Correlation of dental pulp stones, carotid artery and renal calcifications using digital panoramic radiography and ultrasonography

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Abstract

Background: The human tissues continuously undergo modification as deposition of calcium (CA) salts either in an organized or disorganized pattern. The latter pattern usually occurs in the soft tissues such as in arteries, brain, kidneys, lungs, and dental pulp. The purpose of this study is to evaluate the presence of pulp calcification and carotid artery calcification (CDC) as a marker for renal calcification and altered serum biomarkers such as serum CA, phosphorus (P), and alkaline phosphatase (ALP). **Materials and Methods:** Digital panoramic radiographs of 50 patients with the presence of pulp stones and suspected CAC were subjected to carotid artery and renal ultrasonography (USG) examination for the presence of vascular calcification and also to evaluate the alterations in serum CA, P, and ALP levels. Data were analyzed statistically using Chi-square test. **Results:** Panoramic radiographs of 50 patients showed 88.28% of teeth with the presence of pulp stones stones and 91% carotid arteries with calcification. The sensitivity of panoramic radiograph was greater than that of USG (93.67%), but the specificity of USG was more than the panoramic radiograph (44.44%) in detecting CAC. The prevalence rate of renal calcification on USG was 92%. The statistical difference between the patients with or without alteration in serum Ca levels was not significant ($\chi^2 = 0.581$ and $P = 0.446$). On comparison of serum P and ALP, the difference was found to be statistically significant. **Conclusion:** Presence of pulp stones and CAC's on panoramic radiograph have remarkably proved to establish the chances of renal artery calcification associated with alterations in serum CA levels.

Keywords: Carotid artery, dental pulp calcification, panoramic radiography, ultrasonography

Introduction

Human body tissues undergo continuous alteration morphologically, biologically, physiologically, and pathologically. In few exceptions, these alterations may be seen as calcification, that is the process in which the organic tissue becomes hardened by disorganized deposition of the calcium (CA) salts in the tissues and this may occur in arteries, kidneys, lungs, brain, and even in the dental pulp tissue.[1] Pulp stones are discrete calcified aggregates that occur most frequently in the dental pulp. The pulp stones are detected accidentally during routine radiographic examination as discrete radiopaque masses which may exist freely within the pulp tissue or be attached to or embedded in dentine. Norman and Johnstone[2] suggested that these pulp stones form much in the same manner as calcification in arteriosclerosis and that they are the local manifestation of constitutional metabolic disturbance or dysfunction. Hypercalcemia is also regarded as a predisposing factor to this pulpal calcification.[3-5]

Vascular calcifications are common in carotid arteries causing cardiovascular diseases and the chronic kidney diseases in renal vasculature.[6] The carotid bifurcations are at the highest risk of atherosclerosis, where flow velocity and shear stress are reduced, and flow departs in a laminar, unidirectional pattern and such flow characteristics tend to increase the residence time of circulating particles in the bifurcations.[7] Carotid artery calcifications (CAC) can be detected on the panoramic radiograph below the

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mandibular angle and adjacent to the cervical vertebrae at the level of the C3–C4 intervertebral junction. Friedlander and Lande[8] first reported the incidence of calcified carotid atherosclerosis on panoramic radiographs and suggested that it may be a useful aid in detecting patients at risk of stroke.

Intrarenal vascular calcifications are seen as echogenic foci involving the second order and third order arterial branches extending into the renal sinus. Stenosis of renal arteries usually results from atheromatous lesions, and thus prevalence increases with age and with atherosclerosis at extracranial sites. The anatomic presence of the atherosclerotic renovascular disease is a threat to renal function since it leads to hypertension secondary to renovascular disease.[9,10] The interrelation between the atherosclerosis of renal vasculature and coronary artery disease has been proved by various studies. Recently, the elevated levels of serum CA, phosphorus (P) and their products are also seen associated with vascular calcification and the cardiovascular diseases in patients with the chronic kidney disease or prior cardiovascular disease. Alterations in the serum CA levels have also been reported as a powerful early predictor of clinical coronary artery disease and cerebrovascular events.[11,12] Thus, the purpose of this study was to evaluate the presence of pulp and CAC as a marker for renal calcification and altered serum biomarkers.

