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Original Article

Assessment of carotid calcifications on digital panoramic radiographs: Retrospective analysis and review of the literature

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ABSTRACT

Objectives: To assess the validity of digital panoramic radiographs as an effective means of diagnosis for atherosclerosis and as a potential aid in the early detection of the disease.
Study design: We reviewed 2014 digital panoramic radiographs taken throughout 2012 and 2013 to identify the presence of calcified atherosclerotic plaques of both female and male patients all aged over 18 years. In addition the medical records of these patients were reviewed in order to establish if there were any predisposing risk factors for atherosclerosis. Statistical analysis was performed to identify any possible link between radiographic atherosclerotic plaques and predisposing risk factors for atherosclerosis using univariate and multivariate models. Statistical significance criteria was defined as $P < 0.05$.
Results: Out of 2014 patients (1149 female and 865 male), 191 (9.5%) were determined to have calcified atherosclerotic plaques on panoramic radiography. There was a statistically significant relationship between the presence of calcified atherosclerotic plaques and the established risk factors of atherosclerosis such as gender (OR = 2.39, $P < 0.001$), age (OR = 1.5, $P < 0.001$), stroke (OR = 5.38, $P < 0.001$) and hypertension (OR = 2.11, $P < 0.001$).
Conclusion: To our knowledge this is the largest study investigating atherosclerotic plaques on digital panoramic radiographs ever carried out in Portugal. Dental practitioners need to be aware of these incidental findings and to consider referring these patients for further investigations to confirm diagnosis.

1. Introduction

Cerebral vascular accidents (CVA) are the third greatest cause of death in industrialized countries [1], being considered one of the greatest public health problems due to their high incidence and the cost of physical and psychological rehabilitation of patients [2]. There are two types of CVA: hemorrhagic which occurs when there is rupture of a blood vessel in the brain and ischemic occurring due to the obstruction of arteries due to thrombosis [3].

When atherosclerosis occurs in arteries that supply blood to the brain, namely the carotid arteries, it can lead to a CVA, and when atherosclerosis develops in the arteries that supply blood to the heart a myocardial infarction may occur resulting in thousands of deaths annually [1,4].

Atherosclerosis is a chronic inflammatory disease associated, in part, with aging. It is characterized by narrowing and loss of elasticity of blood vessels, in which fatty deposits, called atheromas, adhere to the inner layers of arteries which in turn reduce blood flow [4]. The calcified atheromas are composed of lipids, calcium and fibrous tissue [5]. They start forming following the deposition of small cholesterol crystals that subsequently grow in size and volume, leading to increased calcium deposition and production of fibrous tissue by fibroblasts causing hardening of the arteries and resulting in the formation of the atheroma [6].

The presence of calcifications in the lateral areas of the soft tissues of the neck (especially in the bifurcation of the internal and external carotid arteries, located laterally and inferiorly to the hyoid bone) in maxillofacial images has received special attention since they were first observed and reported in 1981 [3].

There are several predisposing factors for atherosclerosis, many of which are similar to those associated with stroke. These include diabetes mellitus, obesity, hypercholesterolemia, hypertension,

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alcoholism, smoking status, menopause and history of cardiovascular disease [4,6].

In digital panoramic radiographs (DPRs), atherosclerotic calcifications of the carotids are described as a nodular and heterogeneous mass, independent of the hyoid bone and epiglottis, situated below, above or between the spaces of the intervertebral discs C3 and C4 or at a 45° angle to the angle of the jaw [1,2]. The diagnosis of atherosclerotic calcification by DPR requires acuity and experience on the part of the clinician, since it is possible to have false positives due to the proximity of radiopaque anatomical structures such as the triticeous cartilage [4].

Dentists frequently prescribe and report on DPRs and therefore are well placed to identify possible atherosclerotic plaques. Consequently, we intend to investigate more fully the relationship between atherosclerotic plaque on DPR and risk factors for atherosclerosis, to consider this as a possible aid to diagnosis.

2. Material and methods

We performed a retrospective descriptive analysis of 3843 patients (all patients seen in "Clinical Nova Saúde de Gandra" in the years 2012 and 2013). "Clinical Nova Saúde de Gandra" receives patients from the Oporto community who are self referred or referred by General Practitioners (GP) or General Dental Practitioners (GDP) to this Central University Clinic. Inclusion criteria consisted of individuals of both genders, aged over 18, who had undergone high quality DPR investigation, where the field included the cervical vertebrae and who had completed a screening form. Exclusion criteria were individuals under the age of 18, DPRs of poor resolution or which did not include the cervical vertebrae, clinical files with incomplete screening forms, and cases with unclear or missing data.

