Detection of incidental carotid artery calcifications during dental examinations: Panoramic radiography as an important aid in dentistry

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Objective. This study aimed to determine the diagnostic reliability of panoramic radiographs (PRs) in the detection of carotid artery calcifications (CACs) during routine dental examination by comparing them with color Doppler ultrasound (CDUS) examination as the criterion standard. The correlations between CAC formation and systemic diseases, body mass index, smoking, and age were also examined.

Study design. A total of 70 patients ≥40 years old diagnosed with CACs from PRs obtained during routine dental examination between January 2008 and September 2009 and 35 patients with no CACs (control group) were referred for further ultrasound examination.

Results. Compared with CDUS examination of 210 carotid arteries in 105 patients, PRs were found to have sensitivity, specificity, and accuracy rates of 79.8%, 81.1%, and 80.5%, respectively, in the diagnosis of CACs. CACs were found to be significantly correlated with chronic diseases, such as hypertension, hyperlipidemia, and heart disease, but not with diabetes mellitus or renal disease. In addition, correlations were found between CACs and smoking and between CACs and menopause.

Conclusions. The findings of PRs and ultrasound are consistent enough to warrant the referral of patients prediagnosed with suspected CACs from PRs for further medical evaluation. (Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2011;112:e11-e17)

Atherosclerosis is a progressive inflammatory disorder that may lead to coronary artery disease and stroke. There is a very high association between atherosclerosis and mortality and morbidity in developed countries, with atheroemboli reported to be an underlying cause of ~50% of all deaths in Western countries. In Turkey, stroke or cerebrovascular accident follows cardiovascular disease and cancer as the third highest cause of death, making atherosclerosis and its more dramatic consequences—strokes and heart attacks—major health problems.

Arterial stenosis due to carotid atheroma is the most important risk factor in stroke. Whereas 20% of all strokes are hemorrhagic in nature, 80% are ischemic strokes caused by atherosclerotic disease in the region of the carotid bifurcation. Numerous studies have shown that neurologically asymptomatic patients with >50% stenosis of the internal carotid arteries (ICAs) are at increased risk of developing strokes caused by the occlusion of intracerebral arteries by emboli formed from ulcerated and detached atherosclerotic debris, making the identification of an occult atherosclerotic calcification of vital importance. Early diagnosis and timely medical or surgical treatment may reduce the incidence of ischemic strokes and subsequent serious consequences, including billions of dollars annually in direct and indirect costs.

Calcifications in the region of the 2nd, 3rd, and 4th cervical vertebrae may often appear on panoramic radiographs (PRs), which are a routine and indispensable part of dental examinations. Several studies have evaluated the use of PRs in the detection of carotid artery calcifications (CACs) and the correlation between findings from PRs, patient medical histories, cervical spine radiographs, and Doppler spectral analysis. Overall, studies have found prevalence rates ranging from 2% to 11% in adult populations, with higher rates of CACs observed in PRs of certain subgroups, e.g., males, individuals ≥40 years old, smokers, individuals with hypertension, diabetes, or hypercholesterolemia, and individuals who have undergone renal transplantation or head and neck radiation therapy. Considering the widespread use of PRs in most dental clinics today, as well as their ease of use of the carotid bifurcation.
and low cost compared with other imaging methods, PRs may represent an efficient diagnostic tool for detecting CACs. While not all calcifications observed on PRs represent significant stenosis of the ICAs, and not all hemodynamically significant stenosis includes calcifications that are detectable on radiographs, the incidental detection of calcifications on PRs during routine dental examination of neurologically asymptomatic patients has been suggested as a cost-effective screening method for color Doppler ultrasound (CDUS) referral.

Therefore, the present study aimed to perform CDUS examinations on neurologically asymptomatic subjects with CACs detected incidentally from routine dental radiographs and to compare the use of PRs and CDUS images in the diagnosis of clinically significant carotid stenosis. A further aim was to investigate associations between the carotid calcifications and risk factors such as medical history, age, body mass index (BMI), and smoking.

MATERIALS AND METHODS

This research was independently reviewed and approved by the Research Ethics Committee of the Dental School of Erciyes University, Kayseri, Turkey.

A total of 105 patients were selected from among those presenting at the Erciyes University Faculty of Dentistry’s Department of Oral Diagnosis and Radiology for dental treatment between January 2008 and September 2009. Inclusion criteria were the existence of a PR taken during routine dental examination that clearly showed the 3rd and 4th cervical vertebra region, age ≥40 years, and the ability to undergo CDUS examination if the radiograph showed a possible calcification. Patients with poor-quality radiographs (overexposed, underexposed, incorrect patient positioning, processing errors) were excluded from the study, as were those with radiographs in which the presence of a CAC was indeterminable. Patients whose PRs showed CACs were included in the study group (n = 70), and patients whose PRs showed no CACs were included in the control group (n = 35). All study participants were informed about the aim of the study, and informed written consent was obtained before CDUS examination.

