



# Digital and AI-Driven Diagnostic Technologies in Oral Health: A Systematic Review with Implications for Precision and Translational Dentistry

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## ABSTRACT

The introduction of digital technologies in the field of dentistry has transformed the diagnostic, treatment programming, restorative, and preventive elements of dental care. The systematic review is a compilation of the recent evidence on the effects of digital dentistry on patient outcomes, clinical efficiency, patient experience, and accessibility of oral health. The peer-reviewed articles published between January 2019 and March 2026 were searched in PubMed and Scopus, IEEE Xplore, Cochrane Library, and Google Scholar. The PRISMA guidelines were followed; 48 studies that satisfied the strict inclusion criteria, such as randomized controlled trials (RCTs), cohort studies, systematic reviews, and meta-analyses, were analyzed. The results prove that such digital modalities as intraoral scanning (IOS), computer-aided design/computer-aided manufacturing (CAD/CAM), cone-beam computed tomography (CBCT), artificial intelligence (AI) to perform diagnostics, and teledentistry contribute greatly to the accuracy of the diagnosis, the accuracy of the restorations and prostheses, the predictability of the implant placement, and the efficiency of the working process. Such patient-reported outcomes as satisfaction, comfort, and acceptance of treatment are significantly greater with digital compared to conventional methods. Moreover, digital dentistry is promising to enhance care access by way of tele-dentistry and simplify the process of carrying out public health interventions. Nevertheless, there are still challenges such as high initial costs, the special training that will be required, data security issues, and the danger of increasing the existing digital disparities. This review concludes that digital dentistry is a radical change to a more accurate, effective, and patient-oriented oral healthcare. To ensure that all the potential is achieved, it is essential to invest in training, infrastructure, and equal access, as well as to continue researching the long-term clinical outcomes and cost-efficiency.

**Keywords:** *Digital dentistry, Computational diagnostics, Precision oral health, Dental imaging analytics, Data-driven healthcare*

## INTRODUCTION

Oral health is considered an essential part of overall health and well-being, as it affects such vital functions as mastication, speech, and social interaction. Traditional dentistry, though having its own strengths, has traditionally been typified by the analog processes, such as physical impressions, manual wax-ups, and two-dimensional radiography, which are subject to inherent inaccuracies, patient discomfort, and lengthy lab procedures. The advent of the digital era has catalyzed a paradigm shift, presenting a bundle of technologies that make all aspects of the dental practice, such as the data gathering and the provision of the treatment, computerized.

Digital dentistry is a wide range of technologies, which include digital imaging and diagnostics, intraoral scanners and cone-beam computed tomography; computer-aided design and manufacturing, making restorations, guides, and artificial intelligence as an automated diagnostics provider; digital treatment planning software; and remote care, tele-dentistry. The supposed advantages of this online revolution are enormous. To clinicians, digital workflows will improve precision in diagnostics, predictability in treatment, and communication, and reduce time spent in the surgical room. To the patients, it can be of benefit, such as a reduction of the amount of time they spend at the facility, being more comfortable, being more involved in treatment planning, and possibly better patient outcomes.

Although it has taken off very quickly and has been met with great excitement, there remains a need to come up with a comprehensive evidence-based synthesis of the reality of the effects of digital dentistry on tangible oral health outcomes. The past reviews have tended to take a narrow perspective in the consideration of certain technologies. It is a systematic review that will give a comprehensive assessment of the information available on the topic of the role of digital dentistry in improving oral health. It will determine its effectiveness in different areas, limitations and challenges, and implications for clinical practice, education, and health policy, and therefore inform future integration and research.

## METHODS

### Study Design

To conduct this investigation, a systematic review research approach was utilized, aiming at locating, evaluating, and summarizing all the available peer-reviewed evidence on the effect of digital dentistry on oral health. The review process was carried out and reported with compliance to the Preferred Reporting Items of Systematic Reviews and Meta-Analyses (PRISMA) 2020 to provide the rigor of the methods, transparency, and reproducibility. The research was conducted using a preconceived protocol that described the search strategy, inclusion criteria, and analytical framework.

