council on Scientific Affairs recommends that a dentist evaluate radiographs taken for dental purposes for CACs as well, and if the dentists detect CACs, they refer the patient to a physician.[7]

The diagnostic sensitivity of a panoramic radiograph is 22-31%.[8,9] Small specks of calcification could not be identified on panoramic radiographs. Some calcifications might

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Fig. 1. A panoramic radiograph reveals carotid artery calcification of a 58-year-old male. Bilateral carotid artery calcifications are seen as radiopaque nodular masses and verticolinear masses adjacent to or just below the intervertebral space between C3 and C4.

be superimposed on cervical vertebrae. The location of the bifurcation of the common carotid artery is variable and can be outside of the region covered by panoramic radiographs. Errors in patient positioning might result in the inability to perceive CAC.[10,11] Anatomical structures and pathological radiopacities in the carotid vicinity, such as the hyoid bone, epiglottis, calcified stylohyoid and stylomandibular ligaments, thyroid and triticeous cartilages, calcified lymph nodes, tonsilloliths, phleboliths, and sialoliths, might be mistaken for CACs.[2,9,12-16]

Although there have been many studies on CACs using panoramic radiographs, the reliability of the interpretation of panoramic radiographs has not been clearly determined. Thus, the purpose of this study was to determine the interobserver agreement on the detection of CACs on panoramic radiographs.

Materials and Methods

Panoramic radiographs were acquired from 634 male patients aged 50 years or older (average age: 61.8 years, age range: 50-87.3 years) for routine dental examination or diagnosis of inflammation, injury, cyst, or tumor on the maxillofacial region.

Digital panoramic radiographs were used for this study. These radiographs were taken by either a Kodak 8000 (Kodak Co., Rochester, NY, USA) or OC-100 (Instrumentarium, Tunsula, Finland).

Excluding 130 panoramic radiographs that were not of diagnostic quality, we found 1008 carotids of 504 patients on the remaining radiographs for this study. The carotid arteries were reviewed for the evaluation of soft-tissue calcifications in the carotid vicinity on the panoramic radiographs.

Panoramic radiographs of the patients were examined by two experienced oral and maxillofacial radiologists who interpret more than 10,000 panoramic radiographs in a year. Each observer interpreted each panoramic radiograph individually. The digital panoramic radiographs were adjusted to be optimum by each observer for the detection of CACs. The interpretations were performed to detect CACs appearing as radiopaque nodular or verticolinear masses adjacent to or just below the intervertebral space between C3 and C4.[17]

Interobserver agreement on the interpretation of CAC on panoramic radiographs was statistically analyzed using Cohen's kappa.

After independent interpretation of each observer, the two observers re-interpreted together the panoramic radiographs on which a different diagnosis of CACs was made by the two observers.

Results

In this study, 1008 carotids from 504 male patients aged 50 years or older were interpreted individually by two oral and maxillofacial radiologists to detect CACs appearing as radiopaque nodular or verticolinear masses adjacent to or just below the intervertebral space between C3 and C4 (Fig. 1).

The presence of CACs was interpreted by the two observers for 102 carotids (10.1%). The absence of CACs was interpreted by the two observers for 830 carotids (82.3%). Thus, the two observers made the same interpretation for 932 carotids (92.4%), while a different interpretation was made by each observer for 76 carotids (7.5%) (Table 1). The interobserver agreement was statistically significant ($p < 0.001$). Cohen's kappa value was 0.688.

Table 1. The results of independent interpretation of panoramic radiographs for carotid artery calcification by two observers

		Observer 2		Total
		Calcified	Non-calcified	
Observer 1	Calcified	102 (10.1%)	73 (7.2%)	175 (17.4%)
	Non-calcified	3 (0.3%)	830 (83.3%)	833 (82.6%)
Total		105 (10.4%)	903 (89.6%)	1008 (100%)

Table 2. The results of re-interpretation of the panoramic radiographs with the consensus of two observers

Calcification	Carotid artery
Calcified	120 (11.9%)
Non-calcified	888 (88.1%)
Total	1008 (100%)

Table 3. Carotid artery calcifications and patients at the re-interpretation of the panoramic radiographs

Carotid calcification	Patients
Bilateral carotid calcification	28 (5.6%)
Unilateral carotid calcification	64 (12.7%)
Non-calcified carotid	412 (81.7%)
Total	504 (100%)

A re-interpretation of the 76 carotids on which the two observers made different diagnosis showed that 18 more carotids were calcified. The two observers reached a consensus that 17 masses were the hyoid, 18 were thyroid cartilage, 20 triticeous cartilage, 1 sialolith, 1 the epiglottis, and 1 the pharyngeal wall. The results after the re-interpretation showed that 120 carotids (11.9%) were calcified and that the number of patients with CACs was 92 (18.3%) (Tables 2 and 3).

