Panoramic radiograph as a method for detecting calcified atheroma plaques. Review of literature

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Roldán-Chicano R, Oñate-Sánchez RE, López-Castaño F, Cabrerizo-Merino MC, Martínez-López F. Panoramic radiograph as a method for detecting calcified atheroma plaques. Review of literature. Med Oral Patol Oral Cir Bucal 2006;11:E261-6.

Received: 13-04-2005
Accepted: 2-04-2006

Indexed in:
-Index Medicus / MEDLINE / PubMed
-EMBASE, Excerpta Medica
-Indice Médico Español
-IBECS

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ABSTRACT

Cerebrovascular accident (CVA) is the third cause of death in industrialized countries, following cardiovascular disease and cancer. It is therefore a significant public health issue, not only due to its high incidence, but also to the high costs involved in the physical and psychological rehabilitation of these patients.

Dental Practitioners, as health care providers, ought to play their part in this issue and contribute, within their means, to the early detection of patients at risk of having a CVA.

Since the eighties, different authors have described the possibility of detecting calcified atheroma plaques located at carotid artery bifurcation through panoramic radiograph. In this way, the Dental Practitioner's possibilities in this field have been extended. However, this new use of panoramic radiograph must overcome certain obstacles before it is implemented as a new screening method for patients at risk of having a CVA. Amongst these, we would have, on the one hand, the assessment of the real clinical significance, as regards prognosis, of atheroma plaque calcification as well as its usefulness as a factor for predicting the appearance of CVA symptoms and, on the other hand, the possibility of making a correct differential diagnosis regarding other calcified structures that may appear on panoramic radiograph.

Key words: *Cerebrovascular accident (CVA), panoramic radiograph, atheroma plaques.*

RESUMEN

Los accidentes cerebrovasculares (ACV) constituyen la tercera causa de muerte en los países industrializados, tras la cardiopatía isquémica y el cáncer. Se trata pues de un importante problema de Salud pública, no sólo por su elevada incidencia, sino también por el alto costo que genera la rehabilitación física y psicológica de estos pacientes.

El Odontoestomatólogo, como profesional de la salud, debe implicarse ante esta situación y contribuir, dentro de sus posibilidades, a la detección precoz de los pacientes con riesgo de sufrir un ACV.

Desde la década de los ochenta, distintos autores han descrito la posibilidad de detectar las placas de ateroma calcificadas localizadas en la bifurcación de la arteria carótida a través de la ortopantomografía (OPG). De este modo, las posibilidades del Odontoestomatólogo en este campo han sido ampliadas. Esta nueva aplicación de la OPG, sin embargo, debe superar ciertos obstáculos antes de poder afianzarse como una nueva medida de cribaje de pacientes con riesgo de sufrir un ACV. Entre éstos estaría, por una parte, la valoración del auténtico significado clínico, a nivel pronóstico, de la calcificación de las placas de ateroma al igual que su utilidad como factor predictor de aparición de cuadros de ACV y por otra, el realizar un correcto diagnóstico diferencial con otras estructuras calcificadas que pueden aparecer en la ortopantomografía.

Palabras clave: *Accidente cerebrovascular (ACV), ortopantomografía (OPG), placas de ateroma.*

INTRODUCTION

Atherosclerosis is the primary cause of heart disease and stroke. In western societies, it is the underlying cause of about 50% of all deaths (1). Specifically, stroke or cerebrovascular accident is the third cause of death in the U.S.A. today, preceded only by cardiovascular disease and cancer. It is also the leading cause of severe disability, because 60% of the patients who survive a stroke suffer long-term physical and psychological disability (2, 3). Bearing in mind that approximately 700,000 strokes occur each year in the U.S.A., in 2005 the estimated direct and indirect cost has been 56.8 billion dollars (4). Not only in the U.S.A., but also in the rest of western countries, atherosclerosis and its more dramatic consequences - heart attacks and strokes - represent a significant public health issue. In Spain, although the rate of cerebrovascular accident death has declined over the past decades, it is still the second cause of death in men and the first in women (5). In view of such a significant problem, all measures aimed at preventing atherosclerosis, and early detection of all those patients at risk of cerebral isquemic attacks, are the main tools for reducing the prevalence of this disease. With regard to prevention, epidemiological studies have revealed several important environmental and genetic risk factors associated with atherosclerosis. After understanding the molecular mechanisms that connect altered cholesterol metabolism and other risk factors to the development of atherosclerotic plaque, it is now clear that atherosclerosis is not simply an inevitable degenerative consequence of ageing, but it is also a chronic inflammatory condition that may lead to an acute clinical event due to plaque rupture and thrombosis (1).

