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Atherosclerosis and arteriosclerosis: two case reports of CBCT incidental findings

Aterosclerose e arteriosclerose: relato de dois casos de achados incidentais em TCFC

Aterosclerosis y arteriosclerosis: informe de dos casos de hallazgos incidentales de CBCT

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Abstract
Different types of vascular calcifications can be observed as incidental findings on Cone Beam Computed Tomography (CBCT) images. Atherosclerosis consists of atherosclerotic plaque accumulation, an inflammatory condition that can result in the narrowing of the blood vessel lumen. On the other hand, arteriosclerosis is the hardening of the artery wall, and Mönckeberg's arteriosclerosis, a non-obstructive calcification of medium and small-sized muscular arteries, is the most common type of arteriosclerosis. The aim of this paper is to report two cases of soft tissue calcifications observed on CBCT images. Case report 1: a 75-year-old female patient was scanned on CBCT unit KaVo OP 3D Pro for implant planning, and a unilateral radiopacity presenting high density and irregular shape was observed on soft tissues, located inferiorly and internally to the right gonial angle of the mandible, suggesting a calcified carotid atheroma. Case report 2: a 60-year-old female patient was scanned on CBCT unit KaVo OP 3D Pro for implant planning, and bilateral radiopacities presenting circular and elongated shapes with radiolucent interior and tortuous course were observed on soft tissues of the buccal aspect of the mandible, suggesting Mönckeberg's arteriosclerosis of the facial vasculature. Even though these soft tissue calcifications do not require specific treatment, their presence is commonly associated with patients at risk of cardiovascular and cerebral complications. Therefore, their recognition on CBCT images is of great importance, being the dental practitioner's responsibility to ensure a timely referral to the patient's medical physician for further assessment.
Keywords: Arteriosclerosis; Atherosclerosis; Carotid artery diseases; Cone-beam computed tomography; Monckeberg medial calcific sclerosis.

Resumo
Diferentes tipos de calcificações vasculares podem aparecer como achados incidentais em imagens de tomografia computadorizada de feixe cônico (TCFC). A aterosclerose consiste no acúmulo de placas ateroscleróticas, condição inflamatória que pode resultar no estreitamento da luz de vasos sanguíneos. Por outro lado, a arteriosclerose é o endurecimento da parede arterial, e o tipo mais comum é a arteriosclerose de Mönckeberg, uma calcificação não obstrutiva de artérias musculares de médio e pequeno calibre. O objetivo deste trabalho é relatar dois casos de calcificações de tecidos moles observadas em imagens de TCFC. Relato de caso 1: paciente do sexo feminino de 75 anos foi escaneada na unidade de TCFC KaVo OP 3D Pro para planejamento de implante, e uma radiopacidade unilateral apresentando alta densidade e formato irregular foi observada em tecidos moles, localizada inferiormente e internamente ao ângulo da mandíbula direito, sugerindo um ateroma de carótida calcificado. Relato de caso 2: paciente do sexo feminino de 60 anos foi escaneada na unidade de TCFC KaVo OP 3D Pro para planejamento de implantes, e radiopacidades bilaterais apresentando formato circular e aspecto alongado, com interior radiolúcido e curso tortuoso foram observadas em tecidos moles por vestibular da mandíbula, compatível com arteriosclerose de Mönckeberg da vasculatura facial. Embora essas calcificações de tecidos moles não requeiram tratamento específico, sua presença é comumente associada a pacientes em risco de complicações cardiovasculares e cerebrais. Portanto, seu reconhecimento em imagens TCFC é de grande importância, sendo responsabilidade do dentista garantir o encaminhamento do paciente para avaliação médica.
Palavras-chave: Arteriosclerose; Aterosclerose; Doenças da artéria carótida; Tomografia computadorizada de feixe cônico; Esclerose calcificante da média de Monckeberg.

