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Review Article

Role of Artificial Intelligence in Dental Diagnostics

Monica Rajmalani

Bharati Vidyapeeth Dental College and Hospital, Pune, Maharashtra, India

ABSTRACT:
Applications of artificial intelligence (AI) in oral diagnostics are potentially transformative. Assessment of the role, current use, and potential use of AI in dental diagnostics are discussed in this review. Critical evaluation of AI usage in dental diagnostics, comparison with traditional diagnostic methods, and new developing trends are included in this review. Recently, there has been improvement of diagnostic capabilities through the application of computational processes, including artificial intelligence (AI) algorithm approaches such as machine learning algorithms, convolutional neural networks, and image processing. Clinical application of AI systems is being seen in areas of diagnosis, use in assessing early caries development, diagnosis of periodontal disease, screening for lesions for malignancy, and radiographic interpretation. Evidence indicates that AI systems are often found to demonstrate comparably, or superior accuracy rates than the human practitioner and can potentially decrease the amount of time used to make diagnostic decisions. However, some of the obstacles to implementing AI into clinical practice include less transparency to the algorithm, absence of common data-acquisition standards, and difficulties of implementation into a clinical setting. Some examples of the positive developments referencing the challenges outlined above are AI diagnostic products that are integrated, or combine various data domains, or use interpretative AI systems that provide an understandable rationale for decision-making or point-of-care products that provide real-time clinical decision-making capability. Overall, AI technologies appear to have a great deal of promise and potential to improve the accuracy of diagnosis and treatment, however, for this to occur in a clinically relevant manner, the technical constraints must be resolved first, there needs to be recommendations on regulations, and lastly, obtaining an understanding of how, and when to optimally train practitioners. Future work includes multimodal integration, a growing emphasis on interpretability, and federated learning for improved patient data privacy. Continued research and collaborations are necessary if we wish to leverage AI technology to drive dental diagnostics forward and improve patient services.

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Corresponding author: Monica Rajmalani, Bharati Vidyapeeth Dental College and Hospital, Pune, Maharashtra, India

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INTRODUCTION

The swift growth of artificial intelligence (AI) and more sophisticated levels of artificial intelligence are facilitating substantial changes in the health care field, including dental medicine whereby these technologies are continually assuming a deeper role. The conventional strategies used for diagnosis in dentistry, which are predominantly based on visual clinical examination and conventional radiographic diagnosis, are being greatly bolstered by computational intelligence. Advanced machine learning technologies, advanced designs in neural networks, and tailored computer vision technologies can provide more effective ways to increase the accuracy of diagnosis enhance the efficiency of clinical workflows and create a standardized evaluation system for many types of oral pathological conditions [1, 2].

The primary rationale for implementing AI in dental diagnostics is the technology's remarkable ability to recognize complex patterns and analyze large amounts of data. This facility enables the identification of subtle clinically pathological signs that may consistently go unnoticed by even well-trained practitioners. Current development involves many specific applications, such as automated systems for caries detection, computational systems for assessing periodontal disease, AI-enhanced systems for orthodontic assessment, and systems developed from algorithms that use machine learning to detect malignant lesions in oral tissue [3]. These technologies now routinely serve as indispensable clinical decision support systems used in support of dental clinical practice and specialized disciplines [4, 5].

This paper provides a broad context for the existing capabilities of AI technologies in dental diagnostic applications. It will review the distinct approaches in which AI is being developed and utilized to assist the detection and diagnosis of oral diseases and associated challenges. By examining more recent scientific research, and clinical validation studies, this paper aims to provide dental practitioners and researchers with useful insights on how computational intelligence is to redefining diagnostic paradigms in dentistry, and to impart an evidence-based perspective on the expected future development of these systems in clinical dental practice [6].

