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Prof. Adrian Lussi
Klinik für Zahnerhaltung, Präventiv- und Kinderzahnmedizin
Freiburgstr. 7
3010 Bern

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Ich bedanke mich bei den unten aufgeführten Kolleginnen und Kollegen für ihre wertvolle Mitarbeit, die sie in den vergangenen zwei Jahren geleistet haben.

Adrian Lussi

Recognizing Calcifications of the Carotid Artery on Panoramic Radiographs to Prevent Strokes

Sonja Baumann-Bhalla*[1]
Roland M. Meier*[1]
Annika Burow[2]
Philippe Lyrer[2]
Stefan Engelter[2]
Leo Bonati[2]
Andreas Filippi[1]
J. Thomas Lambrecht[1]

* S. Baumann-Bhalla and R. Meier contributed equally to the present study (equivalent first authorships)

[1] Departement for Oral Surgery, Oral Radiology and Oral Medicine, School of Dental Medicine, University of Basel, Hebelstrasse 3, 4056 Basel, Switzerland

[2] Clinic for Neurology/Stroke Unit, Basel University Hospital, Petersgraben 4, 4031 Basel, Switzerland

Correspondence
Dr. med. dent. Roland Meier
Klinik für zahnärztliche Chirurgie, -Radiologie, Mund- und Kieferheilkunde, Universitätskliniken für Zahnmedizin, Universität Basel, Hebelstrasse 3, 4056 Basel
Tel. 061 267 26 10
Fax 061 267 26 07
E-Mail: R.Meier@unibas.ch

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Summary Panoramic radiographs are made routinely in dentistry and are regarded as a standard component of an initial dental examination. Often, these radiographs show opacities in the carotid artery territory (CAT), which frequently arise as a result of calcification in the internal (ICA) or external carotid artery (ECA). This study details the examination of patients with suspected calcifications in the carotid artery (CA), using a sonographic examination based on the panoramic radiographs to confirm or rule out a possible stenosis in the cervical bloodvessels.

Thirty-three patients were examined sonographically. Based on the ultrasound investigation in 4 patients, hemodynamic stenoses were detected. Eighteen patients had an atheroma in the ICA, but no hemodynamic stenosis, and 5 patients showed no sign of calcification. Three patients were not examined sonographically at the University Hospital in Basel and were therefore excluded from the evaluation. Three patients did not attend the sonographic examination.

The diagnosis of panoramic radiographs should not be restricted to teeth and jaws; especially in patients over 50 years old and in those with health risk factors, greater attention should be paid to the lateral areas. Using the radiographs they already have, dentists can also contribute to the prevention of cerebrovascular events.

Introduction

Stroke is the third most common cause of death in Europe, the USA, and most other countries world-wide (Fatahzadeh et al. 2006). Furthermore, it is one of the most important causes of permanent handicaps in adulthood (Fluri & Lyrer 2008). The most frequent cause of stroke is atherosclerotic plaque at the bifurcation of the common carotid artery (CCA) and the internal carotid artery (ICA) (Friedlander & Gratt 1994). Atherosclerosis is the most critical and frequent arterial alteration, manifesting as hardening, thickening, loss of elasticity, and narrowing (stenoses) of the arteries. Atherosclerosis develops predominantly at bifurcations, bends in the larger arteries, and in sections of the vessel behind stenoses. Hyperlipidemia, arterial hypertension, Diabetes mellitus (metabolic syndrome diseases), and nicotine abuse are recognized as risk factors. Atherosclerotic changes of the carotid artery (CA) are responsible for 5–10% of all strokes (Mahler et al. 2006). 50% of all strokes result from such changes in the vessel wall, which may remain symptom-free for years. In 1999, Hubar documented that extracranial calcification of the CA correlates with the risk of suffering an ischemic stroke and that 60% of thrombo-embolic strokes are caused by plaque buildup at or near the carotid bifurcation (Hubar 1999). Plaque morphology also plays an important role in assessing the risk of carotid stenoses. Various researchers have shown that echolucent plaques are associated with a higher ischemia risk than are echorich plaques (Polak et al. 1998, Mathiesen et al. 2001, Sztajzel 2005).