Resumen
Diferentes tipos de calcificaciones vasculares pueden aparecer como hallazgos incidentales en imágenes de tomografía computarizada de haz cónico (CBCT). La aterosclerosis es la acumulación de placas ateroscleróticas, una condición inflamatoria que puede resultar en el estrechamiento de la luz de los vasos sanguíneos. Por otro lado, la arteriosclerosis es el endurecimiento de la pared arterial, y el tipo más común es la arteriosclerosis de Mönckeberg, una calcificación no obstructiva de las arterias musculares. El objetivo de este trabajo es reportar dos casos de calcificaciones de tejidos blandos observados en imágenes CBCT. Informe de caso 1: Una paciente de 75 años de edad fue escaneada en CBCT KaVo OP 3D Pro para la planificación de implantes, y se observó una radiopacidad unilateral con alta densidad y forma irregular en los tejidos blandos, ubicada inferior e internamente al ángulo de la mandíbula derecho, lo que sugiere un ateroma carotídeo calcificado. Informe de caso 2: Una paciente de 60 años de edad fue escaneada em CBCT OP 3D Pro de KaVo para la planificación de implantes y se observaron radiopacidades bilaterales de forma circular y apariencia alargada, con un interior radiolúcido y un curso tortuoso en los tejidos blandos bucales a la mandíbula, compatible con arterioesclerosis de la vasculatura facial de Mönckeberg. Aunque estas calcificaciones de tejidos blandos no requieren un tratamiento específico, su presencia se asocia comúnmente a pacientes con riesgo de complicaciones cardiovasculares y cerebrales. Por lo tanto, su reconocimiento en imágenes CBCT es de gran importancia, y requiere evaluación médica.
Palabras clave: Arterioesclerosis; Aterosclerosis; Enfermedades de las arterias carótidas; Tomografía computarizada de haz cónico; Esclerosis calcificante de la media de Monckeberg.

1. Introduction

Vascular calcifications are characterized by mineral deposits in the arteries' walls, consisting of biological processes that cause crystallization of hydroxyapatite in the extracellular matrix and in the cells of the media or intima of the arterial wall (Lanzer et al., 2014)]. Intimal layer calcification occurs in atherosclerosis and is characterized by diffuse arterial involvement (Stack et al., 2020), while medial layer calcification occurs in several diseases found under the umbrella of arteriosclerosis, Mönckeberg's arteriosclerosis (MA) being the most common one (Stack et al., 2020).

Atherosclerosis is a disease of elastic and large muscular arteries, and its lesion, atheroma, is associated with the enlargement of arterial intima with different components, such as lipids, connective tissues, inflammatory cells and extracellular components that can form cholesterol crystals (Dos Santos et al., 2021; Fishbein & Fishbein, 2009). The main complication associated with atheroma is acute and chronic obstruction of the arterial lumen (Dos Santos et al., 2021). The pathogenesis of atherosclerosis is related to injury or dysfunction of endothelial cells, determined by the risk factors associated with this disease, such as smoking, lipid-rich diet, sedentary lifestyle, diabetes mellitus and systemic arterial hypertension (Dos Santos et al., 2021). Since atherosclerosis is the number one killer in industrialized countries (Fishbein & Fishbein, 2009), it has been broadly reported and discussed in the literature.

Mönckeberg's arteriosclerosis (MA), also known as Mönckeberg's medial sclerosis, is a non-inflammatory degenerative condition of unknown etiology that was first reported in 1903 by German pathologist Johann Georg Mönckeberg (Thomas et al., 2021). MA is a non-obstructive calcification of medium and small-sized muscular arteries caused by the deposition of calcium in the form of crystalline hydroxyapatite in the tunica media (Berrigan, Rao, Francis, Beals, & Parashar, 2021). The arteries of the extremities are the most affected by MA, and a systemic distribution involving visceral arteries is uncommon (Pisani et al., 2018).

The prevalence of MA is estimated to be around 0.5% in adults (Pisani et al., 2018), affecting mostly patients with type 2 diabetes and chronic kidney disease, but it has been reported in young individuals with no underlying disease (Mowafy et al., 2019). The arterial blood changes seen in most MA patients is related to an alteration in the regulation of calcium and phosphate homeostasis, resulting in vascular smooth muscle cell changes (Berrigan et al., 2021), while its expression in young patients might be associated with dysregulated osteogenic commitment of vascular progenitors (Mowafy et al., 2019).

Even though the terms atherosclerosis and arteriosclerosis describe different lesions, they are often used interchangeably, and inappropriate practice of these terms have been reported in the literature (Fishbein & Fishbein, 2009; Schwartz & Mitchell, 1962).