EXISTING AI APPLICATIONS IN DENTAL DIAGNOSTICS

Caries Detection and Classification

Among the multitude of applications of AI in dental diagnosis, particular emphasis has been placed on identifying tooth decay as an active area of research. Artificial intelligence systems, specifically complex computer models called convolutional neural networks (CNNs), have displayed remarkable capacity for locating nearby cavities in X-ray images. In fact, in numerous cases, AI demonstrates diagnostic accuracy that is similar to, or better than, highly trained dental professionals [2].

Thanh et al. (2022) examined the functionality of deep learning algorithms of YOLOv3 and Faster R-CNN to identify smooth surface caries from smartphone-captured intraoral images [7]. The authors report obtaining substantial sensitivity for locating cavitated lesions with an AI system retaining 87.4% sensitivity and 71.4% sensitivity, respectively.The sensitivity of the models to identify visually non-cavitated lesions was greatly reduced at 36.9% and 26%. The specificity values for each type of lesion were consistent in both lesions being above 86% and 71%, respectively. Based on these findings, a reasonable argument can be made supporting the potential for mobile AI in dental diagnosis of caries, with this work being an early stage of clinical use [7]. Casalegno et al.[1], in 2019, created a deep learning model to automatically locate and categorize incipient dental lesions using near-infrared transillumination (TI) images [8]. Even with only 185 images to train from alongside restrictions in applying techniques to mitigate the limited dataset, their model achieved a mean intersection-over-union (IOU) value of 72.7 percent in segmenting lesions into 5 groups. For simply detecting occlusal and proximal lesions, the area under the curve (AUC) from the ROC analysis was 83.6% and 85.6%, respectively. The authors conclude that the analysis of dental TI images using deep learning can vastly improve the speed, precise nature, and ultimately aid in not only the caries detection process but also patient care. [8].

AI could enable a dramatic shift from standard approaches, such as visual assessment and radiographic techniques, to provide better precision detected in earlier stages of development when identifying dental caries. ForouzeshFar et al. (2024) looked at the use of CNNs to automatically detect dental decay on Bitewing X-rays [9]. The research used 713 patient images and employed four individual CNN methods (AlexNet, ResNet50, VGG16, and VGG19). Analysis revealed that the model VGG19 had the better accuracy when detecting dental caries, reaching an accuracy of 93.93%. The authors' findings are promising that there is an opportunity for AI-based tools, such as a mobile application or cloud service, that would be accessible to patients and dentists to assist in the diagnosis of dental caries, thus providing efficiency and access to treatment [9]. Luke and Rezallah's systematic review and meta-analysis in 2025 evaluated studies that utilized artificial intelligence: focusing on artificial intelligence that included the use of CNNs that were applied to X-ray images, for the application of dental cavity (caries) detection. Their review and synthesis of fourteen papers relevant to this topic showed that artificial intelligence systems were accurate and highly sensitive and specific to the presence of cavities. However, the differences noted across studies indicate more research is necessary to understand the factors that affect artificial intelligence performance. The review states, while the barriers and challenges around collecting, implementing, and accessing data exist, there is great potential for AI to improve caries detection, standardize the diagnosis of caries, and improve the quality of the dental patient care [10]. The challenges of technology integration into established dental practice workflow remain [11].

Periodontal Disease Evaluation

Overall, there have been tremendous advances in a number of areas using artificial intelligence in the diagnosis of periodontal disease. These advances include clinical parameter assessment, radiographic bone loss assessment, and detecting microbial pathogens using diverse techniques [4].