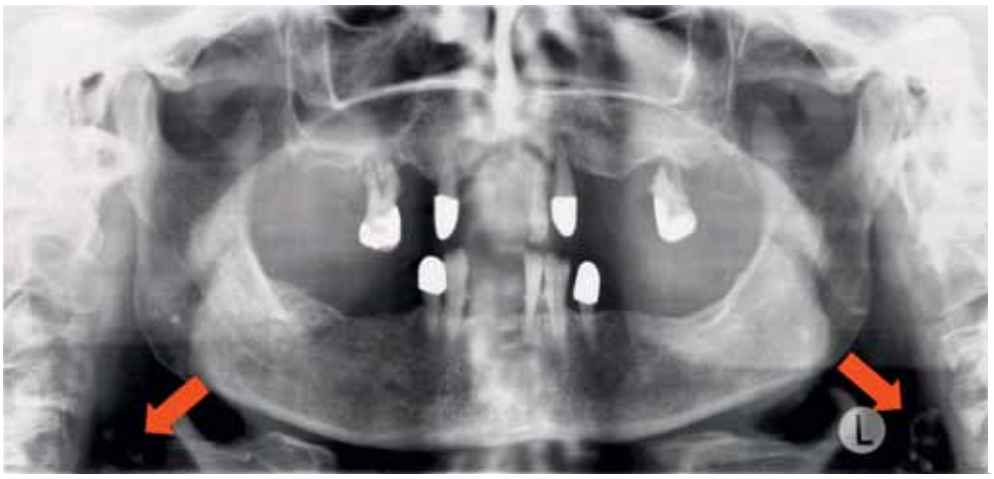

Fig. 1 Panoramic radiograph of a patient with bilateral calcifications in the CAT

Tab. I Possible differential diagnostic findings in the CAT

Differential diagnoses of radio-opaque structures in the CAT	
Anatomical structures	Calcified triticeous cartilage Calcified thyroid cartilage Hyoid bone Calcified stylohyoid ligament Calcified thyrohyoid ligament Epiglottis
Pathological changes	Calcified lymph nodes Calcifications of the CCA Phleboliths Submandibular sialoliths Tonsilloliths

Panoramic radiographs are taken as standard radiographs during initial dental examinations. Every year, approximately 200,000–300,000 of these panoramic radiographs are taken in Switzerland. These radiographs occasionally exhibit opacities in the carotid artery territory (CAT), which can occur both uni- and bilaterally (Friedlander & Friedlander 1998) (Fig. 1). Anatomic structures as well as pathological changes can cause such opacities (Tab. I). In terms of differential diagnostics, opacities in the CCA region are critical, because such calcifications may be markers of cerebrovascular and cardiovascular diseases (Cohen et al. 2002). The first article on this topic was published in 1981 (Friedlander & Lande 1981). The authors pointed out that not only must panoramic radiographs be examined for pathology of the teeth, temporomandibular joints, and adjacent structures, but that careful attention should also be paid to the lateral regions of the CAT, which may provide life-saving information. Since then, interest in this topic has grown steadily. Almog et al. showed that patients who exhibited visible calcification in the CAT on the panoramic radiograph demonstrated a significantly greater number of carotid artery stenoses, so that subsequent sonographic examination of the cervical vessels was recommended (Almog et al. 2002). Pornprasertsuk-Damrongsri & Thanakun also recommend that patients whose routinely acquired panoramic radiographs display carotid artery plaque be referred to a specialist for further diagnosis (Pornprasertsuk-Damrongsri & Thanakun 2006).

However, critical studies on this topic have also been published. Madden et al. showed that due to low sensitivity and predictive value, panoramic radiographs should not be considered reliable methods for diagnosing plaque or stenoses in the CAT (Madden et al. 2007). In addition, Damaskos et al. regarded panoramic radiographs as an unsuitable screening instrument. Nevertheless, because calcifications in the C3–C4 region indicate atherosclerotic stenoses of the carotid artery, the authors emphasized the importance of referring even asymptomatic patients to a specialist for further examination (Damaskos et al. 2008).