Materials and Methods

The Ethical Committee clearance was obtained from the Institutional Review Board, and the patient's consent was obtained prior to the beginning of this study. Digital panoramic radiographs were evaluated for the presence of pulp stones and CAC bilaterally.

Inclusion criteria
- Patients with the presence of pulp stones and CAC (simultaneously) detected on the digital panoramic radiographs
- Posterior teeth with the presence of pulp stones should be free from caries, restoration, prosthesis, and fractures.

Exclusion criteria
- Patients with edentulous arches, central nervous system disorders, and obscured panoramic images.

Study group
The study group comprised 50 patients (30 males and 20 females), age ranged of 30–60 years selected from the outpatient Department Oral Medicine and Radiology with accidental detection of pulp stones and CAC on digital panoramic radiographs. All the patients were further subjected to ultrasonography (USG) of carotid arteries and intrarenal vascular system along with serum biochemical analysis of CA, P, and alkaline phosphatase (ALP).

Panoramic images
Panoramic examinations were performed with ProMax II Digital Panoramic X-ray unit (Planmeca, Helsinki, Finland) exposed at 68 kV, 5 mA, and 16 s and interpreted using Planmeca Dimaxis Pro 4.1.4 software (Planmeca, Helsinki, Finland) for the presence of pulp stones and CAC.

Ultrasound scans
Carotid artery ultrasound was performed by high-resolution B-mode ultrasound system Philips HD-7 with a 7–9 MHz linear probe. The USG examination sequence included the transverse and longitudinal scan of the carotid system, followed by a detailed longitudinal examination of the specific arterial segments for the presence of CAC. The renal scans were obtained using a 3.5–5 MHz real-time transducer probe for the presence of renal calcifications. Both right and left carotid arteries were assessed by an experienced sonologist.

Serum biochemical analysis
Two milliliters of the venous blood was collected and centrifuged to separate the serum. Serum Ca, P, and ALP were evaluated using Span BT-1000 fully automated package tester (TM electronics, Boylston, Massachusetts, USA).

Interpretations
On the digital panoramic radiographs, pulp stones were interpreted[8] as discrete radiopaque masses within the coronal pulp chamber of maxillary and mandibular molar teeth. CAC were interpreted as nodular, punctate, or vertico-linear radiopacities in the soft tissues of the neck postero-inferior to the angle of mandible, at the level of the lower margin of C3 and C4 vertebra, adjacent to the epiglottis and the hyoid bone; either above or below it [Figure 1]. On USG examination, CAC were interpreted as echogenic foci around the carotid bifurcation area and renal calcifications as echogenic foci within the renal sinus with acoustic shadowing [Figures 2 and 3].

Statistical analysis
The data obtained was analyzed using SPSS Software (Statistical Package for Social Science, IBM Corporation, N.Y, U.S.A) version 11.5 for windows to evaluate the accuracy of panoramic radiograph and ultrasound for CAC, validity of both tests, that is, sensitivity, specificity, and percentage accuracy was performed. The correlation of calcifications and the biochemical parameters were analyzed using Chi-square test.

Results

On panoramic examination of the 50 patients, the total incidence of teeth with pulp stones was found to be 88.28%, that is, 407 out of 467 teeth (44.90% - left and 43.38% - right) [Table 1]. Out of 50 patients with evidence of pulp stones and CAC on panoramic images, 46 patients on ultrasound examination showed the confirmatory presence of CAC.

Among 100 carotid arteries evaluated, 91% ($n = 91$) showed the calcifications on panoramic radiographs and 79% ($n = 79$) on USG. Detection of CAC on panoramic radiographs and USG showed 93.67% and 81.32% of sensitivity, 19.05% and 44.44% of specificity, and percentage accuracy of 78% and 78%, respectively, [Table 2].

Renal USG of all the patients showed an acoustic shadowing of calcifications in only 46 patients. Among 46 patients ($n = 92$), 22 had bilateral calcifications ($n = 44$), 11 had calcifications in the left kidney ($n = 11$), and 13 had calcifications in the right kidney ($n = 13$).