2. Methodology

The present paper is a case study of qualitative nature (Pereira et al., 2018) aiming to provide detailed information regarding Cone Beam Computed Tomography (CBCT) assessment of two different types of soft-tissue calcifications, being one case report of atherosclerosis and one case report of MA.

This is a retrospective assessment of CBCT images and patient information recorded on University of São Paulo's database, approved by the local Research Ethics Committee under the number 3.239.265. The patients provided informed consent for the use of their anonymized CBCT images.

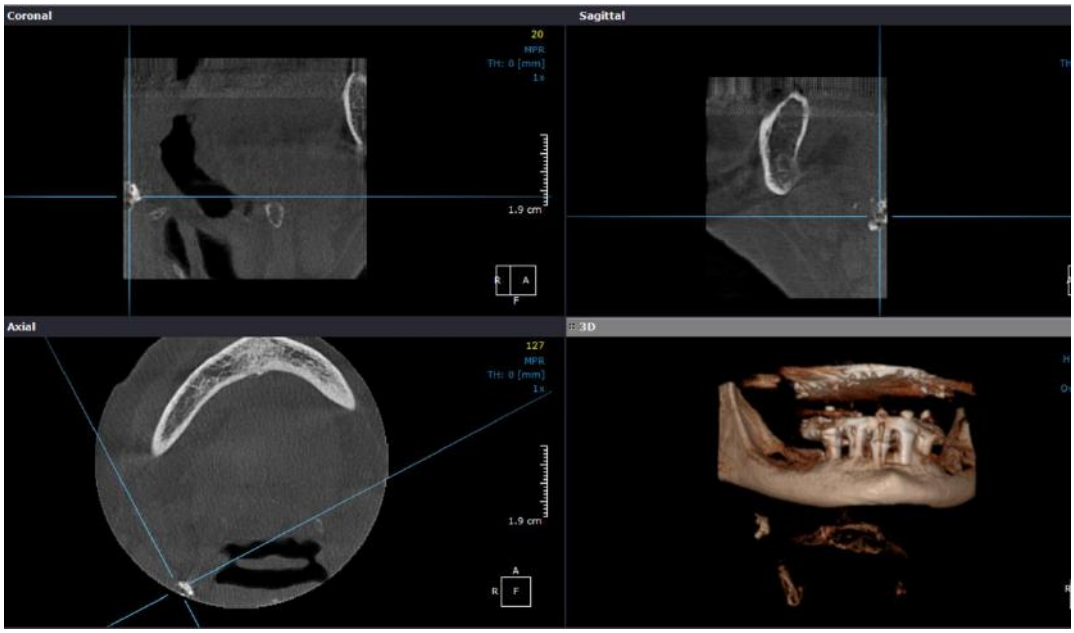
3. Case Report 1

A 75-year-old female patient was scanned on CBCT unit KaVo OP 3D Pro to assess the possibility of future implant placement in the mandible. The acquisition protocol was 10 mA (milliampere), 89.8 kVp (kilovoltage), 4.8 s in a field-of-view of 8x8 cm and with voxel size 0.3 mm. The images were part of University's database LAPI (Laboratory for Assessment and Processing of Images) and due to general data protection regulation, the images were anonymized and there was no information regarding the patient's medical history. The only available information was the patient's gender, date of birth and the primary reason why the scan was requested.

The images were exported in DICOM format and evaluated on OnDemand3D planning software (CyberMed,Seuol, Korea) by an experienced oral and dentomaxillofacial radiologist that assessed the region of interest on three main planes: sagittal, coronal and axial.

Radiographic interpretation revealed a complete edentulous mandible with generalized moderate horizontal bone loss and five osseointegrated implants located in the anterior region. Unilateral radiopacities presenting high density and irregular shape were observed on soft tissues, located inferiorly and internally to the right gonial angle of the mandible, posterior to the hyoid bone. These radiopacities were located in areas corresponding to the region where the common carotid artery bifurcates into internal and external carotid arteries, suggesting the presence of calcified carotid atheromas (Figures 1 and 2).