The structures analyzed in the present study are solely restricted to calcifications visible on panoramic radiographs in the region of the CCA. The purpose of the study was to determine whether calcifications of the carotid artery can be diagnosed as an ancillary finding on panoramic radiographs and whether the suspicion of such calcifications can be confirmed by sonographic examination of the cervical bloodvessels. The study did not intend to introduce a new screening method. Vascular sonography of the neck is taken as the gold standard for detecting carotid plaque.

Materials and Methods

As part of a previous dissertation at the University of Basel (Ariayi et al. 2009), 4007 conventional panoramic radiographs taken between 1992 and 2005 were retrospectively evaluated by a senior dentist with years of experience in dentomaxillofacial radiology. The panoramic radiographs were evaluated using the same x-ray viewer under standardized illumination. In 144 images, calcifications in the CAT were found with suspected calcification of the carotid artery. All panoramic radiographs taken at that time were done conventionally with the Cranex 3+ x-ray unit (Soredex OY, Finland). Kodak T – MAT G (Eastman Kodak Co, Rochester, NY, USA) film was used and developed with the Kodak M35 X-OMAT Processor (Eastman Kodak). The settings of the x-ray unit were selected according to the patient profile (63–81 kV, 6–10 mA). Exposure time was 19 seconds.

In the following study, the attempt was made to summon all 144 patients to have new panoramic radiographs taken and, in the case of suspected carotid artery calcification, undergo sonographic examination at Basel University Hospital. Possible calcification in the cervical bloodvessels was to be definitively confirmed or ruled out given the sonographic results. Because some of the initial images were almost 10 years old, many of the patients written to had moved away, died, or declined to participate in further examinations (Fig. 2). Forty of the 144 original patients responded that they would participate in a follow-up exam. Additionally, 11 more dental-clinic patients, whose panoramic radiographs exhibited CAT calcifications as

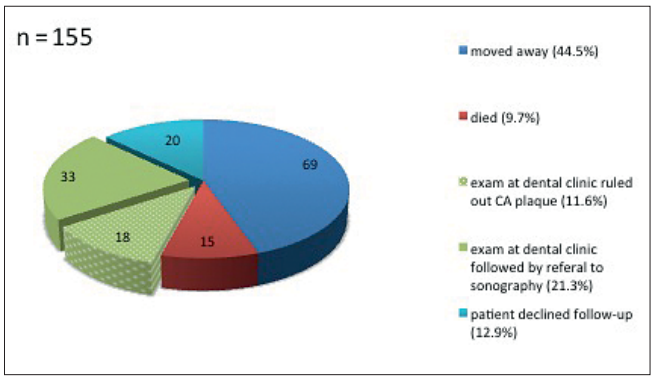

Fig. 2 Percent distribution of results from 155 patients invited to follow-up exams

ancillary findings, were integrated into the study between March 2010 and March 2011. Thus, 51 patients were included in the present study. As part of the dental examination at the Basel University Dental School, possible risk factors (history of hypertension, Diabetes mellitus, adipositas, nicotine abuse, hypercholesterolemia, myocardial infarction, or stroke) were recorded in addition to digitally taking panoramic radiographs (Scanora/Cranex D, Soredex OY, Tuusula, Finland); the new panoramic radiographs were taken digitally, because digital radiography has since replaced conventional methods. As before, the settings varied depending on the patient profiles (70–77 kV, 10 mA), but the exposure time had shortened to 11 seconds. Thanks to new options offered by digitalization, for instance, viewing digital images on a diagnostic monitor (Viewmedic RV-C219, resolution 1280×1024) or using the contrast setting, more exact analysis of the panoramic radiographs was possible. Particularly the CAT, which is so important for the evaluation, often appeared very dark on the conventional images. Thus, of the 51 patients examined here, only 33 (29 original and 4 recent) were referred with suspected carotid artery plaque for neurovascular sonography at Basel University Hospital's neurology clinic. Among the other 18 patients, the follow-up image no longer exhibited calcifications, or CA plaque could not be confirmed given the location of the suspected calcification; hence, the indication for sonography was no longer given or the patients did not wish to undergo sonographic examination. The digital panoramic radiographs were printed out with a dry imager (Fuji Drypix 1000), the calcifications in the CAT were marked with a permanent marker and given to the patient to present at the sonographic examination for exact localization of the finding. Thirty of the 33 patients referred to Basel University Hospital registered for a sonographic exam. Three patients had the sonographic exam done by a specialist closer to their place of residence, and not at Basel University Hospital. However, to ensure the comparability of the findings, the reports of these sonographic exams were not integrated into this study. Only the 27 patients who were sonographically examined at Basel University Hospital were included in the present study.