When the above results were correlated, 43 patients out of 50 in the study population had pulp stones, CAC and renal

Figure 1: Panoramic image showing pulp stones and carotid artery calcification

Figure 2: Ultrasonography showing hyperechoic foci suggestive of carotid artery calcification

Figure 3: Ultrasonography showing hyperechoic foci suggestive of renal calcification

calcifications. Among these patients 19 (44.19%) showed increased serum Ca levels ($\chi^2 = 0.581$ and $P = 0.446$), 3 (6.98%) patients showed increased serum P ($\chi^2 = 31.837$ and $P = 0.000$), and 5 (11.63%) patients showed increased serum ALP levels ($\chi^2 = 25.326$ and $P = 0.000$) [Table 3].
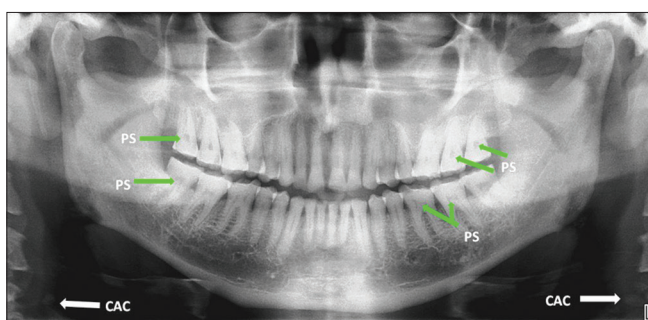
Discussion

The Panoramic radiography is a method that uses low doses of radiation, is of low cost, and technical simplicity that makes it extremely useful in identifying the soft tissue calcifications of the head and neck, such as pulp stones, sialoliths, CAC, tonsiloliths, triticeous cartilage calcifications, and calcified lymph nodes.[13]

In this study, the presence of intrarenal calcifications among the patients with pulp stones and CAC was assessed. The total incidence of pulp stones on panoramic radiograph was found to be 88. 28% which was much more than the previously reported studies since variations in the incidence of pulp stones determined by geographical areas, ethnicity, lifestyle, dietary factors, etc.[14,15]

Atheromas are the base plates of atherosclerosis, especially constituted of lipids and fibrous tissue, which are deposited on the carotid arterial walls and become calcified, making it feasible to identify them easily on routine panoramic radiographic examinations.[13]

In the present study, 91% and 71% of carotid arteries were detected with calcification on the panoramic radiographs and the USG examination, respectively. The prevalence of CAC was found to be higher in males than females, and this could be due to the higher distribution of males in the study population. The another fact support this higher incidence is that males show a high shared risk factors for atherosclerosis, that is., high levels of low-density lipoprotein cholesterol, elevated triglyceride levels, diabetes, hypertension, cigarette smoking, and increased body mass index.[16] The presence of bilateral calcification was found to be significantly higher than unilateral occurrence, which was in agreement with the previous studies.[16,17] Since the different arteries within the same individual are exposed to the same environment and also due to the similarity in total wall volume and plaque calcification, the atherosclerotic plaque development might progress at same rate bilaterally in the left and right atherosclerosis of human carotid arteries which resulted in the bilateral occurrence of atheromas.[18]
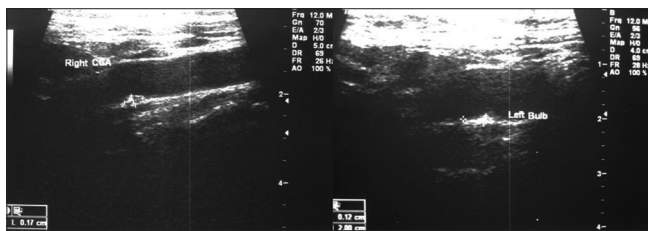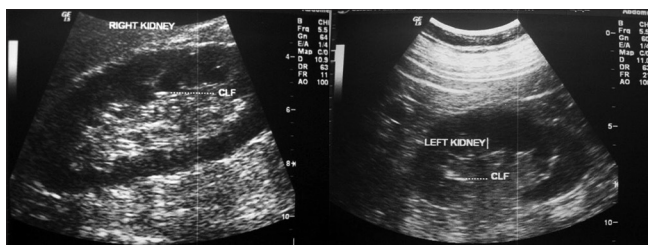
Table 1: Demographic data of PS on panoramic images