The search for an inexpensive and trustworthy system for early detection of patients at risk of a cerebrovascular accident (CVA) has produced disappointing results to date. Although duplex ultrasonography - the most accurate screening method short of angiography - is noninvasive, its cost-benefit ratio is unfavorable, even when limited to the population over the age of 65. Nevertheless, in high-risk groups, there are authors who consider that its use might be profitable (6).

The dentist's role in the prevention of this disease up until now has been based on identifying patients at risk of having a CVA, through the data collected on their medical history, assessing the factors associated with development of atheromas such as hypertension, diabetes mellitus, obesity, hypercholesterolemia, hypertriglyceridemia, smoking, sedentary life and coronary atherosclerosis. Dental Practitioners ought to advise patients with one or several risk factors in order to try to eliminate or control them. Moreover, they should refer them to their primary care physician if they suspect any likelihood of suffering an occlusive or thrombotic cerebrovascular accident (7).

Since 1981 (8), evidence has been found of a circumstance that could contribute to the early diagnosis of CVA. Taking into account that 85% of CVAs are isquemic, out of which 2/3 of are believed to be caused by thrombus and embolus formation in the region of the carotid artery bifurcation, this author postulates the possibility of using Panoramic Radiographs to identify calcified atheroma plaques at this bifurcation, which would be the cause of this embolus formation. These calcifications would appear as radiopaque nodular masses (Figure 1) or as two radiopaque vertical lines adjacent to or just below the intervertebral space between C3 and C4 (Figure 2).

In this review, we shall expound some of the most representative works that have been published following this first study in 1981, and try to evaluate the validity and scientific accuracy of such works. Finally, we shall examine the possibilities available regarding the use of panoramic radiograph as a screening test for those susceptible patients, in the light of the data collected to date.

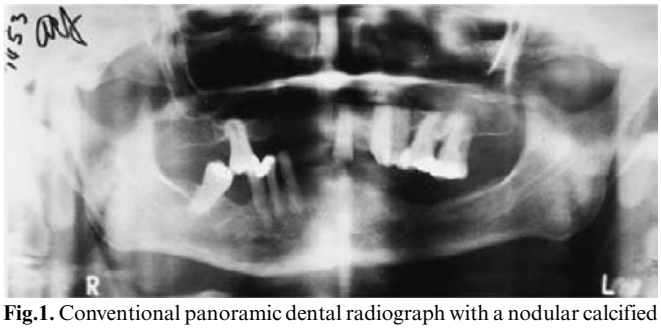

Fig.1. Conventional panoramic dental radiograph with a nodular calcified atheroma plaque, just to the right of the "L" marker. (Courtesy of Dr. Arthur H. Friedlander)

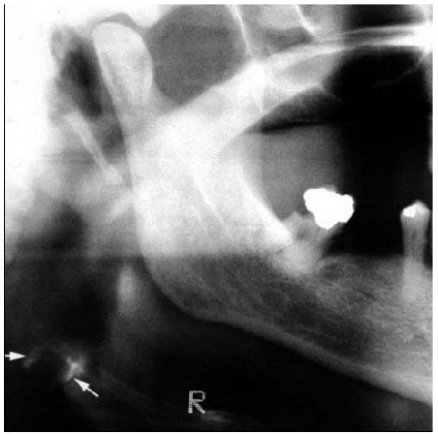

Fig 2. Panoramic radiograph that has been cropped, scanned and digitized to enhance the atherosclerotic process. Two radiopaque vertical lines are observed (arrows). (Courtesy of Dr. Arthur H. Friedlander)

