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The Impact of Clinical Artificial Intelligence in the Digital Workflow in Dentistry - A Narrative Review

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Abstract

Artificial intelligence (AI) is progressively emerging as a significant instrument for enhancing clinical processes due to the quick development of digital technology in dentistry. Digital radiographs, CBCT scans, intraoral scans, and electronic health records all produce vast volumes of complicated data that might be challenging to manually analyze in modern dentistry practices. By evaluating these datasets, AI systems may assist physicians in identifying anomalies, assisting with treatment planning, and directing decision-making. By automating processes like picture segmentation, margin detection, and prosthetic design, such systems could improve diagnosis accuracy, decrease clinician variability, and streamline operations.

Despite its potential, AI incorporation into routine dentistry treatment is still in its infancy due to issues with dataset quality, algorithm transparency, ethical considerations, and clinician acceptability. Research indicates promising improvements in workflow and diagnosis accuracy, but there is still little data on actual results. Clinical decision-making may benefit greatly from AI, but its efficacy requires meticulous validation and cautious integration with current digital procedures.

It is therefore essential to comprehend the possibilities and constraints of AI in dentistry. An overview of recent studies on clinical AI applications in digital workflows is given in this review, which emphasizes how AI may help with diagnosis and treatment planning while also pointing out areas that require more research to guarantee safe and efficient use in everyday practice.

Keywords: Artificial Intelligence, Digital Dentistry, Clinical Workflow, CAD/CAM, Diagnostic Accuracy.

Introduction

Digital technology has generated a dramatic revolution in dentistry during the last 20 years.[1] Digital radiography,

intraoral scanning, CBCT, and CAD/CAM technologies are gradually replacing traditional analog procedures that depended on manual impressions, film radiography, and subjective assessments.[2] These tools have expedited healthcare operations, standardized documentation, and enhanced precision and visualization.[3] Large volumes of clinical data may be gathered and stored thanks to digital dentistry, creating new chances for data-driven decision-making.[4] Tools that can assist physicians in effectively interpreting the increasingly complex datasets generated by dental practices are becoming more and more important. In this regard, artificial intelligence has shown promise as a supplement to digital dentistry, with possible uses in workflow optimization, diagnostics, and treatment planning.[5]

Artificial intelligence includes computational systems that can carry out tasks like pattern recognition, classification, and prediction that have historically required human intellect.[6] AI has been investigated in a number of dental specializations, particularly machine learning and deep learning techniques.[7] For instance, AI can help identify orthodontic landmarks, periodontal bone loss, dental cavities, and periapical diseases.[8–11] AI can be incorporated into CAD/CAM systems in prosthodontics and restorative dentistry to aid in the design of full-arch prostheses, crowns, and bridges.[12–14] AI systems may produce reliable and repeatable results by evaluating sizable datasets from digital photos and electronic health records, which could lower inter-observer variability and enhance clinical decision-making.[15] Promising performance indicators have been shown in several research, but their therapeutic relevance is dependent on the quality of the dataset, validation techniques, and practical applicability.[16]

Even while interest in AI is expanding, the research that has already been done is dispersed and heterogeneous.[17] Without examining workflow integration, physician acceptance, or long-term patient outcomes, many studies concentrate on technical performance, such as sensitivity, specificity, and accuracy.[16] Comparisons are difficult because to variations in reporting standards, algorithm development, and dataset size. Adoption is still hampered by issues with openness, data bias, ethics, and legal obligations. These reasons make it crucial to compile the available data in order to give a more accurate picture of AI's function in digital dental workflows. The purpose of this narrative review is to provide an overview of existing uses, point out possible advantages and drawbacks, and talk about potential future paths for incorporating AI into clinical practice.[18]

Materials and Methodology

To give a general overview of AI applications in digital dentistry, this narrative review was carried out using PubMed and Google Scholar without regard to the year of publication. Research on the clinical use of AI in CAD/CAM workflows, diagnostic imaging, or decision-support systems was chosen. Combinations of "artificial intelligence," "machine learning," "deep learning," "digital dentistry," "CAD/CAM," and "clinical workflow" were found in search results. The entire texts, abstracts, and titles of pertinent papers were used to filter them. Included were only studies that reported clinical significance or the incorporation of AI into dentistry workflows. Without using statistical meta-analysis, the results were summarized descriptively.[18]