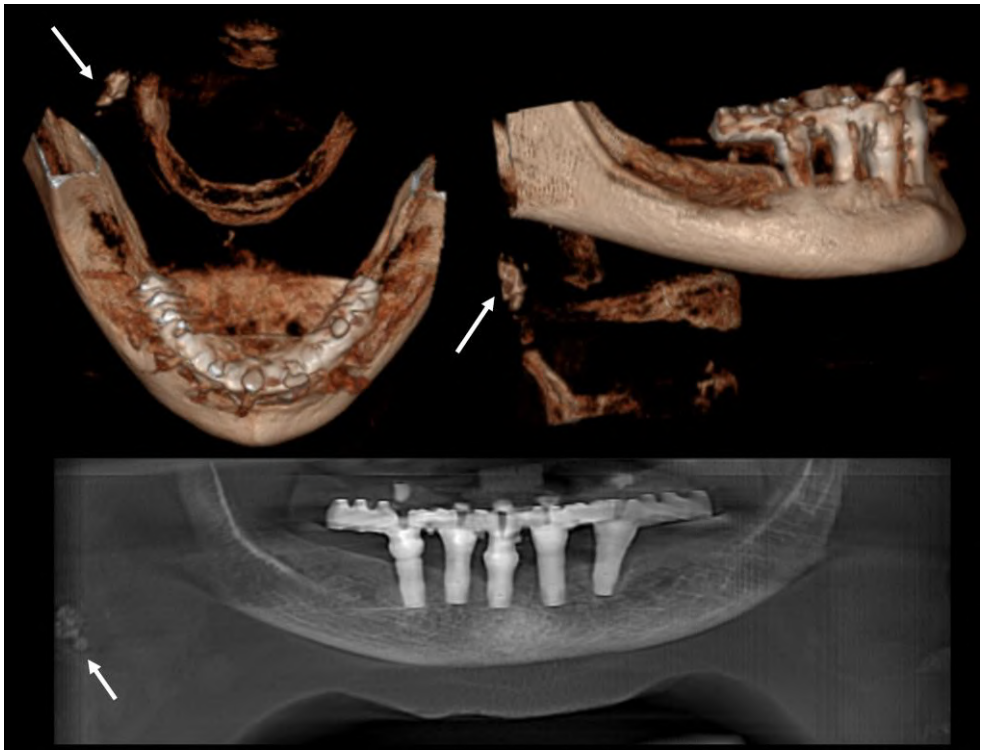
Figure 1 – CBCT Multiplanar reconstruction.



Source: Authors.

Irregular radiopacities located on soft tissues below the right side of the mandible (on the carotid area region) can be observed, presenting irregular shape and high density, suggesting calcified carotid atheromas.

Figure 2 – 3D reconstructions and panorama image showing irregular radiopacities located on soft tissues below the right side of the mandible (white arrows).



Source: Authors.

Irregular radiopacities located inferiorly and internally to the right gonial angle of the mandible, posterior to the hyoid bone, can be observed, suggesting calcified carotid atheromas.