Prior ethical approval was obtained for the use and analysis of all clinical cases of patients for the years 2012 and 2013. The study was performed in full accordance with the World Medical Association Declaration of Helsinki. Data collection involved review of the patient's clinical record, where the following data was extracted: name, case number, age and gender. Later, after analysis of the screening form, data was collected related to diseases such as hypertension, hypercholesterolemia, diabetes, stroke, smoking and alcohol. Finally, we proceeded to the review the DPRs.

The DPRs were reviewed by two independent practitioners. Where there was disagreement, the practitioners would review DPRs together and reach consensus. Training and calibration was carried out before the x-ray analysis. The Kappa coefficient achieved by the practitioners was 0.8.

This study used DPRs performed using an Ortopantomographer Vatech Pax-400C and viewed with the digital program Easy Dent V4 Viewer 4.1.5.1. This programme offers manipulation of contrast and density, allowing for better analysis of the atheromatous plaques. We aimed to identify patients with atherosclerosis, who presented with plaques of calcified atheroma in the bifurcation area of the carotids. A positive finding of atherosclerotic calcifications was considered if one or more nodular and heterogeneous masses were present, independent of the hyoid bone and epiglottis, located immediately below, above or between the spaces of the intervertebral discs C3 and C4 or at an angle of 45 degrees to the angle of the jaw (Fig. 1).

Statistical analysis included descriptive statistical measures (frequencies, means and measures of dispersion) and inferential statistics (comparison of means and association between variables). Prior to the selection of statistical tests, the assumptions of the tests were checked. Specifically for comparing ages between subjects with and without atherosclerosis, the Student's *t*-test for independent samples was used. For this purpose, we combined using the Shapiro-Wilk test (which tests whether the distribution of the variable of interest is significantly different from normal distribution) with the visual inspection of the histogram and asymmetry values (Sk) and kurtosis (K). Where the results were deemed not to be normally distributed, we proceeded to use the alternative non-parametric Mann-Whitney test. To calculate the significance of the association between each of the variables and the presence of atherosclerosis, we used contingency tables. To test whether the differences between groups were statistically significant regarding each of the variable under study, chi-square tests were used if they met the test assumptions (i.e., the number of expected observations is less than 5 or 20% of all observations). Where we could not validate assumptions, we proceeded to use the Fisher test for determination of statistical significance. Finally, we proceeded to the construction of a multivariate model to test: (1) if the combination of the above variables significantly predicts the presence/absence of atherosclerosis; (2) which variables have a statistically significant relationship with the presence/absence atherosclerosis. To this end, we conducted a binary logistic regression model in which the variables gender, age, alcohol consumption, smoking, diabetes, stroke, hypertension and hypercholesterolemia were introduced as independent variables and atherosclerosis as the dependent variable. The multivariate model allows testing of the association of each variable with the

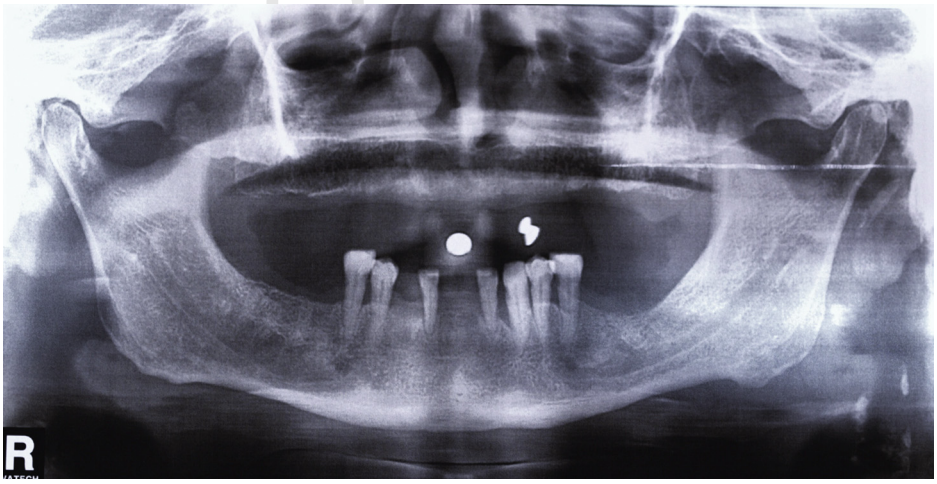

Fig. 1. Image of digital panoramic radiograph (DPR) of a male patient with 65 year-old showing small calcifications on the left side of the DPR.

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