REVIEW OF LITERATURE

In 1981, the Oral and Maxillofacial Surgeon Arthur H. Friedlander (8) for the first time published the possibility of identifying calcified atheroma plaques within the carotid artery on panoramic radiographs. Since then, he and other researchers have continued studying this phenomenon and

publishing the obtained results.
In 1994, Friedlander (9), in a population of 295 persons aged 55 or over, asymptomatic and with no history of either a transient ischemic attack or CVA, checks the presence of atheroma plaques by means of panoramic radiographs. Approximately 3% of this population showed carotid artery calcifications. This same author (10) publishes another study in which he examines 19 men aged between 57 and 76 who have a history of CVAs originating in the internal carotid artery, noting that 37% of the population studied showed calcified carotid arterial plaques on panoramic radiograph.
In 1997, L.C. Carter (11), in a retrospective study of 1,175 patients from a School of Dental Medicine at a North American University, with the average age of patients being 40.1, of which 45.7% were men and 54.3% women, detects that 3.6% (42 patients) of panoramic radiographs displayed calcifications in the area of the carotid vessels. In this study, the author avoids skewed results due to age, or other risk factors such as being a male, hypertension, obesity, hypercholesterolemia, elevated serum triglycerides, smoking or insulin-dependent diabetes mellitus. He simply determines the presence of carotid calcifications without previously selecting the patients. On the other hand, he tries to relate these calcifications to risk factors for developing CVA.
In this sense, only obesity had a statistically significant correlation with the presence of carotid calcifications on the panoramic radiography. The authors themselves admit that the small sample size of patients with carotid calcifications on their panoramic radiographs (n=42) may have prevented the identification of other correlations. Another possibility would be that, although the above-mentioned risk factors may predict the evolution of CVA, perhaps obesity is the most relevant factor regarding the development of calcifications in the arterial tree.
In 1999 J.S. Hubar (12) reported that carotid calcifications were not so frequent on the panoramic radiographs of the Afro-American population. He studied panoramic radiographs of 700 Afro-American males and females, finding that only three (0.43%) of the 700 patients, with ages ranging from 46-77, had one or more radiopacities compatible with carotid calcifications in the area between C3 and C4.
In the year 2002, S.H. Cohen (13) examined 1,879 panoramic radiographs of males over the age of 55 and 3.8% of them showed carotid calcifications.
A year later, T. Ohba (14) examined panoramic radiographs of 659 persons over the age of 80 (262 men and 397 women). 5% of this population was noted to have calcified atheromas of the carotid artery detected on their panoramic radiographs. The prevalence these authors found is slightly higher than previously informed. This fact must be explained by the increase in age of the patients studied.
In 2004, Almong D.M. (15) reviewed dental manuscripts published between 1981 and 2003 reporting the observation of carotid calcifications visible on panoramic radiographs. These studies documented a prevalence of 3% to 5% in the general dental population, being higher in risk population.

DISCUSSION

Despite the validity of all the data collected in the different reports, there are certain difficulties that would currently limit the use of panoramic radiographs as a new public health measure for detecting patients liable to suffer a CVA. 1º the questions arises regarding the significance of carotid calcification, that is to say, to what extent is calcium debris on atheroma plaques related to the development of cerebrovascular accident. 2º, it has been observed that the correct identification of these calcifications on panoramic radiograph is not an easy task, even if one is a professional in the dental field who is used to handling this diagnostical test. 3º, we have to bear in mind anatomical variations that may exist in the cervical area.
When reviewing the bibliography available regarding these difficulties, we find that, although there is no doubt that calcification can be detected in the extracraneal carotid arteries through this kind of dental radiograph, the presence of calcifications does not imply significant stenosis and, on the other hand, not all atherosclerotic lesions are calcified (16). In addition, the interrelation between calcification, atherosclerosis and development of clinical events is somewhat uncertain. As to coronary events, it seems to be that most clinical events result from plaque rupture and thrombosis in arteries whose lumen is only minimally compromised. There are also reasons which lead us to believe that calcification of arteries partly represents an adaptive phenomenon (16). In fact, certain biochemical data suggest that calcified areas of arteries are unlikely to rupture (17). Furthermore, it is not clear whether calcification, when detected, pinpoints a specific vulnerable site that leads to clinical disease (the "culprit lesion") or whether it is merely a marker for other diffusely dispersed atherosclerotic sites, the destabilization of which results in symptom development (17). It is likely that the limitations described regarding coronary events are comparable to cerebrovascular events. That is to say, that extracraneal carotid calcifications are not so easily correlationable with cerebrovascular accidents. Besides, it is necessary to remember that cerebrovascular symptoms are even more pleomorphic in their genesis than are cardiovascular symptoms. Whereas symptomatic coronary heart disease is almost exclusively the result of stenosis or atherothrombosis, cerebrovascular events may, in addition, result from emboli or hemorrhage. Furthermore, the circle of Willis provides an important collateral opportunity for blood to reach the brain when arteries proximal to it are stenotic or occluded (17).
There are, however, research works on this issue that have demonstrated a certain correlation between carotid calcifications and clinical events. Culebras and col. (18) found an association between the degree of carotid calcifications and luminal stenosis. Moreover, the presence of calcification was more commonly associated with severe stenosis than any other morphologic features of atheroma. The value of