Computational methods have greatly improved the radiographic assessment of periodontal structures. In many cases, the complexity of clinical assessment is the most challenging aspect of diagnosing periodontal disease. Improvement in radiographic diagnostics could come from the increasing ability of deep learning to improve the accuracy of diagnostic assessments during the clinical diagnostic process. There was a study that explored AI's detection ability with panoramic radiographs. Ryu et al. (2023) determined that they achieved a high AUC (0.91) with a panel of expert examiners assessing panoramic radiographs [12]. These findings of successful automated detection of periodontitis that compared to human scores suggest that deep learning analysis of panoramic X-rays could help in automated detection of periodontitis and in the use of dental radiography [12]. While these radiographs were not directly evaluated as specifically focused on the radiographic detection of periodontal bone loss, the use of automated detections of periodontal bone loss using AI is promising on a large dataset [12]. Radiograph-based manual detection of periodontal bone loss can incorporate variability by the examiners, which is why automated detection schemes are needed. Chen et al. (2024) explored a new quantitative method that used deep convolutional neural networks (CNNs), to automatically guide the stage of periodontitis using periapical X-rays [13]. The CNN taken from this study provided a 6.5% deviation in the rating of the degree of bone loss by prior expert assessment, along with a strong correlation (PCC = 0.828). The overall accuracy of the AI to classify periodontitis stage was 72.8% with the highest accuracy being for stage III. This AI tool can assist with diagnosis, decrease clinician's workload, and potentially enhance access for specialist care, which is important for recent graduates and clinicians in under-service areas [13].

Non-invasive assessment strategies present a new direction for diagnostic periodontal practices sirtey with Artificial Intelligence support. In 2021, Kim et al. digitally analyzed the relationship between thickness of the labial gingiva and the alveolar bone in healthy periodontal tissues with the incisors and canines [14]. The researchers superimposed cone beam computers tomography with intraoral scans to the alveolar crest determining the thickness at several points from the stable alveolar crest for labial and palatal/gum surfaces. This demonstrated a positive thickness correlation between the gingiva and alveolar bone at the alveolar bone crest, but not at identical positions below the alveolar bone crest. It was also observed that the shapes of the crowns and keratinized widths did not significantly correlate with either tissue thickness [14]. Dritsas et al. (2023) have analyzed, developed and confirmed a method (CC) for accurately measuring gingival recession in a continuous manner using the principles of 3D digital model overlay [15]. Mild and severe recessions were defined and the CC method, which used single tooth crowns for superimposition, was compared with a gold standard adjacent intact structure. Importantly for both mild and severe recession, the difference between the CC and GS was negligible and the reproducibility of the technique high. The method could therefore provide accurate measurement of any change in the gingival margin through time, independent of change in the crowns or teeth of the patient. It is expected that the combination of this form of assessment will enhance the diagnostic efficacy and communication of patient experience and management of gingival pathology.

Artificial intelligence has also shown great potential in microbiological studies to expedite identification of disease causing organisms. Periapical periodontitis and dental caries are examples of prevalent oral diseases. Li et al (2022) developed a deep learning algorithm that automatically detects both of these conditions on periapical radiographs, using a dataset of radiographs. The AI model demonstrated strong performance with F1-scores of 0.829 for detecting caries and 0.828 for detecting periodontitis, which were greater than results for dentists that had less experience. Additionally, the AI support improved the accuracy of expert diagnosis and significantly improved agreement among them, demonstrating its ability to improve diagnostic accuracy and the ability to improve agreement among dentists [16]. Using these diagnostic modalities enhanced by AI could allow periodontal practices to diagnose disease more thoroughly, intervene sooner, and allow for more personalized treatment planning [4].

Radiographic interpretation and analyses

AI has considerable promise to advance the field of dental radiographs through algorithms that identify many pathological conditions and anatomical structures [5].

