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Medial Artery Calcification and Its Detection in Dental Radiographs

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Abstract

Medial artery calcification (MAC) has emerged as a significant predictor of cardiovascular morbidity and mortality, particularly in populations with chronic conditions such as diabetes and chronic kidney disease (CKD). This review examines the potential of dental radiographs as a non-invasive tool for the early detection of MAC, facilitating timely intervention in at-risk populations. By synthesizing current literature, we aim to elucidate the clinical implications of MAC detection in dental practice and its association with systemic cardiovascular risk factors.

1. Introduction

Medial artery calcification (MAC) is characterized by the deposition of calcium in the medial layer of the arterial wall, which is distinct from intimal calcification associated with atherosclerosis. Historically, MAC has been linked to various systemic diseases, including CKD and diabetes mellitus, where it serves as a marker for increased cardiovascular risk (1)(2). The recognition of MAC in dental radiographs presents a unique opportunity for early cardiovascular risk assessment, as dental imaging is routinely performed in clinical practice (3)

2. Background

The pathophysiology of MAC involves complex mechanisms, including vascular smooth muscle cell (VSMC) transdifferentiation into an osteoblastic phenotype, leading to calcification (4). Recent studies have shown that MAC is not merely a consequence of aging but an active process influenced by metabolic disorders and vascular inflammation (5,6). Understanding the implications of MAC is crucial, as it has been associated with adverse cardiovascular outcomes, including increased mortality rates in diabetic patients (7,8).

3. Methodology

This review adheres to the PRISMA 2020 guidelines, systematically evaluating literature published from 2019 to 2023. We included studies that investigated the detection of MAC in dental radiographs and its correlation with cardiovascular risk factors. Exclusion criteria encompassed studies not directly related to dental imaging or those lacking robust methodological frameworks.

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4. Dental Radiographs and Their Role in Detecting MAC

Dental radiographs, particularly panoramic radiographs, have emerged as a valuable tool in the detection of carotid artery calcifications (CAC), which are significant indicators of cardiovascular disease. Recent studies have demonstrated that these radiographs can effectively identify calcifications that may otherwise remain undetected during routine examinations. For instance, (Brar, 2024)(9) found a significant correlation between CAC detected on panoramic radiographs and the prevalence of cerebrovascular accidents and coronary artery disease, highlighting the potential of dental imaging in cardiovascular risk assessment (9). This underscores the importance of integrating dental radiographic evaluations into broader health screenings.

The radiographic appearance of CAC typically presents as radiopaque lesions adjacent to the carotid arteries, which can be identified during routine dental examinations. This characteristic has been supported by various studies, including those by Janiszewska-Olszowska et al. (2022)(10), who reported excellent specificity and good sensitivity of panoramic radiographs in detecting CAC compared to color Doppler ultrasonography (Janiszewska-Olszowska et al., 2022)(10). Furthermore, noted that the prevalence of CAC detected through different dental imaging techniques correlates with cardiovascular risk factors, age, and gender, reinforcing the relevance of dental imaging in identifying at-risk populations (Möst, 2023)(11).

Moreover, the role of cone-beam computed tomography (CBCT) in detecting intracranial and extracranial calcifications has been explored. Polat & Orhan (2022)(12)highlighted that while CBCT is effective in visualizing calcifications, it may not detect all atherosclerotic lesions, as some may remain non-calcified (Polat & Orhan, 2022)(12). This limitation suggests that while dental imaging is beneficial, it should be part of a comprehensive diagnostic approach that may include other imaging modalities such as magnetic resonance angiography and duplex ultrasound for a more thorough evaluation of cardiovascular health (Ahmed et al., 2021)(13).

The integration of dental radiographs into routine health assessments not only aids in the early detection of CAC but also aligns with the growing understanding of the interrelation between oral health and systemic conditions. Ibraheem (2023)(14) emphasized the importance of recognizing CAC in panoramic radiographs as a routine practice, as it can provide critical insights into a patient's overall health status (Ibraheem, 2023)(14). This perspective is increasingly supported by research that links periodontal health with cardiovascular conditions, suggesting that dental professionals play a crucial role in identifying systemic health risks through routine imaging (15).

5. Clinical Significance of Detecting MAC in Dental Practice

The detection of medial arterial calcification (MAC) in dental radiographs holds significant clinical implications for dental practitioners. By identifying these calcifications, dentists can serve as critical intervention points, facilitating referrals for further cardiovascular evaluations. This proactive approach is essential as it can lead to the early diagnosis and management of underlying cardiovascular conditions, ultimately improving patient outcomes (14). Recent

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studies have highlighted the importance of dental professionals in recognizing systemic health issues, aligning with the growing emphasis on integrated healthcare (16)

Recent literature underscores the prevalence of carotid artery calcifications (CAC) detected through dental imaging, particularly panoramic radiographs. Ibraheem (14) noted that the identification of CAC in dental practice is crucial, as it can indicate a heightened risk for severe cardiovascular events such as strokes and myocardial infarctions. Furthermore, Darwin et al. ((16)) emphasized that significant calcifications can lead to the narrowing of the arterial lumen, which is a critical risk factor for ischemic symptoms. These findings reinforce the necessity for dental practitioners to be vigilant in examining radiographs for signs of MAC, as early detection can prompt timely interventions. The integration of advanced imaging techniques, such as cone-beam computed tomography (CBCT), has further enhanced the ability to detect MAC and other calcifications in the maxillofacial region. Missias et al. (17) highlighted that atheromas, which are often visible in dental imaging, serve as important indicators for more severe cardiovascular conditions. The ability to detect these calcifications non-invasively allows dental professionals to play a pivotal role in the multidisciplinary management of patients at risk for cardiovascular diseases.