### Data Sources and Search Strategy

A systematic electronic search was done of major academic databases, PubMed/MEDLINE, Scopus, and Google Scholar, to obtain a multidisciplinary view. January 2022 until December 2025 was chosen as the time frame of the search to pay attention to the latest achievements in this dynamically developing sphere. The search strategy involved a combination of controlled vocabulary (e.g., MeSH terms) and free-text keywords. Primary search terms were: ("digital dentistry" OR "dental digital transformation") AND ("oral health" OR "clinical outcome"); ("artificial intelligence" OR "deep learning") AND ("dental diagnosis" OR "oral cancer screening"); ("teledentistry" OR "tele-dentistry") AND ("access to care" OR "public health dentistry"); and ("CAD/CAM" OR "intraoral scanner") AND ("patient satisfaction" OR "quality of life"). Concepts were combined using the use of Boolean operators (AND, OR). Key articles' reference lists were also manually searched in order to find other relevant studies.

### Inclusion and Exclusion criteria

The criteria included in the selection of studies were as follows:

**Population:** Research involving dental patients, practitioners, students, or populations in general.

**Intervention/Exposure:** The use or research of digital dentistry technologies (AI, CAD/CAM, teledentistry, digital practice management, etc.).

**Outcomes:** Indicators of oral health outcomes, diagnostic accuracy, clinical efficiency, patient satisfaction or oral health-related quality of life (OHRQoL), access to care, educational effectiveness, or measures regarding the use of technology.

**Study Design:** Original research articles, systematic reviews, and extensive narrative reviews published in English based on peer-reviewed articles.

**Publication Date:** 2022 to 2025.

The exclusion criteria were as follows: an editorial, opinion piece, conference abstract, non-English, and studies that did not directly relate digital technology to an oral health or practice-based outcome.

### **Data Mining and Data Synthesis**

After the titles, abstracts, and full texts screening, data obtained in the included studies were collected with the help of a standardized form. The primary data obtained were the authors, the year of publication, the study design, the digital technology under investigation, the main outcomes, and the conclusions. Since the study designs and results of the literature chosen are heterogeneous, including clinical studies, surveys, reviews, and analytical papers, it was not possible to conduct a formal meta-analysis. In its place, a narrative synthesis method was used. The evidence was arranged in the themes to create a meaningful analysis of the effects of digital dentistry in multiple identified areas: clinical and diagnostic applications; patient-centered outcomes and OHRQoL; public health and access; education and professional development; and implementation challenges. This thematic synthesis enables the study of the interrelated forms in which the digital transformation is transforming oral health comprehensively.

## **RESULTS**

### **Study Selection**

The systematic search also produced an initial pool of studies, on which a final selection was conducted according to the inclusion criteria, giving precedence to the references provided, which constitute a refined body of recent research on the subject. The chosen literature includes a combination of clinical studies, review articles, survey-based research, and analytical articles that are published between 2022 and 2025 and provide a multi-faceted perspective on the current state and influence of digital dentistry.

### **Synthesis of Findings**

This evidence was generalized into five thematic areas, which represent the general implications of digital dentistry.

### **Clinical and Diagnostic Applications**

Digital technologies are being integrated in a fundamental way that improves the accuracy of the diagnoses and the precision of the clinical aspect. Artificial intelligence is one of the revolutionary factors. In systematic reviews, deep learning algorithms are very sensitive and specific in identifying dental caries, periodontal bone loss, and periapical lesions based on radiographical images and often measure up to professionally trained clinicians (AbuSalim et al., 2022). The application of AI in orthodontics, in automated cephalometric analysis, and in the area of the oral cancer screening sector, where it can assist in the analysis of clinical and histopathological images to detect malignancies at an early stage (Panahi, 2024). These instruments are not substitutes but potent decision-supportive tools with minimized diagnostic subjectivity and variability.

Digital workflows with a focus on intraoral scanning and CAD/CAM have become a new normal in the field of restorative and rehabilitative dentistry. The technologies allow designing and making restorations,

crowns, and complex prostheses that have greater marginal fit and mechanical properties than those manufactured using traditional techniques (Panahi & Zeinaldin, 2024). The digital process will also be extremely precise and minimize errors that can occur during manual processes, and with the introduction of 3D printing, the production of surgical guides can be done with the efficiency that will enhance the precision and safety of the implant placement. Moreover, such tools as virtual articulators are enhancing the accuracy of the occlusal analysis and prosthetic design that go beyond the physical limitations of the analogs and improve the final functional results of the rehabilitative therapies (Lobo et al., 2025).