Ekert et al. (2019) applied a deep convolutional neural network (CNN) developed on a dataset of 2001 tooth segments to create an automatic detection method for apical lesions (ALs) in panoramic radiographs [17]. The CNN achieved an area under the curve (AUC) of 0.85, with a sensitivity of 0.65 and specificity of 0.87 distinguishing between certain and uncertain ALs. Accuracy was also influenced by the tooth type (anatomical features). Furthermore, results improved significantly with increased agreement among the expert examiners (reference standard); AUC increased to 0.95 suggesting that deep learning offers promising capabilities for detection of ALs in panoramic images even though there may be limitations to the training data [17]. Ba-Hattab et al. (2023) developed an AI system with two convolutional neural networks (CNNs) to automatically classify periapical lesions (PLs) on panoramic X-rays with a goal to assist dentists in determining radiographic presence of PLs [18]. One CNN served as a detector that localized periapical root areas (PRAs); average precision was 74.95%. After obtaining a detector, their AI could classify those PRA images as PL or not-PL using a classifier with an accuracy of 84 %. When using their system of AI as a whole, they achieved an accuracy 84.6%, sensitivity was 72.2% and specificity was 85.6%. A two-phase system using CNNs appears to be a promising method to classify PLs in panoramic images [18]. Lee et al., 2024 performed a meta-analysis to evaluate the accuracy of artificial intelligence and manual approaches to detect anatomical landmarks between dental imaging modalities [19]. From their meta-analysis of ten included systematic reviews, they concluded that there was no average significant difference (0.35, 95% CI −0.09 to 0.78) in detecting landmarks between AI and manual approaches. In subgroup comparisons of cone-beam computed tomography (CBCT) and cephalometric radiographs there were no significant differences. This indicates that AI is as good as manual techniques, when detecting anatomical landmarks in dental imaging [19].

Identifying early oral cancer is key to improving patient prognosis and developments in artificial intelligence offer possibilities to help with this [4]. Talwar et al. (2023) investigated the role of AI using images taken on a smartphone for identifying oral potentially malignant disorders in an Indian population (Talwar et al., 2023). The deep learning algorithms had a high degree of accuracy when classifying the images of suspicious lesions that were taken by trained health professionals. The AI model encountered more difficulty with images taken from untrained individuals, but still has many possibilities for low-cost screening and improving early referrals of oral potentially malignant disorders [20]. The rising incidence of oral squamous cell carcinoma has been associated with poor survival often due to late diagnosis. Tseng et al. (2022) applied machine learning to predict patients with high-risk OSCC based on salivary autoantibodies and patient data [21]. A stacking algorithm fusing them all showed the best prediction accuracy (AUC=0.795) while significantly improving prediction over models without autoantibody data. Thus, the final model could be used as an online tool to facilitate a personal OSCC diagnosis and perhaps improve patient outcomes. [21]

AI-driven risk prediction models are also emerging. There is an increase in possibly malignant and malignancy potential for oral cancers among the low-income countries with no resources to screen our patients adequately and delay for detection. The inactive oral leukoplakia with dysplastic epithelium carries increased risk for malignant transformation to oral cancer with biopsy. Currently, detection of dysplasia is dependent on invasive techniques. Adeoye et al. (2024) explored a deep learning model applied to oral photographs, to predict the probability of dysplasia in patients with leukoplakia [22]. Their AI model displayed good accuracy detecting histo-dysplasia on images, when other clinicians inaccurately classified images, suggesting possible application as a guide for biopsy and monitoring [22].

EFFECTIVENESS VERSUS TRADITIONAL METHODS

Multiple comparative studies suggest that artificial intelligence (AI) systems can achieve diagnostic accuracy equivalent to, or better than, human dentists on certain tasks. For example, deep learning applied to intraoral camera images demonstrates great potential in screening for dental caries. Kang et al. (2024) applied ensemble learning using models like ResNet and Inception on 2,682 images extracted from 534 participants to identify dental caries [23]. Their results established that ensemble models consistently enhance diagnostic performance, and in this study, the best performance for caries classification was achieved using the Inception-ResNet-v2 model, with an AUROC of 0.94 and an average precision (AP) of 0.97. Their model for detecting lesions using explainable AI also performed well [23]. Likewise, Zhang et al. (2024) assessed the performance of an AI model to identify dental caries in more than 4,000 intraoral images [24]. When compared to specialist clinical diagnoses, the AI program had high average accuracy (93.40%) and specificity (95.65%). Yet the sensitivity, or the capacity to identify caries correctly, differed substantially depending on the tooth position and cavity type. Although these findings are promising for clinical use, the research indicates that additional development of the AI model, possibly using more comprehensive data and more complex architectures, would be needed to increase its consistency across different caries presentations [24].

