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Artificial intelligence in dentistry: between clinical efficiency, human judgment, professional responsibility, and humanized care[1]

Inteligência artificial na odontologia: entre eficiência clínica, julgamento humano, responsabilidade profissional e humanização do cuidado

Inteligencia artificial en odontología: entre la eficiencia clínica, el juicio humano, la responsabilidad profesional y la humanización de la atención

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ABSTRACT

The incorporation of artificial intelligence represents one of the most significant transformations in contemporary dentistry, expanding the capacity for pattern recognition, image analysis, clinical data organization, and support for treatment planning. However, its impact should not be assessed solely through algorithmic performance indicators, but also through its implications for clinical judgment, professional responsibility, and humanized care. This study aimed to critically discuss the incorporation of artificial intelligence in dentistry based on four interdependent axes: clinical efficiency, human judgment, professional responsibility, and humanized care. This is a critical and reflective literature review, guided by transparency principles inspired by the SANRA tool. Scientific publications, institutional documents, regulatory frameworks, and theoretical references related to digital dentistry, clinical decision-making, automation bias, explainable artificial intelligence, bioethics, and patient-centered care were analyzed. The analysis indicates that artificial intelligence can enhance clinical efficiency and improve stages of dental diagnosis and treatment planning, particularly in tasks based on pattern recognition. However, its uncritical use may favor automation bias, a false sense of security, displacement of decision-making responsibility, and weakening of the professional-patient relationship. It is concluded that artificial intelligence should be understood as an instrument of augmented intelligence, designed to support, rather than replace, clinical judgment.

Keywords: Artificial Intelligence. Dentistry. Clinical Judgment. Professional Responsibility. Humanized Care.

[1] The authors declare that they used Generative Artificial Intelligence (GenAI) tools to support the conception, writing, and translation of this manuscript. The content was critically reviewed by the authors, who assume full responsibility for the final version of the manuscript. Translations of excerpts from works written in another language, when rendered into English, are likewise the responsibility of the authors, unless a different authorship is declared.

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RESUMO

A incorporação da inteligência artificial representa uma das transformações mais relevantes da odontologia contemporânea, ampliando a capacidade de reconhecimento de padrões, análise de imagens, organização de dados clínicos e apoio ao planejamento terapêutico. Entretanto, seu impacto não deve ser avaliado apenas por indicadores de desempenho algorítmico, mas também por suas implicações sobre o julgamento clínico, a responsabilidade profissional e a humanização do cuidado. Este estudo teve como objetivo discutir criticamente a incorporação da inteligência artificial na odontologia a partir de quatro eixos interdependentes: eficiência clínica, julgamento humano, responsabilidade profissional e humanização do cuidado. Trata-se de uma revisão narrativa, crítica e reflexiva, orientada por princípios de transparência inspirados na ferramenta SANRA. Foram analisadas publicações científicas, documentos institucionais, marcos regulatórios e referenciais teóricos relacionados à odontologia digital, tomada de decisão clínica, viés de automação, inteligência artificial explicável, bioética e cuidado centrado no paciente. A análise indica que a inteligência artificial pode ampliar a eficiência clínica e qualificar etapas do diagnóstico e do planejamento odontológico, especialmente em tarefas baseadas em reconhecimento de padrões. Contudo, seu uso acrítico pode favorecer viés de automação, falsa sensação de segurança, deslocamento da responsabilidade decisória e enfraquecimento da relação profissional-paciente. Conclui-se que a inteligência artificial deve ser compreendida como instrumento de inteligência aumentada, destinado a apoiar, e não substituir, o julgamento clínico.

Palavras-chave: Inteligência Artificial. Odontologia. Julgamento Clínico. Responsabilidade Profissional. Humanização do Cuidado.