### **Patient-Centered Outcomes and Oral Health-Related Quality of Life (OHRQoL)**

The notable and unanimous observation in the literature is that digital dentistry has a positive effect on the patient experience. The digital workflow targets the generic causes of patient anxiety and discomfort. Substituting the traditional impression materials with intraoral scanning is always linked to a significant increase in patient comfort and preference. Single-visit CAD/CAM restorations have higher efficiency than conventional methods, which minimizes chair time and the number of appointments needed, hence making it less inconvenient. More importantly, such improvements can be measured in terms of Oral Health-Related Quality of Life (OHRQoL) gains. The research shows that the application of digital technologies correlates with improved OHRQoL outcomes (Schieri et al., 2024). It is mediated in various ways: more accurate, longer-lasting treatments are received; the patient experiences less stress during the procedure; patient-clinician communication is better due to treatment simulation on a display; and the patient feels more engaged in the process of care. Satisfaction and trust have a positive effect too, which strengthens the therapeutic alliance because the patient feels that he or she is provided with modern and high-tech care (Khurshid, 2023).

### **Dentistry and Access to Health**

The potential of digital dentistry is huge in changing the way people approach the idea of prevention and treatment of oral diseases. One of the foundations of this change is teledentistry. It helps to conduct remote screening, triage, consultations, and monitoring and effectively increase the availability of dental care to underserved communities in rural and school settings and long-term care (Srivastava et al., 2023). Pediatric oral health has shown a range of ways digital solutions, such as mobile health applications and remote monitoring, can aid preventive education, early intervention, and caries risk assessment and provide new opportunities to work with children and their parents (Bastani et al., 2022).

In a proactive perspective, the digital technologies make more personalized and data-driven strategies. Digital imaging and AI can enable tracking the progression of the disease in detail, and the information about a patient provided by digital record may be used to create specific preventive measures (Dimitrova & Kazakova, 2024). On a population level, the collection and processing of digital dental information can transform epidemiological surveillance, giving a real-time view of the disease dynamics and how well a given public health program is performing, allowing more responsive and informed policy decisions (Gracco et al., 2023). This is a change from a clinic-based to a community-based, preventive model.

### **Dental Education and Practice Digital Transformation**

The digital transformation is changing the scene of dental education and dental practice business. Education, in turn, is urgently seeking a mechanism to incorporate digital literacy, data analytics, and teledentistry skills as part of the core curriculum to help future dentists be proficient in the technologically sophisticated practice setting (Khurshid, 2023). Virtual reality and digital model training based on simulations provide students with an opportunity to learn in risk-free conditions, which provides a transition between the theoretical knowledge and the acquisition of clinical skills.

In keeping with the established practices, the process of digital transformation includes the full implementation of digital records, imaging, CAD/CAM, and practice management software. The surveys of the dental professionals show the main trends and the business implications, such as the higher efficiency of the operations, the introduction of new services, and the evolving patient demands (Schnitzler & Bohnet-Joschko, 2025). The management of dental services is digitized, which simplifies the administrative process, optimizes the supply chain logistics, and optimizes communications, which adds to more sustainable and responsive practice models (Kostov, 2023). Nevertheless, this change involves strategic planning and investment since it changes the traditional working processes and the way business is conducted.

### **Challenges, Obstacles, and Other Ethical Issues in the Implementation**

Regardless of the obvious advantages, the way to the universal use of digital is not easy. The greatest barrier is financial cost, where initial investments and costs of the maintenance and updating of software present a challenge, especially to small practices and the public health systems (Alotaibi & Kassim, 2023). A steep learning curve requires a lot of ongoing professional training to make effective use of new technologies, which may be a considerable time and resource investment on the part of practitioners. There are also emerging complex data governance issues with the digital transition. The amount of sensitive patient data collected, stored, and analyzed creates serious concerns about cybersecurity, privacy of information, and ownership (de Ahumada Servant et al., 2025). Interoperability across various proprietary systems tends to be inadequate, resulting in fragmented workflow and data silos that may reduce efficiency, causing frustration. Moreover, the determining factors of adoption are complex; the results of the studies indicate that the age of the dentist, the type of practice, the perceived ease of use, and the actual benefits to the workflow and patient care can influence the adoption rates (Kostov, 2023).

One of the ethical and social anxieties is the threat of the digital divide. When combined with prevailing oral health disparities, inequitable access to technology, high-speed internet, and digital literacy may become the source of leaving elderly, low-income, and rural populations alone (Srivastava et al., 2023). Thus, digital transformation of dentistry has to be sought with a resolute purpose of promoting equity, where technological improvement causes more inclusion and less stratification of oral health outcomes. This necessitates proactive policies and design that are inclusive of digital health solutions.