One of the advantages provided by AI systems is that they possess built-in consistency of diagnostic assessment [4]. Zhu et al. (2023) created an AI system using deep learning to diagnose various dental diseases from panoramic X-rays [25]. The accuracy and speed of this system were tested against dentists with varying levels of experience. The AI showed a high level of accuracy for the majority of the conditions that were evaluated and was much quicker in its analysis, working at a level equal to or better than mid-level dentists. Nevertheless, the performance of the AI in caries detection specifically needed improvement. These findings indicate the great potential of artificial intelligence in dental diagnostics [25].

Another area in which AI diagnostic systems offer a compelling advantage, is in terms of time efficiency [4]. Specifically, rapid advances in the development of neural networks, which are built on the concept of replicating the structure of and function of the human brain, suggested that neural network applications can become standard tools in modern-day dentistry. These tools can increase efficiency, improve diagnosis accuracy, and decrease diagnostics and treatment planning discovery time [26]. Jiao et al. (2024), evaluated the performance of the Mask R-CNN network at automatically detecting cephalometric landmarks from lateral cephalometric radiographs (LCRs) [27]. The authors showed a very high detection rate, 98.29% of 19 identified landmarks from a dataset of 400 LCRs, and average detection time of only 1.48sec/image for all LCRs. Most of the landmarks were identified with high accuracy, with 85.74% detection, within a deviation of less than 4mm from manual marking, illustrating the considerable potential of Mask R-CNN to improve the efficiency and accuracy of cephalometric analysis [27].

Even with these advances, integrating AI technologies into existing dental practice workflows remains challenging [11]. A survey of Indian dental students found that although students are aware of AI, they are learning about it primarily through social media [28]. The majority of students believe AI can improve diagnosis (63%) and treatment planning (71.3%) in dentistry and should be integrated into undergraduate dental education (56%). They also cited a lack of technology and trained personnel as significant hurdles to the widespread uptake of AI in dentistry [28].

At this time, there is a very limited set of data on the economic efficiency of AI diagnostic systems in dentistry [4]. In an economic analysis by Schwendicke et al (2022), the AI was used for detecting proximal caries as part of a randomized clinical trial with 23 dentists examining bitewing radiographs [29]. One finding was the AI resulted in greater sensitivity for caries detection, but the AI led to greater invasive treatment recommendations, resulting in the same tooth retention outcomes (49 years) and almost the same total costs (330 euro) as recommendations without the AI. Therefore, the cost-effectiveness of AI in this situation remained uncertain and the authors concluded that AI would need to be further enhanced to assist not just with detection, but with making the treatment recommendations that followed diagnosis [29]. Alternatively, Schwendicke et al.'s (2021) research studied the cost-effectiveness of AI's detection of proximal caries from bitewing radiographs. They used a U-Net neural network that had been trained on 3,293 images [30]. The authors' findings showed that AI had better accuracy than a dentist (0.80 vs 0.71) and sensitivity (0.75 vs 0.36) and thus enabled better long-term outcomes with lower costs. The study stated that tooth retention with AI-assisted detection (64 years) versus a dentist (62 years) with fewer total costs (298 vs 322 euros) and an incremental cost-effectiveness ratio (ICER) of -13.9 euro per year with dentists managing early lesions non-restoratively [30]. The current lack of comprehensive, long-term cost-benefit analyses is an important gap that has consequences in interpreting the implications of the widespread application of AI in dental diagnostics.