All radiographs were obtained by the same radiology technician using either a conventional (orthopantomograph Op 100, Instrumentarium Corp., Tuusula, Finland) or a digital (orthopantomograph Op 200D, Instrumentarium Corp.) device. Conventional radiographs were processed in an automatic film processor according to the manufacturer’s recommendations, and digital radiographs were printed with a laser printer at the same magnification factor (1:1.3). Radiographs were viewed on a standard view box in subdued ambient light.

Demographic information (age and gender) was recorded for each person, and medical histories were taken to identify the presence of certain conditions considered to be risk factors for atherosclerosis, including hypertension, chronic heart disease, diabetes mellitus, renal disease, and hyperlipidemia. Patients were considered to have any of the above conditions if they reported having been previously diagnosed by a physician or were currently taking relevant medication. BMI was also calculated (kg/m²), and excessive weight and obesity, defined as a BMI of 25-29.9 kg/m² and ≥30 kg/m², respectively, were recorded. Other risk factors assessed included previous radiotherapy to the head and neck region, smoking, and, for female patients, age of natural or surgically induced menopause.

Two oral and maxillofacial radiologists with 6 and 10 years of experience interpreted all of the PRs. Each observer interpreted each panoramic radiograph individually, followed by a discussion of each film between the 2 observers. A diagnosis was made when the 2 observers agreed; a CAC was defined as a single discrete radiopaque nodular mass or multiple masses within the soft tissues of the neck located 1.5 cm inferior and 2.5 cm posterior to the cortical rim of the midpoint of the mandibular angle, with other cervical calcifications, such as calcified triticeous cartilage, calcified thyroid cartilage, hyoid bone, and submandibular salivary gland sialoliths, excluded, in line with the differential diagnosis reported by Carter. CACs were recorded for each patient as present or absent and, for those with CACs, as unilateral or bilateral. Patients with CACs identified from PRs were referred to the Erciyes University School of Medicine’s Radiology Department for CDUS to determine the location and extent of calcification (Fig. 1).

CDUS was conducted using a Toshiba PowerVision 6000 equipped with a 7.5-MHz multifrequency high-

Fig. 1. A panoramic radiograph of a patient showing calcifications on right cervical region.
resolution linear probe. Examination was conducted with the patient in a supine position and head slightly extended. Longitudinal and transverse scans were performed to examine the common, internal, and external carotid arteries and the carotid bulb for plaque formation and/or stenosis, defined as spectral broadening throughout systole and/or peak systolic velocity of $\geq 120$ cm/s (Figs. 2-4). Arteries were scored as 1 if calcifications were detected and 0 if the segments were normal without any plaque formation or intimal thickening. Stenosis was classified according to the North American Symptomatic Carotid Endarterectomy Trial criteria\textsuperscript{17,18} as follows: grade 0: normal arterial structure; grade 1: 0-29% stenosis; grade 2: 30%-69% stenosis; grade 3: 70%-99% stenosis; and grade 4: 100% stenosis (total occlusion of the arterial structure).

**Statistical analysis**

The observed results were analyzed with SPSS 16.00 (Statistical Package for Social Science, Chicago, IL, USA). Data analysis consisted of McNemar $\chi^2$ tests to determine the ability of different PRs (conventional vs. digital) to detect CACs compared with CDUS results. The results were considered to have a significant difference if the significance level was $<.05$. Also, the relationship between the presences of CACs and the risk factors associated with atherosclerosis were compared with logistic regression analysis.

**RESULTS**

A total of 210 carotid arteries were examined in 105 patients. Of these, PRs showed the presence of CACs in 70 patients, who composed the study group (46 female, 24 male, mean age 59.8 years), whereas 35 patients whose radiographs showed no CACs constituted the control group (21 female, 14 male, mean age 54.7 years).

Medical histories revealed hypertension in 53 subjects (50.5%), chronic heart disease in 28 (26.9%), diabetes mellitus in 25 (23.8%), hyperlipidemia in 33 (31.4%) and renal disease in 11 (10.5%). In addition, the majority (85.1%) of the 67 women in the study had gone through menopause, and 1 patient had a history of radiotherapy for laryngeal carcinoma.

**Radiographic findings**

Of the 210 arteries examined, 103 were diagnosed from PRs as having CACs. Of these, 66 were detected in women and 37 in men, but the difference between the 2 groups was not statistically significant ($P = .949$). Regarding location, 59 CACs were located in the right carotid artery and 44 in the left carotid artery, but the difference in location was not statistically significant ($P = .053$).

