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Artificial Intelligence in detecting obstructive sleep apnea using dental radiographs and craniofacial imaging: A mini review

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Abstract

Obstructive sleep apnea (OSA) is a common sleep disorder in which breathing repeatedly stops and starts during sleep. It is often not diagnosed early, but it is linked with serious health problems like high blood pressure and heart disease. The standard test for diagnosis, polysomnography, is costly and not easily available everywhere. Because of this, early detection is often missed.

Dental imaging like lateral cephalograms and cone-beam computed tomography (CBCT) is routinely used in dental practice. These images can also show changes in airway and facial structures that are related to OSA. This gives an opportunity for dentists to help in early screening of patients.

Recently, artificial intelligence (AI), including machine learning and deep learning techniques, has shown good potential in detecting OSA from dental radiographs and craniofacial images. Studies have shown that AI models can identify OSA risk using lateral cephalograms by analysing facial and airway features. AI-based CBCT studies have also shown that airway size and shape can be automatically measured and used for prediction. Some studies also show that combining anatomical features with AI can improve accuracy.

This mini review summarises the current research on the use of AI for detecting OSA using dental imaging. It explains different imaging methods, AI techniques, and their usefulness in clinical practice. Although results are promising, there are some limitations like small sample sizes, lack of large validation studies, and differences in imaging methods.

In conclusion, AI-based analysis of dental imaging has strong potential for early detection of OSA in dental clinics. However, more large studies are needed before it can be used in routine clinical practice.

Keywords: Obstructive sleep apnea; Artificial intelligence; Machine learning; Deep learning; Dental imaging; CBCT; Cephalogram

1. Introduction

Obstructive sleep apnea (OSA) is a sleep-related breathing disorder characterized by repeated collapse of the upper airway during sleep, leading to intermittent breathing pauses and reduced oxygen levels. It is associated with symptoms

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such as snoring, daytime sleepiness, fatigue, and reduced concentration. If untreated, it is strongly linked with hypertension, cardiovascular disease, stroke, and metabolic disorders.

The gold standard test for diagnosing OSA is polysomnography. However, it is expensive, time-consuming, and not widely available, leading to frequent underdiagnosis. This creates a need for simpler and more accessible screening methods.

Dental imaging is routinely used in clinical practice and can help in early identification of craniofacial and airway changes associated with OSA. Lateral cephalograms and cone-beam computed tomography (CBCT) allow assessment of airway space and craniofacial morphology.

Early studies showed that machine learning can be used for image-based detection of OSA, supporting the feasibility of artificial intelligence (AI)-based screening systems [1]. This introduced the foundation for using AI in sleep apnea detection from clinical imaging data.

Following this, more advanced neural network-based models were developed for OSA detection. Automated deep learning systems using cephalometric data demonstrated that AI can assist in identifying patients at risk of OSA in clinical settings [2].

Research then expanded toward understanding systemic associations. Machine learning studies have shown links between obstructive sleep apnea, metabolic dysfunction, and periodontitis, suggesting that AI can integrate dental and medical data for risk prediction [3].

Further studies explored large image-based datasets and confirmed that machine learning models can identify OSA-related patterns from clinical and epidemiological data, supporting the role of AI in screening approaches [4].

Another epidemiological machine learning study reinforced the relationship between oral health conditions and systemic diseases, including sleep apnea, metabolic dysfunction, and periodontal disease, highlighting the usefulness of AI in large dataset analysis [5].

With growing interest in imaging applications, machine learning approaches were applied to cone-beam CT scans to analyze upper airway morphology and identify structural risk factors associated with OSA [6].

In addition, AI-based segmentation models have been developed to automatically analyze craniomaxillofacial anatomy from CBCT scans, improving airway evaluation and diagnostic efficiency [7].

More recently, deep learning models using lateral cephalograms have been developed with improved interpretability for OSA detection, including in pediatric populations, showing clinical potential for early screening [8].

A recent systematic review confirmed that AI-based CBCT airway analysis is promising for OSA detection; however, further validation through large-scale studies is still required before clinical application [9].

Despite these advancements, most AI models remain in the research stage, with limitations such as small datasets, lack of external validation, and variability in imaging techniques.

This mini review aims to summarize current evidence on the application of artificial intelligence in detecting obstructive sleep apnea using dental radiographs and craniofacial imaging, and to discuss its potential role in early screening and future dental practice.

2. Materials and Methods

This mini review was conducted to summarize the current evidence on the application of artificial intelligence in detecting obstructive sleep apnea using dental radiographs and craniofacial imaging.

A literature search was performed using the PubMed database. The search was focused on studies related to obstructive sleep apnea, artificial intelligence, and dental or craniofacial imaging. The search terms included combinations of keywords such as “obstructive sleep apnea,” “artificial intelligence,” “machine learning,” “deep learning,” “dental imaging,” “lateral cephalogram,” and “cone-beam computed tomography (CBCT).”