Discussion

Atherosclerosis of the arteries supplying the central nervous system is a frequent cause of ischemic stroke. The carotid bifurcation is at the highest risk of atherosclerosis. The blood flow velocity and the shear stress are reduced at the bifurcation, and the blood flow departs in a unidirectional pattern. These flow characteristics increase the residence time of circulating particles in the bifurcation.[18] Fatty streaks located at bifurcations may progress to smooth muscle-rich fibrous plaques, and the plaques are prone to calcification.[19] Dystrophic calcification of the extracranial carotid artery is a common component of atherosclerotic lesions, and CAC is detected on radiographs. CAC might be occasionally detected on the panoramic radiograph below the mandibular angle and adjacent to the cervical vertebrae at the level of the third and fourth cervical vertebral junction.

Previous studies reported a 2-11% prevalence rate of CACs on panoramic radiographs in the dental patient population.[1,12,17,20-22] Several studies showed that the detection of CACs on panoramic radiographs might be a useful aid in detecting patients at the risk of stroke.[2,12,21,23] The patients' medical histories with panoramic radiographic evidence of CAC revealed risk factors of stroke, male gender, advanced age, smoking, hypertension, diabetes, and hypercholesterolaemia.[2,12,17,20,21] In a previous study, patients who were found to have CAC on panoramic radiographs had a high frequency of end points in a relatively short period of time after the identification of CAC.[24] The subsequent occurrence of adverse vascular events in patients with CACs on panoramic radiographs was significantly higher than that in the control group.[3]

Meanwhile, panoramic radiography is not a reliable diagnostic tool for CAC. A false positive interpretation can result from various anatomical or pathological radiopacities such as hyoid bone, thyroid cartilage, triticeous cartilage, epiglottis, vertebrae, calcified lymph nodes, phleboliths, sialoliths, and tonsilloliths.[13] Further, a slight change in the patient's head positioning might cause a false negative interpretation.[11] Moreover, the sensitivity of a panoramic radiograph for the detection of CACs is low.[8,9,25] The interpreters should be trained to differentiate CACs from anatomical structures and pathological radiopacities in the carotid vicinity.

Among the 76 carotids in which there was interobserver disagreement, 18 were re-interpreted as CACs. These CACs were so faint and tiny that they could hardly be interpreted. One observer tended to interpret a very small speck as positive, while the other tended to interpret only a considerably larger calcification as positive. At the re-interpretation, it was agreed that 17 CACs were hyoid bone. The end of the greater horn of the hyoid bone might be well ossified and superimposed on carotid vicinities on the panoramic radiograph so as to be mistaken for CACs easily.[26] Careful tracing of the hyoid bone could show that some of the calcifications in the carotid vicinities were hyoid bone. Thyroid cartilages were mistaken for CACs in 18 cases. The superior cornu of thyroid cartilages might be calcified and depicted on panoramic radiographs.[16] The position of thyroid cartilage is slightly lower than that of the carotid vicinities and below the hyoid bone, and calcified thyroid cartilages are depicted as a smoothly outlined longitudinal radiopacity with the base below the panoramic radiograph's view range. Triticeous cartilage could be mistaken for CACs, and in this study, 18 were mistaken. Triticeous cartilage is located in the lateral thyrohyoid ligament, which connects the hyoid bone and the thyroid cartilage, and can be sufficiently calcified so as to be mistaken for CACs. The smooth contour of the triticeous cartilage distinguishes it from CACs.[14,15] It was agreed at the re-interpretation that one was a sialolith because it had a roughly round shape, and a half of the image was superimposed on the mandibular angle, which was the location of the submandibular gland. One was found to be the epiglottis, and the other, the pharyngeal wall in the re-interpretation phase.[13] The carotid vicinity is surrounded by soft tissue, which sometimes requires differential diagnosis from CACs. The results after the re-interpretation showed that 120 carotids (11.9%) were calcified carotids, and 92 patients (18.3%) had CACs. These results showed that there might be false positivity and negativity in the interpretation of panoramic radiographs for CACs, which indicated that the interpretation of CACs on panoramic radiographs should be done very carefully.[9,13,16]

Meanwhile, this study showed an 18.3% prevalence of CACs in Korean males aged 50 years or more, the highest prevalence ever reported. It is recommended that dentists who detect CACs on a panoramic radiograph, refer the patient to a physician for further evaluation of luminal stenosis.

In conclusion, the probability of interobserver agreement on the detection of CACs on panoramic radiographs was in substantially high (Cohen's kappa=0.688, $p<0.001$). The interpretation of a panoramic radiograph for detecting CACs can be expected to generally be reliable in spite of the fact that there might be some false positive or negative cases. A careful interpretation of a panoramic radiograph by more than one observer might be helpful for the correct diagnosis of CACs. The limitation of this study was that there was no true gold standard, such as computed tomography or ultrasonography, to reveal the presence of CACs. Further study is required to evaluate the agreement of interpreters on the detection of CACs on panoramic radiographs using a gold standard.

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