The stenosis degree of the ICA was estimated by doppler sonography. Both morphological and hemodynamic parameters were taken into consideration. The stenosis degree was determined particularly using hemodynamic criteria. Varying degrees of stenosis were distinguished: low-grade (< 50%), intermediate-grade (50–69%), and high-grade (70%).

All patients were informed in detail about the examination and the possible consequences of a positive diagnosis, and each patient signed an informed consent form. The study was approved by the ethics commission of Basel (No. 358/08).

Results

Rate of calcifications and stenoses

In 18 of 27 patients, the sonographic examination showed an atheroma in the CA area without hemodynamic stenosis. Four patients had hemodynamic stenoses in the CA area (Fig. 3), 3 of which were diagnosed as low-grade and 1 as intermediate (Figs. 3, 4 and 5). One of the 3 low-grade stenoses was an ECA

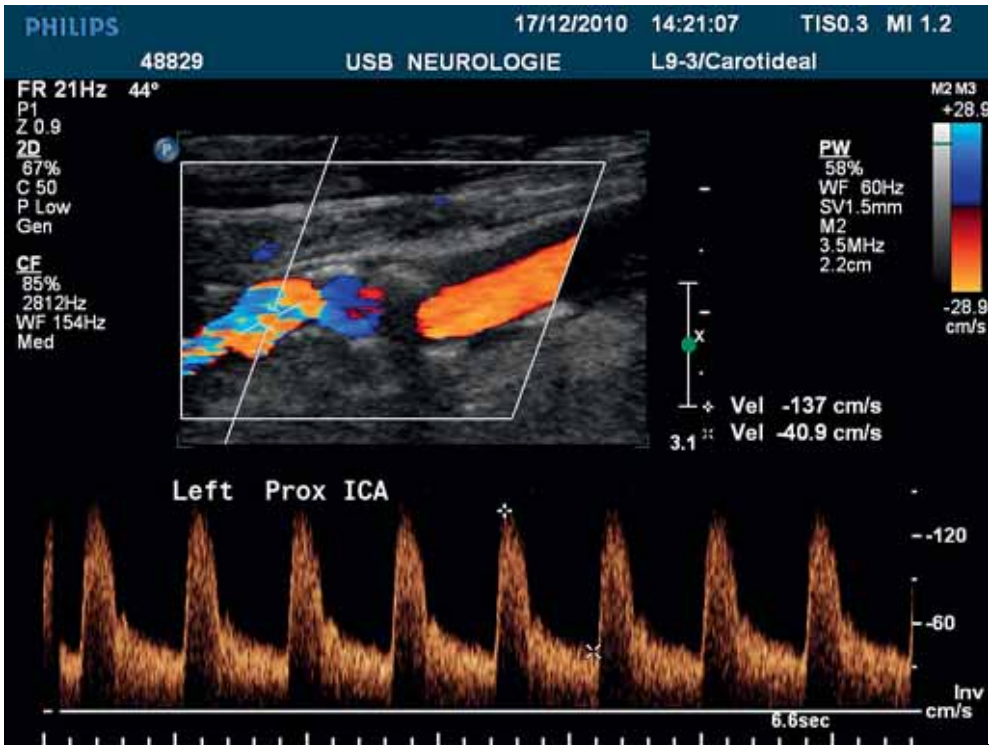

Fig. 3 Sonographic image: left proximal internal carotid artery with low-grade stenosis due to mixed ecogenic plaques