Patients included in the study were grouped into 4 different age groups: 40-49, 50-59, 60-69, and 70-80 years. The difference in CAC rates between age groups was statistically significant ($P = .002$).

**CDUS findings**

CDUS scans showed CACs in 104 arteries in 64 patients. Of these, 41 women (61%) had CACs in 64 arteries, and 23 men (60.5%) had CACs in 40 arteries. Calcifications were unilateral in 24 patients (18 women, 6 men) and bilateral in 40 patients (23 women, 17 men). CACs did not differ significantly by location between the left and right sides ($P = .581$). The increase in CAC
incidence by age was found to be statistically significant ($P = .000$; Fig. 5).

**Panoramic findings versus CDUS results**

PRs were found to have an accuracy of 80.5%, sensitivity of 79.8%, and specificity of 81.1% in the detection of CACs compared with the CDUS scans as criterion standard. False negative and false positive rates of PRs were 20.1% and 18.8%, respectively (Table I). No significant differences were observed between conventional and digital PRs in the detection of CACs (Table II).

CDUS showed 90 arteries (42.9%) to have grade 1 CACs that did not cause hemodynamically significant lesions. An additional 9 arteries were assessed as grade 2 (30%-69% stenosis), 4 arteries as grade 3 (70%-99% stenosis), and 1 artery as grade 4 (100% occlusion) (Table III). All arteries showing clinically significant stenosis in CDUS images were also diagnosed by PR as having CAC; however, carotid disease had not been previously suspected in any of these patients.

Three patients with hemodynamically significant stenosis were referred to a radiologist for digital subtraction angiography (DSA), because diffuse atherosclerosis had negatively affected the CDUS images. Patients were informed of the risks and benefits of the DSA procedure and gave their informed consents. No complications related to DSA occurred. Based on DSA findings, a stent measuring $7 \times 10 \times 40$ mm was placed and dilated with a $6 \times 20$ mm balloon in 1 patient with a history of radiotherapy for larynx carcinoma and 2 occluded arteries (1 grade 3 and 1 grade 4). Postdilation ICA caliber was satisfactory, and there were no procedural complications. Despite the slightly increased risks of morbidity and perinterventional stroke, the other 2 patients who underwent DSA refused further treatment with angioplasty or stenting and were referred to their primary-care physicians for follow-up of their medical status.

Logistic regression analysis found a significant correlation between CACs and hypertension, hyperlipidemia, and chronic heart disease, but no correlation between CACs and diabetes mellitus or renal diseases. CAC was also found to be significantly correlated with menopause in women. Of the 105 patients included in the study, 26 (24.8%) had a history of smoking, and an increase in the length of time smoking was found to correlate with an increased risk of CACs. According to BMI calculations, 46 patients were defined as overweight and 35 as obese, and although CACs were
CAs in 51.4% of the obese patients, no significant correlation was found between BMI and CACs (P = 0.298).

**DISCUSSION**

The present study aimed to determine the reliability of panoramic radiography as a screening tool for the detection of CACs by comparing it with CDUS examination as the gold standard.

In total, 61% of subjects were diagnosed with CACs by CDUS, whereas only 41% were diagnosed with CACs by both PR and CDUS images. Of the 210 carotid arteries examined, 83 arteries (40%) showed calcifications in both PR and CDUS images, 86 arteries showed no calcifications on either PR or CDUS images, 20 arteries showed calcifications on PR images that did not appear on CDUS images, and 21 arteries showed calcifications on CDUS images that had not been detected on PRs. Whereas false positive readings may have been caused by anatomic structures or pathologic calcifications in soft tissues of the neck mimicking CACs, false negative readings may be attributed to anatomic variations that caused the region of bifurcation to fall outside the field of view of a properly positioned and exposed PR, and to the fact that not all hemodynamically significant atherosclerotic lesions are calcified and can be observed on radiographs.

Reports on the use of PRs in the detection of CACs have varied. Whereas 1 previous study recommended against using PRs to detect CACs because of their low sensitivity compared with ultrasound, which was considered to be the criterion standard, another concluded that PRs had moderate accuracy in the detection of CACs, and yet another study found a high level of agreement between PRs and color Doppler images of 32 cervical regions used in the detection of CACs. The present study found that PR images had 79.8% sensitivity, 81.1% specificity, and 80.5% accuracy in the detection of CACs. These rates are relatively high compared with other studies and indicate that incidental findings on PRs can play an important role in the detection of previously undiagnosed atherosclerotic disease. Given that CACs may lead to coronary artery disease, stroke, and death, PRs taken as part of a routine dental examination should be carefully examined for evidence of CACs, and dentists should refer patients with suspected CACs for further medical examination.