carotid calcifications has also been reported as a predictor of vascular death in a homogenous population of Native Americans of the Gila River Pima Indian community in Arizona, finding that these calcifications were a significant predictor of cerebrovascular death (13). Should the correlation between carotid calcification and development of cerebrovascular clinical events be effectively demonstrated, it would be possible, through panoramic radiographs, not only to contribute to the early detection of patients at risk of CVA, but also to that of those at risk of heart failure.

As is stated before, another problem is the difficulty in the identification of the lesions, since, although panoramic radiograph is readily available in the dental community, professionals of this field are used to employing it as a complementary test when diagnosing many orodental pathologies, but not when detecting carotid calcifications as a contribution to early diagnosis of those patients at risk of CVA. This may be a more complex task than it may seem at first, because, although general dental practitioners are trained to identify and describe all visible structures on this radiograph (dentalveolar region, maxillar region, jaw region and temporomandibular joints region, including retromaxillar and cervical regions), we nevertheless have to admit that, in practice, they are more confident in the first three areas than in the last one. In addition, it would be possible to add that, with regard to detection of carotid calcifications, we are faced with a subject that has only been recently described, which means that at present practicing dental practitioners have not been appropriately instructed regarding this detection. On the other hand, those in their training period will probably not be instructed either until this recent description is completely established.

In order to illustrate what this difficulty would mean for us, we can first take a look at the material and methods used in the reports we have reviewed. All of them, whether explicitly, because it appears in the text, or implicitly, because it is inferred from its reading, present an expert maxillofacial surgeon or oral radiologist as the explorer (9-14). For example, in the report that Friedlander published in 1994 (9) it is specified that the radiographs were reviewed by an Oral and Maxillofacial Surgeon (A.H.F) looking for the presence of calcifications within the carotid artery. Moreover, they add that the author reviews more than 2,000 panoramic radiographs each year and has previously reported other data referable to carotid arterial disease. In L.C. Carter's report (11) it is stated that the oral and maxillofacial radiologist who reviews more than 3,000 panoramic radiographs annually, in consultation with other members of the author's group, was the one who interpreted all the radiographs.

Without any doubt, it is obvious that researchers who make these descriptions for the first time are experts on the subject; however, these same authors insist, as well, on the need for implementing this new early detection measure in dental offices, general dental practitioners being the ones who would put them into practice (9, 13, 16, 19-21). After all, their recommendation is logical since, if it is intended to be a public health measure, it should be carried out by general dental practitioners who are the persons who attend most of population. In our view, this is where the problem would arise, since the latter would not have the experience required for currently implementing this measure. In this sense, in the year 2000 (22), a very interesting study was published, which attempted to find out if the prevalence of calcified lesions of the carotid artery seen on panoramic radiograph might change if the examiner happened to be a general dental practitioner instead of an expert oral and /or maxillofacial surgeon. Previous recent studies had documented a prevalence of between 3% and 5% of carotid artery calcifications on panoramic radiograph of the general dental population and around 5% in a population aged 55 years or over (10, 11, 13-15, 19-21). From this premise, a study was designed to determine the interexaminer variability in the detection of calcifications of the carotid artery on panoramic radiograph. General dentists were previously trained for identification of these structures with the American Academy of Oral and Maxillofacial Radiology (AAOMR) training packet. The results found in this study are quite revealing. The first examiner, a second-year General Practice Resident identified 99 subjects, out of a total of 778, with suspected carotid artery calcifications. It would mean a prevalence rate of 12.7%. The second examiner, an Associate Professor of Prosthodontics, who, just like the first examiner, had also received the previous training described, identified 78 positive cases out of the 99 the first examiner had identified. This would mean a prevalence rate of 10.03%. Finally, the third examiner, an Associated Professor of Oral Diagnostics Sciences (who had given the brief training course to both previous examiners) reviewed the 78 suspected positive radiographs and reduced the list yet again, down to 27 individuals with positive radiographs, representing a prevalence rate of 3.5%. All but 5 were confirmed as positive with an anteroposterior cervical spine radiograph unless they had a carotid Doppler ultrasound done. If these cases are deleted from the study, the prevalence rate drops to 2.9%.