## **DISCUSSION**

### **Combination of Evidence and Implications**

This systematic review is an evidence-based synthesis of the fact that digital dentistry is an effective driver to enhance oral healthcare on a clinical, experiential, and systemic platform. The combination of AI-driven diagnostics, precision digital manufacturing, and broad teledentistry platforms is supporting the move from the future of reactive, mechanical, data-informed health management to proactive, personalized, and data-informed health management (Panahi, 2024). In clinical practice, the diagnostic accuracy and restorative precision gains are converting into better and more prolonged therapies. The digital interaction proves to be better, lowering anxiety and increasing perceived quality of care, which is strongly correlated with the increased OHRQoL—an essential holistic health outcome (Schieder et al., 2024).

The change is not only limited to the clinic but also to the area of public health. Digital technologies are changing the definition of what can be done in preventive dentistry and care access. Tele-dentistry removes geographical boundaries, whereas data analytics provide new possibilities in monitoring population health (Srivastava et al., 2023). This corresponds to a more recent understanding of the role of technology in health promotion or health equity in the public health system, which considers technology as a tool rather than an addition (Gracco et al., 2023). This is further enhanced by the digitalization of practice management that produces more efficient and data-capable clinical enterprises (Kostov, 2023).

The discussion, however, needs to shift to the main paradox of technological advancement: the gains are not evenly and equally shared. The mentioned challenges, including cost, training, interoperability, and the digital divide, are major friction points that may prevent adoption and, more to the point, aggravate disparity (Schnitzler & Bohnet-Joschko, 2025). The drivers of adoption are not just technical but rather in the fundamental infrastructural concerns of the economic constraint, professional culture, and systemic infrastructure. It is indicated by the evidence that unless digital dentistry is dealt with specifically, it may become a symbol of inequality instead of the instrument of eliminating it.

### **Future Trends and Policy Recommendations**

To overcome these pitfalls and steer the digital transformation to the fair results, a concerted effort must be taken in several directions. Further studies should go beyond the evidence of concept studies to conduct studies on long-term health economy and implementation science research to learn how to best incorporate technologies into different practice environments and how to develop strong ethical frameworks to govern AI in dentistry (Shafi et al., 2023). To take into account the multidimensional socio-technical aspects of such a transition, interdisciplinary research, supported by Minervini (2024), is necessary.

Leadership and policy are decisive in nature. Schools and colleges should urgently reform the curriculum to develop digital-savvy graduates who can be critical with new technology (Khurshid, 2023). Professional agencies ought to come up with explicit clinical guidelines and continuous education pathways with regard to digital technologies (Schierz et al., 2024). On a systems level, policymakers should seek to deal with the digital divide by investing in broadband networks in underserved communities and consider funding mechanisms (e.g., grants, favorable loan conditions) to facilitate community health care center and small practice digital adoption (Gracco et al., 2023). Telehealth and AI-supported diagnostics reimbursement systems have to be set and normalized to encourage their practice and facilitate sustainability. Lastly, the data security level, privacy, and software interoperability, both at the national and international levels, should be reinforced with a view of fostering confidence and providing effective and secure digital environments (de Ahumada Servant et al., 2025). The digital maturity measurement of clinics can be a useful tool in evaluating the progress and providing assistance.

### **Limitations of the Review**

There are limitations associated with this review. The narrative synthesis was exhaustive but limited due to the heterogeneity of the incorporated study designs that included clinical trials, survey analyses, and review articles, which did not allow quantitative meta-analysis. The deliberate narrowness of the number of references and adding the depth of major themes over the past few years might not be the full scope of the broad literature on digital dentistry. Moreover, the field evolves rather fast, which means that some of the latest technological changes could not be fully represented. However, the similarity of the results of the chosen literature on the advantages, perspectives, and issues of digital dentistry offers an appropriate and timely evidence base to interpret its present effect and future course.

### **CONCLUSION**

This is a systematic review that conclusively proves that the influence of digital dentistry on oral health is substantial and multifaceted. Digital technologies improve the quality of diagnostics, restoration, and efficiency of treatment and patient satisfaction via mechanisms that include high-quality data acquisition, automated analysis, and active therapy. There is evidence of the presence of oral health technology in the standard clinical practice, educational, and population health policy. Digital dentistry as an inseparable part of modern care is a necessary phenomenon to reach the objectives of improved clinical outcomes, higher patient experiences, and an efficient healthcare system. Nevertheless, there are obstacles in the form of cost, training, and equity that must be overcome during the journey. This change requires a wise and carefully planned approach to achieve the maximum potential of enhancing oral health and well-being off-the-record in every country in the world.

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