Fig. 4 Panoramic radiograph of a patient with sonographically confirmed, low-grade stenosis in the left carotid artery

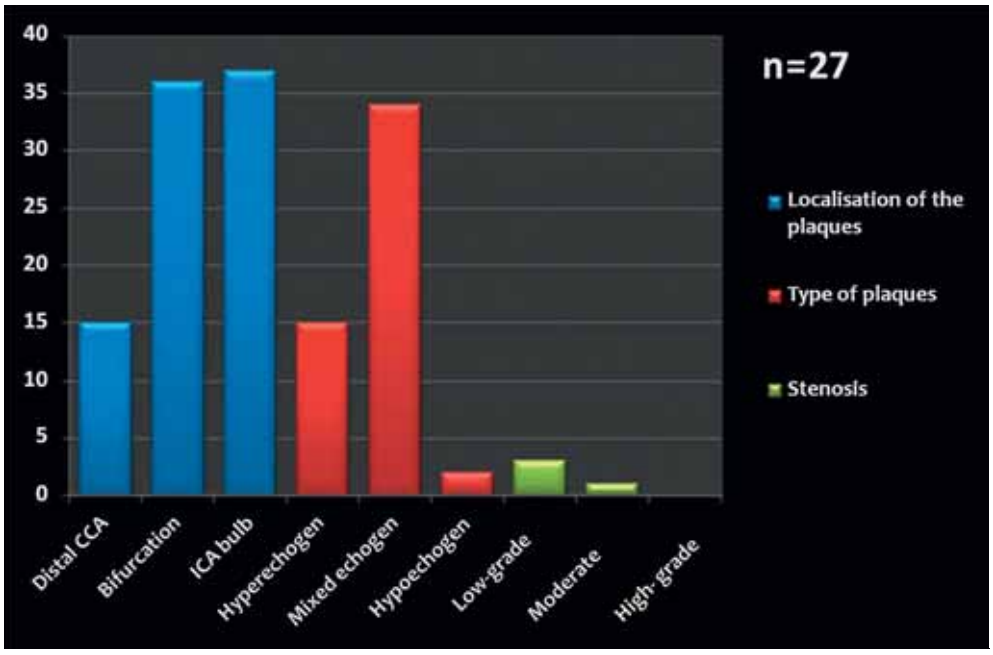

Fig. 5 Location (distal CCA, bifurcation, ICA bulb), morphology (hyperechogenic, mixed echogenic, hypoechogenic) and degree (low-grade, intermediate-grade, high-grade) of stenosis of carotid plaque

stenosis. No calcification was found in 5 patients (Fig. 6). Three patients were not examined at Basel University Hospital and were thus not considered in this analysis (1 patient had an intermediate-grade stenosis, 2 had no stenosis) (Fig. 6).

Location of plaque

Plaques were most commonly found in the ICA bulb area (n=37); 19 patients presented with this on the right side and 18 presented on the left. In the carotid bifurcation area, 19 patients were diagnosed with plaques on the right side and 17 with plaques on the left (n=36), while the fewest plaques (n=15) were found in the distal CCA area (right n=8, left n=7) (Fig. 5).

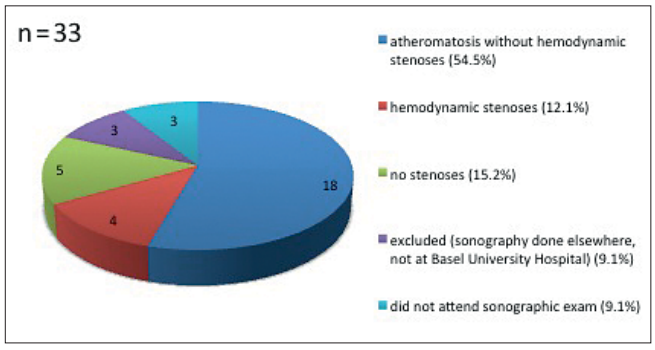

Fig. 6 Results of sonographic examination at Basel University Hospital

Plaque morphology

The majority of the patients demonstrated sonographically mixed echogenic plaque types (n=34). A largely echorich atheromatosis (Fig. 7) was found in 15 patients, but predominantly echolucent plaque types were found in only 2 patients (Fig. 5).