Moreover, the advent of artificial intelligence (AI) in dental radiography has shown promise in improving the detection rates of CAC. Amitay et al. (18) reported that AI algorithms could enhance the sensitivity and specificity of detecting carotid calcifications in panoramic radiographs, thus supporting dentists in making informed clinical decisions. This technological advancement not only aids in the identification of MAC but also streamlines the referral process for further cardiovascular evaluation.

6. Correlation Between MAC and Cardiovascular Risk Factors

Numerous studies have established a strong correlation between MAC and cardiovascular risk factors, including hypertension, diabetes, and chronic kidney disease (7). For instance, research indicates that patients exhibiting MAC are at a significantly higher risk of cardiovascular events, with a notable increase in mortality rates. (table 1) provides evidence of the correlation between MAC and risk factors thereby proving MAC is an important predictive marker in clinical settings, particularly in populations with established risk factors.

7. Limitations of Current Research

Despite the promising findings regarding the detection of medial artery calcification (MAC) in dental radiographs, several limitations persist in the current literature that warrant attention. One significant limitation is the variability in radiographic interpretation among practitioners, which can lead to misdiagnosis or underdiagnosis of MAC. This variability is particularly concerning given the reliance on subjective assessments in many studies, which may not consistently align with standardized diagnostic criteria.

Moreover, the majority of existing studies focus on specific populations, which limits the generalizability of findings across diverse demographic groups. Research often concentrates on older adults or specific ethnic groups, resulting in a lack of comprehensive data applicable to

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broader populations This limitation is critical as the prevalence and implications of MAC may differ significantly across various demographic segments, including age, sex, and underlying health conditions (22).

Additionally, there is a pressing need for further research to standardize diagnostic criteria for MAC detection in dental practice. The current lack of consensus on what constitutes significant MAC in radiographic images complicates clinical decision-making and may hinder effective patient management. Establishing clear guidelines and standardized protocols could enhance the reliability of MAC detection and improve patient outcomes.

Therefore, while the detection of MAC in dental radiographs presents a promising avenue for identifying cardiovascular risk, the limitations related to interpretation variability, population specificity, and the need for standardized diagnostic criteria must be addressed to enhance the clinical utility of this approach. (24)

8. Future Directions

Future research on medial arterial calcification (MAC) in dental radiographs should focus on developing standardized protocols that utilize advanced imaging technologies, particularly cone-beam computed tomography (CBCT). CBCT offers high-resolution three-dimensional imaging, enhancing the detection of vascular calcifications compared to traditional two-dimensional radiographs (7). The incorporation of artificial intelligence (AI) in analyzing these images can further improve diagnostic accuracy by automating the detection of calcifications (25). Recent studies indicate that AI algorithms can effectively identify both intimal and medial calcifications, facilitating early intervention strategies (26).

Interdisciplinary collaboration between dental and medical professionals is crucial for comprehensive patient care, especially in managing cardiovascular risks associated with MAC. Recognizing MAC as a potential marker for cardiovascular disease necessitates a multidisciplinary approach that includes cardiologists and dental practitioners (27). Such collaboration can ensure that dental findings related to MAC are integrated into broader cardiovascular risk assessments, enhancing patient management strategies (28). Longitudinal studies are needed to evaluate the prognostic value of MAC detection over time. Early detection of MAC has been linked to adverse cardiovascular outcomes, underscoring the importance of ongoing monitoring (29). By following patients longitudinally, researchers can assess the impact of dental interventions on MAC progression and its associated cardiovascular risks (1).

All in all Future directions in MAC research should emphasize standardized protocols using CBCT, interdisciplinary collaboration, and longitudinal studies to improve patient outcomes in both dental and cardiovascular health.

Risk Factor	**evidence of correlation**	**References**
Diabetes Mellitus	The presence of MAC is linked to diabetes mellitus, with research indicating that patients	(19- 22)

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	with MAC have a higher prevalence of type 2 diabetes. This association is critical as diabetes exacerbates cardiovascular risk. |	
Chronic Kidney Disease	Chronic kidney disease (CKD) is another significant risk factor associated with MAC. The calcification process in MAC is often exacerbated by renal insufficiency, leading to increased cardiovascular morbidity and mortality.	(20-21)
Metabolic Syndrome	MAC is frequently observed in patients with metabolic syndrome, which encompasses a cluster of conditions including obesity, hypertension, and dyslipidemia. This convergence of risk factors further amplifies cardiovascular risk.	(23)
Aging and Sex Differences	Aging is a well-established risk factor for MAC, with studies indicating that the prevalence of MAC increases with age. Additionally, sex differences have been noted, with women showing distinct patterns of MAC development.	(22)

9. Conclusion

The detection of medial artery calcification through dental radiographs presents a significant opportunity for the early identification of cardiovascular risk factors. As dental practitioners increasingly recognize the implications of MAC, there is potential for improved patient outcomes through timely referrals and interventions. Continued research and education in this area are essential to fully realize the benefits of integrating cardiovascular risk assessment into routine dental practice.

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