4. Case Report 2

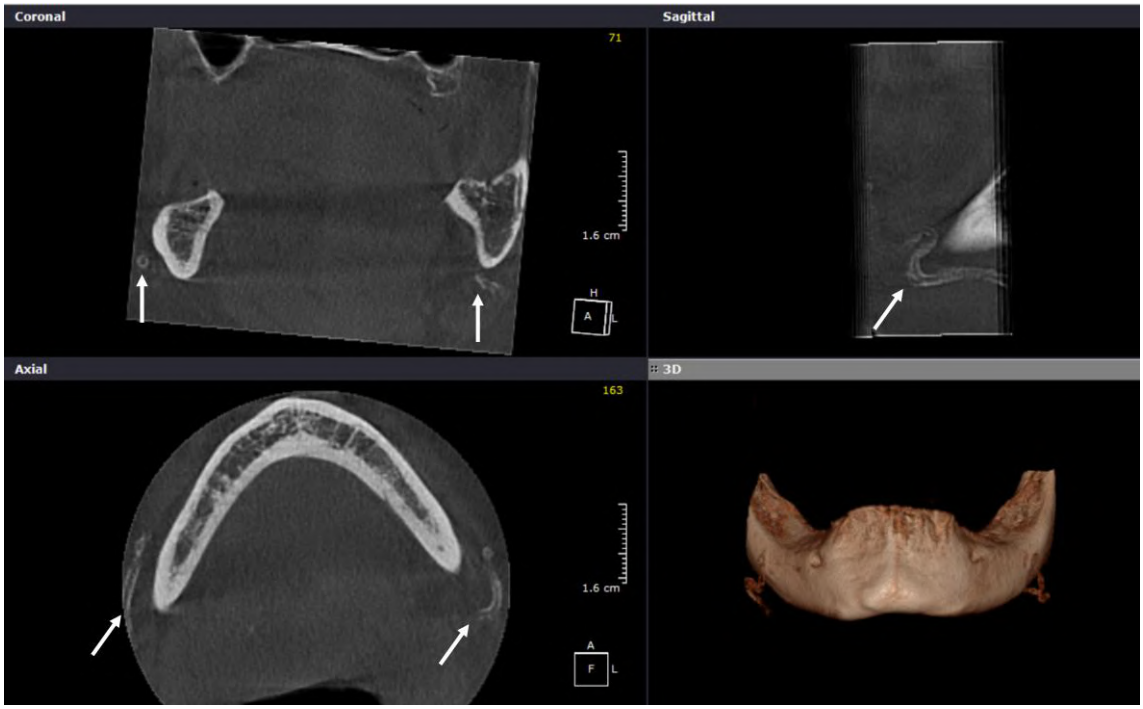
A 60-year-old female patient was scanned on CBCT unit KaVo OP 3D Pro to assess the possibility of future implant placement in the mandible. The acquisition protocol was 10 mA, 89.8 kVp, field-of-view of 8x8 cm, with voxel size 0.3 mm and 4.8 s exposure time. The images were part of University's database LAPI (Laboratory for assessment and processing of images) and due to general data protection regulation, the images were anonymized and there was no information regarding the patient's medical history. The only available information was the patient's gender, date of birth and the primary reason why the scan was requested.

The images were exported in DICOM format and evaluated on OnDemand3D planning software (CyberMed,Seuol, Korea), by an experienced oral and dentomaxillofacial radiologist that assessed the region of interest on three main planes: sagittal, coronal and axial.

Radiographic interpretation revealed a complete edentulous mandible with generalized moderate horizontal bone loss. Bilateral radiopacities presenting circular and elongated shape with radiolucent interior and tortuous course were observed on soft tissues, extending from the mental foramen region, where they were observed on the buccal aspect of the mandible, to the posterior region, where they were observed inferiorly and internally to the mandible base (Figures 3 and 4). These radiopacities

were located in areas corresponding to the right and left facial arteries, suggesting Mönckeberg's arteriosclerosis of the facial vasculature.

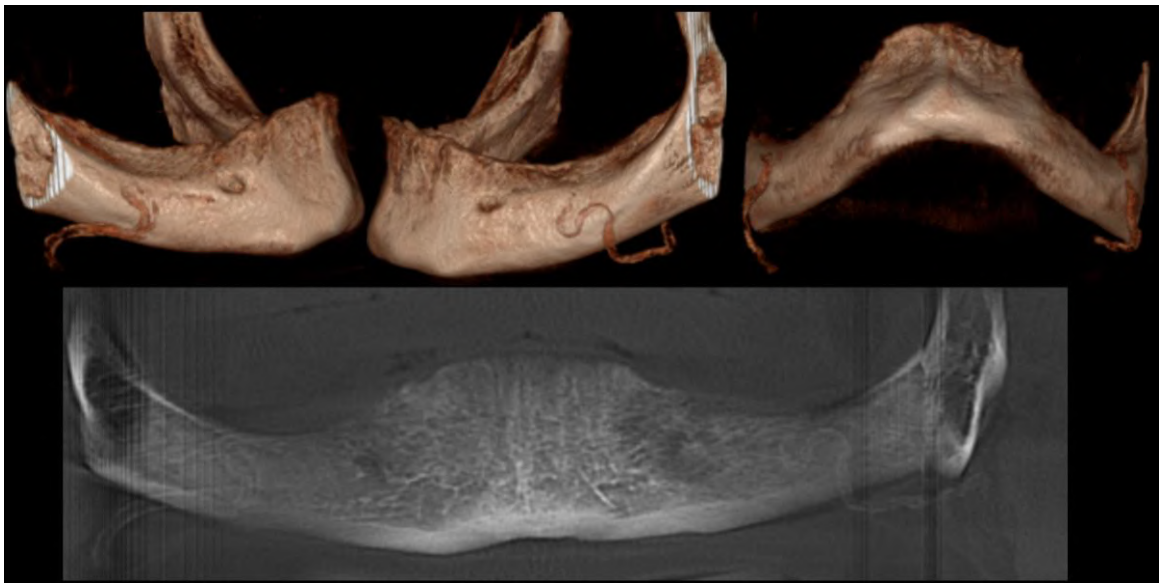
Figure 3 – Multiplanar reconstruction showing bilateral radiopacities presenting radiolucent interior and tortuous course (white arrows).