Age

The average age of the 27 patients who underwent sonography was 70.8 years. The women (n=12) were on average 73.8 years old; the average age of the men (n=15) was 68.4 years. The average age of patients with atheromatosis lacking hemodynamic stenoses was 72.3 years. The average age of the patient group without calcification in the carotid artery area was the lowest, 63.4 years, and that of patients with stenoses was the highest, 73.3 years.

General medical history

At the recall, several risk factors were anamnestically evaluated. Currently or in the past, 15 patients were addicted to nicotine. One-third of the patients (n=11) suffered from arterial hyper-

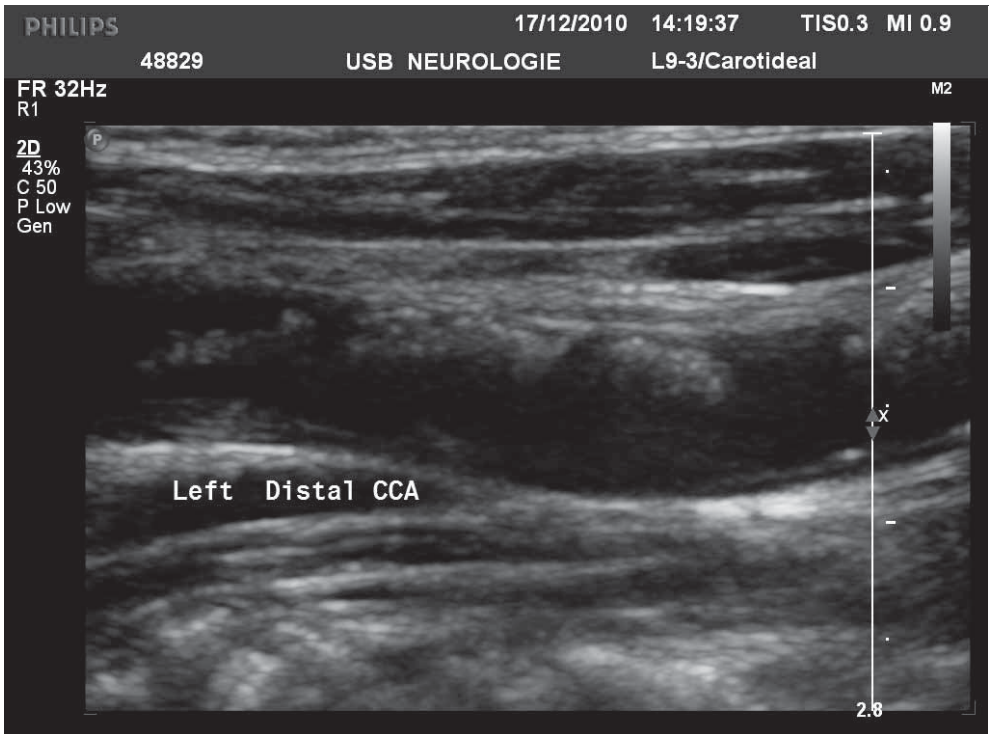

Fig. 7 Common carotid artery with predominantly hyperechogenic and mixed echogenic plaques

tension, 8 patients suffered from hypercholesterolemia and 6 from diabetes. Six of the patients examined had already suffered a myocardial infarction, and 1 had had an ischemic stroke. Rheumatological disease was recorded in 3 patients.

Medication

Both before and after participation in the study, 16 patients took antihypertensive medication. Prior to the study, 14 patients took coagulation inhibitors, and after sonographic examination, 15 did. At the start of the study, 10 patients were taking medication to lower cholesterol, and 13 patients did so after conclusion of the study.