Gender	Left		Right		Total	
	Teeth observed	Teeth with PS (%)	Teeth observed	Teeth with PS (%)	Teeth observed	Teeth with PS (%)
Total	228	207 (44.90)	233	200 (43.38)	461	407 (88.28)

PS: Pulp stones

Table 2: The result of interpreting panoramic radiographs and ultrasound scans for detection of CACs in 100 carotid arteries of 50 patients

	Ultrasound scans (%)		Total (%)
	Present	**Absent**	
Panoramic radiographs			
Present	74 (74)	17 (17)	91 (91)
Absent	5 (5)	4 (5)	9 (9)
Total	79 (79)	21 (21)	100 (100)

CACs: Carotid artery calcifications

Table 3: Comparison of serum biomarkers with total patients with calcifications (PS, carotid artery and renal calcification)

Serum biomarkers	Total patients with calcification	Number of patients with +ve serum biomarkers (%)	Number of patients with −ve serum biomarkers (%)	χ^2	*P*
Calcium	43	19 (44.19)	24 (55.81)	0.581	0.446 NS
Phosphorus	43	3 (6.98)	40 (93.02)	31.837	0.000 VHS
ALP	43	5 (11.63)	38 (88.37)	25.326	0.000 VHS

NS: Not significant; VHS: Very highly significant; ALP: Alkaline phosphatase; PS: Pulp stones

The sensitivity of panoramic radiography was found to be more than USG, whereas USG was more specific in detection of CAC, which is consistent with the previous studies.[16] The fact might be due to radiopacities of various anatomic, and pathologic structures are seen in the region of C_3–C_5 vertebrae misinterpreted as CAC on panoramic images.[19,20] In this study, ultrasound scans detected a few calcification which were not observed on the panoramic radiographs as reported in previous studies.[21] This could be due to the fact that ultrasound is considered as gold standard and the most accurate noninvasive screening method short of angiography in the detection of CAC.[6,22] In the present study, the percentage accuracy of digital panoramic images and ultrasound in the detection of CAC was equal which is consistent with the previous studies.[21,23]

Atherosclerotic renal disease is frequently associated with other cardiovascular complications. According to Kane and Manco[24] renal artery calcifications must be suspected in patients with increased atherosclerosis. For this reason, the presence of renal arterial disease may be considered a risk marker for all-cause and cardiovascular mortality.[25] In this study, the prevalence rate of renal calcification by USG among the 50 patients was 92% which was much more than reported by various authors.[10,24] The difference in the prevalence rate of renal calcification by USG may be due to ethnicity, dietary factors, lifestyle, and other risk factors for the development of atherosclerosis.[15,26] Furthermore, the bilateral occurrence was found to be more common than unilateral which may be due to the reason stated above.

Vascular calcifications are known to be a multifactorial condition that involves macro and micro mineral imbalances involving serum CA, P, and ALP.[27,28] Many authors have quoted correlation of altered serum biomarkers with vascular calcifications.[29] In our study, the increased serum CA levels

were observed remarkably than the serum P or ALP, which is in agreement with the previous studies.[30-32] This could be due to the higher levels of serum CA levels found in atherosclerotic patients and CA, which may directly or indirectly and adversely influence the balance of skeletal and extraskeletal calcification.[30,31]

In the present study, on comparing the serum biomarker levels among the patients with pulp calcification, CAC and renal calcification, there was marked alteration of serum CA levels in 19 patients which was statistically not significant [Table 3]. Further studies with larger sample size are required to ascertain these parameters.

Conclusion

We can state that if the patient is detected with multiple pulp stones, further evaluation for CAC and renal calcification is required. Hence, the present study might widen the perspectives to a possible interdisciplinary partnership approach where properly trained and informed dentists can advise their patients for necessary steps to be taken in order to receive a correct medical treatment and prevent the risk of cerebrovascular and cardiovascular events.

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Nil.

Conflicts of interest
There are no conflicts of interest.

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