Panoramic radiography is not considered to be a reliable method for detecting degree of stenosis, because it is unable to detect differences in blood flow characteristics; however, PRs may be viewed as a cost-effective accessory to subsequent Doppler ultrasoundography, which is viewed as the criterion standard imaging procedure for diagnosing arterial calcifications. This is clearly illustrated in the present study, in which 3 patients were subsequently diagnosed with hemodynamically significant carotid occlusive disease after incidental findings of calcifications on routine dental PRs.

DSA, which is generally regarded to be the criterion standard for determining the exact degree of stenosis, involves radiation exposure and a morbidity rate of between 1% and 4%, and a 1% risk of periinterventional stroke has been associated with this procedure; however, PRs may be viewed as a cost-effective accessory to subsequent Doppler ultrasoundography, which is viewed as the criterion standard imaging procedure for diagnosing arterial calcifications. This is clearly illustrated in the present study, in which 3 patients were subsequently diagnosed with hemodynamically significant carotid occlusive disease after incidental findings of calcifications on routine dental PRs.

Table I. Cross-tabulation of panoramic radiography and color Doppler ultrasound results.

<table>
<thead>
<tr>
<th>Ultrasound</th>
<th>CAC absent</th>
<th>CAC present</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Panoramic radiography</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CAC absent</td>
<td>86</td>
<td>21</td>
<td>107</td>
</tr>
<tr>
<td>CAC present</td>
<td>20</td>
<td>83</td>
<td>103</td>
</tr>
<tr>
<td>Total</td>
<td>106</td>
<td>104</td>
<td>210</td>
</tr>
</tbody>
</table>

CAC, carotid artery calcification.

Table II. Specificity, sensitivity, and accuracy values (%) of conventional and digital panoramic radiography (PR) used to detect carotid artery calcifications.

<table>
<thead>
<tr>
<th></th>
<th>Specificity</th>
<th>Sensitivity</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional PR</td>
<td>83</td>
<td>74.5</td>
<td>80</td>
</tr>
<tr>
<td>Digital PR</td>
<td>71</td>
<td>87</td>
<td>82</td>
</tr>
</tbody>
</table>

Table III. Distribution of arteries by degree of stenosis detected from color Doppler ultrasound images.

<table>
<thead>
<tr>
<th>Grade</th>
<th>No. of arteries</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 (normal arterial structure)</td>
<td>106</td>
<td>50.5</td>
</tr>
<tr>
<td>1 (0%-29% stenosis)</td>
<td>90</td>
<td>42.9</td>
</tr>
<tr>
<td>2 (30%-69% stenosis)</td>
<td>9</td>
<td>4.3</td>
</tr>
<tr>
<td>3 (70%-99% stenosis)</td>
<td>4</td>
<td>1.9</td>
</tr>
<tr>
<td>4 (total occlusion)</td>
<td>1</td>
<td>0.5</td>
</tr>
<tr>
<td>Total</td>
<td>210</td>
<td>100</td>
</tr>
</tbody>
</table>

diagnosed in 51.4% of the obese patients, no significant correlation was found between BMI and CACs (P = 0.298).
With the exception of a study by Bayram et al., which used digital radiography to detect CACs, most previous studies in the literature have been conducted using conventional radiography, whereas our study separately evaluated both conventional and digital radiographs. One other study conducted with both conventional film and digital radiography found conventional film images to perform statistically better than digital images in the diagnosis of CACs, whereas our study found no significant differences between the 2 techniques. Rather, our findings suggest that properly trained and informed dentists can diagnose CAC pathologies from adequately positioned, exposed, and processed radiographs, whether conventional or digital.

The literature has reported subgroups of patients with a history of certain medical problems to have a higher prevalence of calcifications detected on PRs, including patients with a history of cerebrovascular accidents, whereas our study found no significant differences between the 2 techniques. Rather, our findings suggest that properly trained and informed dentists can diagnose CAC pathologies from adequately positioned, exposed, and processed radiographs, whether conventional or digital.

CONCLUSIONS

Panoramic radiography is an indispensable diagnostic tool routinely used in dental examinations. Although clinicians usually focus on the teeth and jaws only, the same radiographs may be used for other purposes, such as detecting CACs. Therefore, dentists have the ability to identify thousands of patients at risk of stroke with no additional cost to either public or private health systems. Given that aggressive medical treatment of early as well as advanced atherosclerotic disease has been shown to decrease the risk of fatal and nonfatal strokes, dental practitioners have a professional responsibility to refer the patient to a specialist for further examination and treatment when a CAC is identified on a PR.

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REFERENCES


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