Clinical AI and Digital Dentistry

Digital Workflows in Dentistry

Data collection, processing, analysis, treatment planning, and clinical execution are all common components of modern dentistry processes.[12] Rich datasets produced by digital technology, such as radiography, 3D scans, and medical records, can be challenging to manually

evaluate. Clinicians may digitally plan treatments, create restorations, and model results thanks to these workflows. However, manual interpretation might differ throughout practitioners and is frequently time-consuming. By evaluating data, identifying trends, and assisting with clinical decision-making, AI technologies have the ability to support these procedures and increase accuracy and productivity.[14]

AI in Diagnostic Imaging

AI has been used in radiographic interpretation for tasks like orthodontic measures, periapical lesions, caries detection, and bone loss.[7–11] Convolutional neural networks and other machine learning and deep learning models can detect minute details that medical professionals might overlook. According to a number of studies, AI can reduce interpretation time while achieving results on par with skilled physicians.[8] AI may also reduce subjectivity by standardizing evaluations. However, a number of variables, including algorithm validation, image resolution, and training dataset quality, affect diagnostic performance. Despite their potential, these technologies need to be thoroughly tested before being widely used in clinical settings.[9]

Applications in Restorative and Prosthodontic Workflows

AI integration in CAD/CAM systems can automate prosthesis design, occlusion analysis, and preparation margin detection in restorative dentistry.[12–14] AI may decrease manual changes, boost productivity, and enhance reproducibility by providing automatic recommendations. AI can support treatment planning in difficult circumstances by integrating imaging and patient-specific anatomical data. However, physician familiarity, confidence in AI outputs, and interoperability with current systems are necessary for successful implementation.[14]

Key Variables for Evaluation

Both quantitative and qualitative metrics are frequently used to assess the effects of clinical AI. Accuracy, sensitivity, specificity, precision, recall, and area under the curve are examples of quantitative metrics. [8], [10] Time savings, automation level, and a decrease in manual activities are examples of workflow-related metrics. Clinician acceptance, output interpretability, ease of integration, and perceived utility are examples of qualitative variables. Because sample size, validation technique, and dataset quality all affect performance, presented results should be evaluated cautiously.[16]

Workflow Integration and Clinical Impact

By automating repetitive processes, assisting in decision-making, and lowering errors, AI may improve productivity. Shorter diagnostic times and more uniform treatment planning are reported in several trials.[2],[15] Adoption, however, is contingent upon process reform, training, and clinician trust. Implementation is also impacted by legal accountability, data protection, and ethical issues. According to available data, AI should complement clinical competence rather than take its place.[17]

Summary of Evidence

In general, AI exhibits growing promise in orthodontic evaluation, CAD/CAM processes, radiographic analysis, and decision assistance.[7–14] Benefits could include increased standardization, less work, and better diagnostic accuracy. However, differences in clinical integration, dataset quality, and study design underscore the need for additional research to ascertain its practical implications.[18]

Conclusion

With the ability to enhance treatment planning, expedite processes, and increase diagnostic accuracy, artificial intelligence has become a promising tool in digital

dentistry. Research shows that by offering consistent analyses, automating tedious procedures, and lowering practitioner variability, AI systems can enhance clinical knowledge.[8],[14] Particularly in controlled or experimental environments, applications in radiographic interpretation, orthodontics, CAD/CAM-based prosthodontics, and clinical decision support exhibit great promise. AI may potentially improve treatment planning uniformity, enabling medical professionals to provide more accurate, data-driven care.[15]

Despite these possible advantages, AI is still not widely used in daily life. Direct comparisons are challenging because to variations in dataset quality, algorithm design, validation techniques, and outcome metrics. Challenges also arise from ethical concerns, such as data privacy, transparency, and legal accountability. Clinician acceptance, training, and careful integration into current procedures are all necessary for successful adoption. Crucially, rather than taking the role of human judgment, AI should be seen as a supporting tool.[17]

In conclusion, AI has a lot of potential to enhance digital workflows in dentistry, but its effects need to be carefully considered. Clinical validation, workflow integration, performance metric standardization, and patient-centered outcomes should be the main areas of ongoing study. AI has the potential to significantly influence dentistry practice in the future by solving both practical and technological issues and enhancing productivity, consistency, and ultimately patient care.[18]

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