Source: Authors.

Well-defined radiopacities presenting circular and elongated shape with radiolucent interior and tortuous course can be observed on soft tissues of the buccal aspect of the mandible.

Figure 4 – CBCT 3D reconstructions and panorama image.



Source: Authors.

Bilateral radiopacities located on the buccal aspect of the mandible body can be observed, extending from the mental foramen region, where they are located on the buccal aspect of the mandible, to the posterior region, where they are located inferiorly and internally to the mandible base.

5. Discussion

CBCT is a three-dimensional diagnostic imaging method that was created specifically for assessment of the dentomaxillofacial complex. It originated from Computed Tomography (CT), but instead of using a linear array of detectors, CBCT emits X-rays in the form of a large cone that covers the area to be examined, being able to acquire all the information needed to reconstruct the region of interest without rotating as many times as CT (Nasseh & Al-Rawi, 2018).

CBCT imaging presents many advantages in relation to CT, such as lower cost, better spatial resolution (i.e., smaller voxels), lower radiation dose, and increased patient comfort and acceptance, due to the possibility of image acquisition in a seated position (Nasseh & Al-Rawi, 2018; Scarfe, Farman, & Sukovic, 2006). Currently, CBCT images are increasingly being used in various clinical applications, such as identification and location of pathological lesions, implant planning, temporomandibular joint imaging, orthodontic assessment, and endodontic diagnosis (Park et al., 2017). Notwithstanding, even though CBCT images are acquired for a specific clinical purpose, abnormalities outside the predetermined area of interest and unrelated to the initial purpose of the examination can often be found, being called incidental findings (de Onofre et al., 2021; Zinman et al., 2010), such as soft tissue calcifications.

The main limitation of CBCT concerns its lower contrast resolution that leads to less discrimination between different tissues such as bone, teeth and soft tissues (Adibi et al., 2012; Nasseh & Al-Rawi, 2018), making it difficult to distinguish the exact site of calcification in tomographic images, whether they affect arterial intima or media (Dos Santos et al., 2021). In such cases, the general location as well as the radiographic characteristics of the calcification must be carefully evaluated in order to determine the diagnostic hypothesis.

Vascular calcification, a term employed in the literature referring to ectopic calcifications in vascular territories, might be discovered as incidental findings on radiographs taken for medical or dental evaluation. In general, vascular calcifications are characterized by mineral deposits in the walls of the arteries, being divided into two types: intimal layer calcification and medial layer calcification (Stack et al., 2020).

Calcification of the tunica intima is associated with atherosclerotic plaque accumulation, an inflammatory condition that can result in the narrowing of the blood vessel lumen (Berrigan et al., 2021). Atheromatous lesion development consists of focal deposition of fat, primarily cholesterol, in the arterial intima, resulting in fibroblastic proliferation as well as calcium and salt encrustations. The variable proportion of these elements determine different morphological aspects and varying degrees of calcification, which are related to different clinical presentations and are associated with varying cardiovascular risks (Dos Santos et al., 2021; Friedlander & Lande, 1981). Recent studies have shown that carotid artery atherosclerosis affects approximately 21.1% of the population aged 30-79 (Song et al., 2020; Vieira et al., 2023).

Atheromatous lesions responsible for extracranial cerebrovascular disease usually occur at sites of arterial bifurcations, the most common location being the carotid bifurcation. The common carotid artery ascends within the neck to the mid-cervical region and bifurcates into internal and external carotid arteries in the region opposite to the upper border of thyroid cartilage (Friedlander & Lande, 1981). The precise location of this bifurcation can vary, possibly occurring either above or below this point, thus atheromatous lesions of this region can often appear as incidental findings on panoramic radiographs (Friedlander & Lande, 1981) and on CBCT images acquired for dental assessment. A recent study showed an association between elevated risk of cardiovascular diseases and calcified carotid artery atheromas observed on panoramic radiographs, proving that dental x-rays can be useful tools for identifying individuals without cardiovascular symptoms that are

at increased risk of cardiovascular diseases, and should be referred to a physician, in order to assess other potential risk factors, such as hypertension, obesity, diabetes and hyperlipidemia (Gustafsson et al., 2022).