Discussion

In the present study, the average age of the patients examined was 70.8 years. Looking more closely at each group, it is apparent that the group of patients with stenoses was also the oldest group, with a mean age of 73.3 years. Ariayi et al. indicated that the rate of soft-tissue calcification increases with age (Ariayi et al. 2009). Almog et al. also found that higher percentages of CA calcifications are observed in older patients (>55 years) (Almog et al. 2002). Mahler et al. noted that with increasing age, the prevalence of carotid stenoses also increases (Mahler et al. 2006).

Because the 27 patients who were referred to Basel University Hospital for sonography constitute a relatively small sample size, the evaluation was conducted purely descriptively. To increase the number of cases, additional patients were recruited from the dental clinics during the course of the study. Many studies in the literature were also conducted with a low number of patients (Almog et al. 2002; Madden et al. 2007, Griniatsos et al. 2009, Christou et al. 2010) (Tab. II). Examining 778 panoramic radiographs for CA calcifications, Almog et al. identified 27 patients with a positive finding who were then referred for sonographic diagnosis (Almog et al. 2002). The study design employed by Griniatsos et al. was just the reverse: in 40 patients with obstructive atherosclerosis of the carotid artery, panoramic radiographs were taken, showing plaque in 28 patients (Griniatsos et al. 2009). However, this demonstrates that not every atherosclerotic lesion can be confirmed radiologically by a panoramic radiograph.

In the current study, sonographic examination detected calcification of the CA – plaque with and without hemodynamic stenoses – in 22 of 27 patients (81.5%). Almog et al. found a somewhat lower percentage, 65%, in their study (Almog et al. 2002).

In their study, Fatahzadeh et al. drew attention to non-manipulable risk factors such as advanced age, male gender, ethnicity, and genetic predisposition (Fatahzadeh et al. 2006). Risk factors which can be influenced to a certain degree include arterial hypertension, diabetes, hyperlipidemia, adipositas, nicotine abuse, and atherosclerosis (Pornprasertsuk-Damrongsri & Thanakun 2006). In this study, the risk factors nicotine abuse, arterial hypertension, hyperlipidemia, and diabetes were found in 4 patients who exhibited a stenosis in the CA area, as was also the case in the group with calcification of the carotid artery. Male gender could not be confirmed as a risk factor. Two of these 4 patients with stenoses were women.

The sonographic exam had a therapeutic effect for some patients. After the exam, one patient was prescribed a thrombocyte-aggregation inhibitor, and 3 patients received medication to lower cholesterol. In some patients, cholesterol-lowering medication, thrombocyte-aggregation inhibitors, and anti-hypertensives were re-adjusted.

Calcifications of the CA detected on panoramic radiographs must be distinguished from other radio-opacities which, due to their topographical proximity to the CA, can also project into this area of the radiograph (Tab. I). Kamikawa et al. found that in a large percentage of patients, calcification of the triticeous cartilage was erroneously identified as an CA calcification (Kamikawa et al. 2006). Similarly, Pornprasertsuk-Damrongsri & Thanakun also call attention to mistaking calcified triticeous cartilage, thyroid cartilage, hyoid bone, and calcified lymph nodes for CA calcifications (Pornprasertsuk-Damrongsri & Thanakun 2006). For this reason, in differential diagnostics,

Tab. II Comparison of similar studies: Ariayi et al., Almog et al., Griniatsos et al., Christou et al., Madden et al.

Authors	No. of panoramic radiographs examined	Positive finding (visible calcification)	Study population	Study design	Special feature
Aryayi et al. (2009)	4007	144	$\bar{x}$* 71 years	Retrospective	Other calcifications also examined
Almog et al. (2002)	778	27	$\bar{x}$* 64 years	Retrospective	
Christou et al. (2010)	14	21,15 of these visible on panoramic radiograph	Stenoses of AC sonographically confirmed $\bar{x}$* 71 years	Prospective	Reverse study design (first sonography, then panoramic radiograph)
Griniatsos et al. (2009)	40	28	Artherosclerosis of AC confirmed $\bar{x}$* 70 years	Prospective	Reverse study design (panoramic radiograph taken before endarterectomy)
Madden et al. (2007)	52	25	Previously conducted sonographic examination $\bar{x}$* 67 years	Prospective	Reverse study design (first sonography, then panoramic radiograph)

* Mean age of patients examined

anatomical and pathological structures at or near the carotid bifurcation must always be taken into consideration (Tab. I). In 18 of the recalled patients, suspected CA calcification was not confirmed on the new panoramic radiograph. Either the calcification could no longer be radiologically detected on the second image or it could be differentially diagnostically ruled out based on its location or form.