CHALLENGES AND LIMITATIONS

AI is rapidly becoming an integral part of a number of different dental domains, including diagnostics, treatment planning, and image evaluation, and offers significant opportunity to streamline patient care, and support a more personalized and preventive approach [31, 32]. While AI holds much promise in this regard, the integration of AI into dentistry is surrounded by barriers such as limited access to data, methodological flaws present in current studies, and well-documented ethical implications [31, 32]. At this point, AI applications to dentistry primarily exist in research or educational capacities, suggesting that both the technology itself and the user-interface still need further development and improvement before AI can be successfully implemented as part of routine clinical practice [32]. Continued work in this area will require balance between the advancement of technology and the need to protect patient privacy, foster trust with appropriate human oversight, construct interpretable AI systems that explain their reasoning (effective and well-structured algorithms), and enhance the digital literacy of dental professionals via informative and specific educational programs [31, 32].

Knowledge about AI systems of 200 dentists in Croatia was limited as per a cross-sectional survey of Ivanišević & Tadin conducted in 2024, when they had an average knowledge score of merely 3.62 out of 7 [33]. Interestingly, 76% of the respondents dentists were not currently implementing AI technologies within their practice despite the fact that 71% of them perceived that AI was likely to benefit patient care. The most significant adoption barriers found in this research were the high cost of acquiring AI systems (59%) and overall financial limitations (58%). Notably, the survey also pointed to the significance of education, as dentists who indicated interest in being trained further on AI had significantly higher knowledge of these technologies [33]. The diagnostic validity of SmileMate, an AI application that relies on intraoral photographs to evaluate 19 various orthodontic and dental parameters among 35 patients, was compared in a prospective UK-based study by Vaughan et al. (2025) [34]. The findings of this comparison were statistically significant between the clinicians' and AI evaluations in 9 out of 19 parameters. The agreement between the two was good on the whole (kappa 0.29), from poor for tooth fracture and lateral open bite to near perfect for retained or missing teeth. The AI had a sensitivity of 72% but a specificity of just 54%, which prompted the researchers to say that the existing version of the AI tool is not suitable for extensive malocclusion assessment, specifically in parameters like gingivitis and oral hygiene evaluation [34]. Bonny et al. (2024) conducted a systematic review wherein they compared 52 various studies from the years 2018-2023 that compared the implementation of AI in dental imaging [35]. In their review, they identified convolutional neural networks as the most common AI framework employed for detection and diagnosis functions in all fields of dentistry. Whereas the findings suggested that AI has great promise to extend diagnostic support and augment clinical efficiency, particularly for non-specialist clinicians, there are challenges to be overcome. Two compelling requirements in leveraging AI in patient-specific optimization effectively are the existence of larger, more extensively annotated datasets with which to train AI models and translating research findings from AI into effective practical clinical applications [35].

Regulatory frameworks for the use of AI in dentistry are currently in an early stage of development [36]. The ethical use of AI requires the consideration of proper application areas and the development of appropriate use practices. This encompasses maintaining patient transparency about the ways in which their data are used and to what degree AI is applied within decisions concerning their care, as the adoption of these technologies advances at a quicker pace within transforming regulatory environments

[36]. US FDA Software as a Medical Device (SaMD) categorization mandates rigorous testing of AI systems for diagnosis [37]. As an example, the Medical Device Regulation (MDR) of the European Union does have special provisions for medical devices with AI technology incorporated, yet the specific detailed guidelines for executing these regulations remain under development [38]. The complete ethical structure to assess applications of AI in dentistry has been created by Rokhshad et al. (2023) in a consensus process with 29 participants in the ITU/WHO Focus Group AI on Health [39]. This structure outlines 11 ethical principles of importance, such as diversity, transparency, protection of privacy, equity, and autonomy, which should be followed by stakeholders in formulating and deploying dental AI technologies. This ethical checklist takes cognizance of the increasing alarm raised about the ethical considerations of AI as it finds its way into dental practice [39].