Arteriosclerosis, on the other hand, consists of the hardening or stiffening of the artery wall, which might lead to increased systolic and pulse pressure, with consequent ventricular hypertrophy, a risk factor associated with cardiovascular disease mortality (Dos Santos et al., 2021; Johnson et al., 2006). The progressive stiffening of the artery wall can also lead to limited blood flow, clot formation and reduction in the perfusion of the organs (Thomas et al., 2021).

Mönckeberg's arteriosclerosis (MA) is the most common type of arteriosclerosis, being a degenerative, apparently non-inflammatory condition that primarily affects the tunica media of muscular arteries (Couri et al., 2005). Since there is no primary involvement of the intimal layer of the artery, there is minimal or no lumen narrowing of arteries affected by MA (Thomas et al., 2021), and the calcifications resulting from this condition can occur independently of atherosclerosis (Couri et al., 2005). The exact etiology of MA still remains unclear, but it is reportedly driven by hyperphosphatemia (Shioi et al., 2001) and frequently related to specific medical conditions such as type 2 diabetes, chronic kidney disease, autonomic neuropathy, osteoporosis, disorder of calcium, systemic lupus erythematous, phosphate metabolism and end-stage renal failure (Berrigan et al., 2021; Friedlander & Lande, 1981; Stack et al., 2020). The prevalence of MA is relatively unreported, but it has a tendency to be greater in males, and similarly to atherosclerosis, an important risk factor associated with MA is aging (Ho & Shanahan, 2016; Lanzer et al., 2014; Thomas et al., 2021). Both atherosclerosis and MA have risk factors in common and can cause problems regarding access, catheterization, angioplasty, re-entry techniques, clamping and anastomosis in surgeries and endovascular procedures (Dos Santos et al., 2021).

MA is diagnosed radiographically, typically seen as annular calcifications in soft tissues frequently described as "rail tracking", "tramlines", "railroad" or "train track", a characteristic configuration that is seen on the longitudinal aspect of the affected artery (Mowafy et al., 2019; Thomas et al., 2021). Since the calcification only affects the medial layer of the artery, it presents a diffuse circumferential shape associated with a preserved arterial lumen (Berrigan et al., 2021), also described as having a "ring-like" or "pipeline" appearance. In contrast, atheromatous lesions are reported to have splotchy appearance (Berrigan et al., 2021). The observation of MA of the facial vasculature on CBCT images is rare, and to the best of the authors' knowledge, there are only two cases reported on the literature (Berrigan et al., 2021; Vijayan & Potluri, 2020). The presence of these "rail tracking" calcifications on dental radiographic images warrants follow-up, and the dental practitioner should take them as a sign that the patient might present underlying systemic problems (Berrigan et al., 2021).

Even though these soft tissue calcifications observed on dental CBCT images can be considered incidental findings that per se do not require specific treatment, their presence might signal existing vascular diseases, being commonly associated with patients that are at risk of cardiovascular and cerebral complications. Therefore, their recognition on CBCT images is of paramount importance, being the dental practitioner's responsibility to ensure a timely referral to the patient's medical physician for further assessment (Damaskos et al., 2016; de Onofre et al., 2021).

6. Final Considerations

The present paper illustrated different aspects of two types of soft tissue calcifications that can be observed on CBCT images: atherosclerosis and arteriosclerosis, detailing radiographic features that should be noted by the dental practitioner assessing the CBCT images in order to facilitate the elaboration of differential diagnosis. It can be concluded that atherosclerosis and arteriosclerosis are vascular calcifications that might be observed in patients at risk of cardiovascular diseases, thus, dental practitioners must be able to recognize and identify both types of vascular calcifications on CBCT images, as they are incidental findings that require further medical investigation.

Future studies longitudinally assessing these conditions and correlating CBCT findings to the patient's clinical manifestations should be performed in order to further assess each type of vascular calcification and their implications.

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