The search strategy used was: ("obstructive sleep apnea" OR OSA OR "sleep disordered breathing") AND ("artificial intelligence" OR "machine learning" OR "deep learning") AND ("dental imaging" OR cephalometric OR panoramic OR CBCT OR "cone beam computed tomography" OR "maxillofacial imaging").

Studies were included if they focused on the use of artificial intelligence techniques for the detection, prediction, or analysis of obstructive sleep apnea using dental or craniofacial imaging modalities. Both original research articles and systematic reviews were considered.

Only articles published in the English language were included. Studies involving human subjects and published in peer-reviewed journals were selected. Articles that were not related to AI-based imaging analysis or did not focus on obstructive sleep apnea were excluded.

No strict time limit was applied, but priority was given to recent studies to reflect current advances in artificial intelligence. The final selection of studies was based on relevance to the topic and contribution to understanding AI applications in dental imaging for OSA detection.

The selected studies were reviewed and summarized narratively, focusing on imaging modalities used, artificial intelligence methods applied, and their diagnostic or predictive outcomes.

3. Results and Discussion

This mini review highlights the growing role of artificial intelligence (AI) in the detection of obstructive sleep apnea (OSA) using dental radiographs and craniofacial imaging. The included studies demonstrate that AI, especially machine learning and deep learning methods, can effectively analyze dental imaging data for early identification of OSA risk.

Most evidence comes from studies using lateral cephalograms. Kim et al. developed a deep learning model using knowledge distillation techniques that showed promising results in screening OSA patients using cephalometric images [1]. Similarly, Jeong et al. reported that automated deep neural network analysis of lateral cephalograms can assist in detecting OSA in clinical settings with good diagnostic performance [2]. These findings suggest that cephalograms combined with AI can serve as an important screening tool in dental practice.

Beyond imaging-based diagnosis, AI has also been used to explore systemic associations of OSA. Machine learning studies have demonstrated links between obstructive sleep apnea, metabolic dysfunction, and periodontitis, suggesting that AI can integrate dental and medical data for better risk prediction [3]. Early exploratory work also showed that machine learning can be used for image-based detection of OSA patients, supporting the feasibility of AI-based screening systems [4]. In addition, large epidemiological AI analyses have further confirmed relationships between oral health conditions and systemic diseases, including OSA and metabolic dysfunction [5].

With advancements in imaging analysis, AI has been increasingly applied to cone-beam computed tomography (CBCT) for airway evaluation. Machine learning techniques have been used to analyze upper airway morphology and identify structural risk factors associated with OSA [6]. Similarly, AI-based segmentation models have been developed for automatic assessment of craniomaxillofacial anatomy and airway structures from CBCT scans, improving diagnostic accuracy and efficiency [7].

More recent studies have focused on improving AI interpretability and clinical applicability. Deep learning systems using lateral cephalograms have shown improved diagnostic performance and better interpretability, including applications in pediatric OSA detection [8]. Furthermore, a recent systematic review confirmed that AI applications in CBCT-based airway analysis are promising for OSA detection; however, they still require strong external validation before clinical use [9].

Despite promising results, several limitations exist across the studies. Most AI models are trained on small datasets, which limits generalizability. There is also a lack of external validation across different populations and imaging systems. Differences in imaging protocols and AI methodologies further reduce comparability between studies. Additionally, most studies are retrospective in nature, which may introduce selection bias.

From a clinical perspective, AI-based analysis of dental imaging has strong potential for early identification of patients at risk of OSA. Dentists and orthodontists can play an important role in screening patients during routine radiographic evaluation and referring high-risk individuals for further sleep studies. This is particularly important because OSA often remains undiagnosed in early stages.

Future research should focus on developing large-scale, multi-center datasets and improving AI model generalizability. Integration of multimodal data such as clinical history, imaging, and sleep study parameters may further improve diagnostic accuracy. Real-time AI-based screening tools could also be developed for routine use in dental clinics, but further validation is required before clinical implementation.

4. Conclusion

Artificial intelligence shows strong potential in the detection of obstructive sleep apnea using dental radiographs and craniofacial imaging. The reviewed studies demonstrate that machine learning and deep learning models can effectively analyse lateral cephalograms and cone-beam CT images to identify airway-related changes associated with OSA.

Dental imaging, which is routinely used in clinical practice, can play an important role in early screening of patients at risk of OSA. AI-based tools can support dentists in identifying suspicious cases and help in timely referral for sleep studies.

However, most of the current AI models are still in the research stage and are not yet ready for routine clinical use. Limitations such as small datasets, lack of external validation, and variability in imaging methods need to be addressed in future studies.

In conclusion, AI-assisted analysis of dental imaging is a promising approach for early detection of OSA, but further large-scale validation studies are required before clinical implementation.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors declare no conflicts of interest.

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