FUTURE DIRECTIONS

Future artificial intelligence (AI) systems in dentistry are increasingly likely to use integrated multiple diagnostic approach to drive higher accuracy and more comprehensive patient evaluation. Kumari et al. (2024) described a multimodal AI model for the early detection of diseases by analyzing histopathological images and clinical notes [40]. The model included a convolutional neural network (CNN) for analyzing the images and a Transformer model for analyzing the text notes. The models characterized the descriptive context for lesions and significantly drove improved diagnostic accuracy, resulting in higher accuracy metrics compared to conventional methods [40]. The use of AI models with potential for increased interpretability presents an important area for further investigation. Radiographic assessment of periodontal bone loss is important for assessing the severity and treatment requirements for a common oral health issue. Erturk et al. (2024) developed a deep learning approach that classified the radiographic staging of periodontal bone loss using a machine learning approach. The YOLOv8 model was used on 1752 bite-wing images to classify periodontal bone loss into four clinical severity stages [41]. The authors trained and validated the model on a subset of images, and found results for classification of severity of bone loss to be promising, particularly for healthy and severe periodontal bone loss cases [41].

Deep convolutional neural networks (CNNs), a branch of artificial intelligence, show great potential in oncology. Warin et al. (2022) performed a review of some CNN algorithms in terms of how well they perform in classifying and detecting oral potentially malignant disorders (OPMDs) and oral squamous cell carcinoma (OSCC) from mouth images [42]. The DenseNet-169 model performed the top multiclass image classification, being as accurate as experts and higher than general practitioners, indicating potential as an oral cancer early detection tool [42]. Rokhshad et al. (2024) summarized 36 studies that employed artificial intelligence (AI) to classify, detect, or segment oral mucosal lesions in images [43]. The review showed that although AI lesion detection accuracy varied from 74% to 100%, and performed better than clinicians in certain instances, the overall risk of bias across studies was high [43]. The results suggest AI has the potential to help with screening, but how much of its accuracy gains and health benefits are needed to be researched in comparison to experts [43].

Federated learning allows AI model training between institutions without centralizing sensitive patient information, providing data privacy solutions and increasing training datasets. Rischke et al. (2022) emphasized that creating effective AI for dentistry requires large, high-quality datasets typically held in independent, privacy-protected silos at different institutions [44]. By enabling AI models to be jointly trained without directly sharing data, federated learning provides a solution, with institutions sharing learned observations instead. Here, federated learning is being presented to the dental research community, and the potential and limitations for furthering AI applications within the field [44]. This is the first application of Federated Learning (FL) to dentistry for automated tooth segmentation on panoramic radiographs from nine different centers to assess the effectiveness of a FL model while maintaining data privacy. The federated model achieved similar or superior performance to models trained on data from a single institution while generally showing better generalizability across sites than models trained on a single institution's data, indicating that FL may improve efficiency and utility of the model [45]. Centralized models using pooled data achieved the best results overall, yet FL presents a viable alternative preserving privacy while developing robust generalizable models for AI in dentistry [45].

CONCLUSION

Applications of artificial intelligence into dental diagnostics may have the potential to improve clinical practice by enhancing the accuracy, efficiency, and consistency of disease detection and evaluation. AI has already proven to achieve diagnostic accuracy comparable to, or in some contexts superior to, human clinical colleagues across various applications including caries detection, periodontal disease evaluation, radiographic interpretation, and oral cancer screening. Future AI systems that provide multiple diagnostic modalities, enhance interpretability, and operationalize data privacy through federated learning models are particularly exciting. Nevertheless, while advancement and opportunity exist, barriers still exist to improved data access, data methodology, data validity, and improving technology to create cost-effectiveness and seamless workflow integration. Issues associated with the ethics of AI, data privacy of patients, and transparency, also necessitate careful consideration for proper integration. Understanding regulations and the implementation of AI requires ongoing research, collaboration, and development across disciplines to harness AI better to address shortcomings in dental diagnostics and provide the highest standard of care for patients.

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