One advantage of digital radiographs is that after they have been taken, it is possible to manipulate and improve the contrast. The ability to do so greatly facilitates the recognition of possible calcifications, because the areas of interest can be better visualized. Particularly the lateral areas of panoramic radiographs of the CAT, which are often very dark, can be adjusted on the screen. As a consequence of digital replacing conventional radiography at the Basel University Dental School, all panoramic radiographs at the follow-up examinations were done digitally. This enabled better diagnosis of the calcifications at the second examination. This also explains why calcification of the CA was no longer detectable or could be ruled out in 18 patients at the follow-up examination.

Seven of the patients examined in this study had already suffered a heart attack or stroke in the past. In these patients, sonography detected calcification of the CA but no hemodynamic stenosis. It bears mentioning that the risk of another infarction was greater when the patient had already suffered a stroke (Fatahzadeh et al. 2006).

The mortality rate due to strokes is predicted to double by the year 2020, because the proportion of older people in the population is growing (Warlow et al. 2003). Thus, preventing cerebrovascular events is becoming increasingly important. For medical and economic reasons, it is important to find cost-efficient measures that can contribute to reducing stroke-related morbidity and mortality.

From an economic point of view, it probably does not make sense to conduct preventive sonographic screening of the cervical bloodvessels in the broader population. However, where calcification is suspected, sonography is the gold standard among noninvasive diagnostic methods (Mahler et al. 2006). Cerebrovascular sonography proved helpful in the diagnosis of carotid calcifications in asymptomatic patients with advanced atherosclerosis (Wyman et al. 2005).

Based on the data presented here, we consider it important to more closely examine the numerous panoramic radiographs taken daily in Switzerland in terms of calcification in the CAT and then to refer potentially affected patients to a specialist for further diagnosis. In panoramic radiographs, dentists should not just look at the teeth and jaws but also pay more attention to the lateral areas of the radiograph, especially in patients over 50 years of age and in patients with risk factors. In this way, early recognition of calcifications in the panoramic radiograph can contribute to the prevention of cerebrovascular events.

Résumé

Les radiographies panoramiques dentaires sont faites régulièrement en dentisterie et sont considérées comme standard lors d'un premier examen chez le dentiste. Sur ces radiographies, on distingue souvent des ombres dans le domaine du soi-disant «territoire de l'artère carotide» (CAT), qui surviennent souvent en raison de la calcification dans l'artère carotide interne (ACI) ou externe (ACE). Dans la présente étude, un examen échographique a été initié chez les patients suspectés d'avoir une calcification dans le secteur de l'artère carotide d'après la radiographie panoramique. A l'aide de cet examen, une calcification probable des vaisseaux du cou pouvait être confirmée ou infirmée.

33 patients ont été envoyés à l'échographie. Basé sur l'enquête échographique, une sténose hémodynamique a pu être détectée. 18 patients montraient des athéromes dans les ACI, mais sans sténose hémodynamique. Cinq patients n'avaient pas de calcifications. Chez trois patients, l'échographie n'a pas été effectuée à l'hôpital de l'Université de Bâle, par conséquent ils ont été exclus de l'étude. Trois patients ne se sont pas présentés à l'échographie.

Lors du diagnostic de la radiographie panoramique, non seulement les dents et les parties des maxillaires doivent être jugées, mais il faut porter une plus grande attention aux domaines latéraux, en particulier chez les patients de plus de 50 ans présentant des facteurs à risque.

Les dentistes peuvent ainsi contribuer à la prévention d'événements cérébro-vasculaires grâce à une radiographie déjà disponible.

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