Except for the likelihood of these interexaminer differences being due to the two first examiners not making the most of the previous training course, the most probable cause, and which the referred report suggests, is the difficulty to carry out a correct differential diagnosis. Differential diagnosis of carotid artery calcifications includes both anatomical and pathological radiopacities. Amongst the anatomical ones are the hyoid bone (Figure 3), styloid process, calcified stylohyoid ligament, calcified stylomandibular ligament, calcified thyroid cartilage, calcified triticeous cartilage, epiglottis, soft palate, tongue, ear lobe, anterior tubercle of the atlas and vertebrae. Amongst the pathological ones are calcified lymph nodes, phleboliths, submandibular salivary glands sialoliths, loose body, tonsilloliths and calcified acne. Most of these structures are distinguishable based on their location and morphological features. Triticeous cartilage, however, is frequently confused with a calcified atheroma plaque (23).

Fig 3. Panoramic radiograph that has been cropped, scanned and digitized to enhance the atherosclerotic process. Two radiopaque vertical lines are observed (arrows). The small arrow delimits an area of plaque superimposed over the superior horn of the thyroid cartilage. (Courtesy of Dr. Arthur H. Friedlander)

In the study object of the report (22), triticeous and other laryngeal cartilage calcifications contributed to 82% of the misinterpretations. According to the authors of the study, the correct professional interpretation of carotid artery calcifications on panoramic radiographs has a tedious learning curve and may require seeking an opinion from an oral and maxillofacial radiologist (22).

In a similar study carried out by Rushton et al (24), it was proved again that radiologic interpretation of atherosclerosis detected on panoramic radiograph may not be often detected by a general dental practitioner. In this study, dental radiologists found evidence of carotid calcification on 9 out of 1,818 panoramic radiographs studied, whereas the general dental practitioner who examined the same panoramic radiographs failed to identify these calcifications.

Apart from the aforementioned, another chance of misinterpretation when diagnosing would be anatomical variations. The common carotid artery ascends to roughly the midcervical region, where it bifurcates into the external and internal carotid arteries. The location of this bifurcation varies slightly and may, in rare occasions, occur below its usual level and then fall outside the area covered by a clinically-acceptable panoramic radiograph (9, 10).

CONCLUSIONS

The possibility of detecting carotid calcifications through panoramic radiograph has been demonstrated among different populations, such as patients who have already suffered a CVA (3, 10), those who are at risk situation (9, 13, 14) and among normal outpatient population (11). The role of this test has also been studied regarding the detection of cervical atheromas in patients treated with therapeutic irradiation (25, 26). Likewise, the prevalence of carotid atheromas seen on panoramic radiographs of patients with obstructive sleep apnea syndrome (27) has been studied, as well as in patients with type II Diabetes Mellitus (28), postmenopausal women (29) and patients with dilated cardiomyopathy (30), who can be risk population as their prevalence is very high in patients who have already suffered a CVA.

All those risk factors for the development of atherosclerotic disease, as well as all associated pathologies, may be studied individually in their relation to the appearance of carotid calcifications on panoramic radiographs. Undoubtedly, it is a very extensive field that is full of possibilities for researchers interested in the subject. New lines of research have been opened and therefore, in the future, it will be possible to define the sensitivity, specificity and positive predictive value of panoramic radiograph as a method for detection of calcified atheroma plaques (21).

Finally, it would be interesting to emphasize that, if we wish to make the best of this useful discovery for the benefit of our patients, it would be essential to look for the necessary means to generalize this knowledge and appropriately train general dental practitioners. Perhaps new studies similar to those carried out by Almong (22) and Rushton are necessary (24) in order to get to know which attitudes should be taken.

We agree with the authors referred to throughout the report, that it is a significant measure for detecting stroke-prone patients. Moreover, this would not generate any additional cost in public o private health terms, as the radiographs are initially obtained for another diagnostic purpose, but they can, however, be used for this other purpose.

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