RESUMEN

La incorporación de la inteligencia artificial representa una de las transformaciones más relevantes de la odontología contemporánea, al ampliar la capacidad de reconocimiento de patrones, análisis de imágenes, organización de datos clínicos y apoyo a la planificación terapéutica. Sin embargo, su impacto no debe evaluarse únicamente mediante indicadores de desempeño algorítmico, sino también a partir de sus implicaciones sobre el juicio clínico, la responsabilidad profesional y la humanización de la atención. Este estudio tuvo como objetivo discutir críticamente la incorporación de la inteligencia artificial en la odontología a partir de cuatro ejes interdependientes: eficiencia clínica, juicio humano, responsabilidad profesional y humanización de la atención. Se trata de una revisión narrativa, crítica y reflexiva, orientada por principios de transparencia inspirados en la herramienta SANRA. Se analizaron publicaciones científicas, documentos institucionales, marcos regulatorios y referentes teóricos relacionados con la odontología digital, la toma de decisiones clínicas, el sesgo de automatización, la inteligencia artificial explicable, la bioética y la atención centrada en el paciente. El análisis indica que la inteligencia artificial puede ampliar la eficiencia clínica y mejorar etapas del diagnóstico y de la planificación odontológica, especialmente en tareas basadas en el reconocimiento de patrones. Sin embargo, su uso acrítico puede favorecer el sesgo de automatización, una falsa sensación de seguridad, el desplazamiento de la responsabilidad en la toma de decisiones y el debilitamiento de la relación profesional-paciente. Se concluye que la inteligencia artificial debe comprenderse como un instrumento de inteligencia aumentada, destinado a apoyar, y no a sustituir, el juicio clínico.

Palabras clave: Inteligencia Artificial. Odontología. Juicio Clínico. Responsabilidad Profesional. Humanización de la Atención.

INTRODUCTION

Contemporary dentistry is undergoing a profound technological transformation, driven by the progressive incorporation of digital tools capable of enhancing diagnostic precision, optimizing clinical workflows, and supporting therapeutic planning. Intraoral scanners, CAD/CAM systems, cone-beam computed tomography, virtual planning,

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three-dimensional printing, and digital data integration have substantially changed the way clinical information is acquired, processed, and incorporated into dental care (Mangano *et al*., 2017; Joda; Brägger; Gallucci, 2015; Van Noort, 2012).

Within this context, artificial intelligence (AI) has assumed an increasingly prominent role, particularly because of its ability to recognize patterns, interpret imaging exams, assist in risk classification, and support clinical decision-making in areas such as cariology, periodontology, radiology, orthodontics, implant dentistry, endodontics, and three-dimensional image analysis (Schwendicke; Samek; Krois, 2020; Chen; Stanley; Att, 2020; Thurzo *et al*., 2022; Lee *et al*., 2025). These advances have raised expectations regarding increased clinical efficiency, reduced diagnostic variability, and expanded analytical capacity for dental professionals. However, the incorporation of intelligent systems into dental practice should not be assessed solely through indicators such as accuracy, sensitivity, or specificity, since their presence also modifies the dynamics of clinical decision-making, professional responsibility, and the professional-patient relationship.

Although algorithms may achieve high performance in circumscribed tasks, clinical practice cannot be reduced to pattern recognition. Clinical judgment involves the integration of scientific evidence, professional experience, contextual interpretation, patient values, risk assessment, communication, ethical responsibility, and the management of uncertainty. In dentistry, many relevant decisions are not made in the presence of absolute certainty, but rather within probabilistic, ambiguous, and individualized scenarios. The indication of restorative treatment, the decision to preserve or extract a tooth, implant planning, or the interpretation of a radiographic lesion requires more than the visual identification of signs; it requires an understanding of the patient in his or her biological, functional, psychological, and social singularity (Croskerry, 2009; Norman; Eva, 2010; Simpkin; Schwartzstein, 2016).

In this context, artificial intelligence introduces a central paradox. On the one hand, it can enhance clinical efficiency, reduce perceptual errors, organize large volumes of data, and provide relevant support for professional reasoning. On the other hand, it may favor uncritical dependence, inappropriate displacement of decision-making responsibility, and weakening of human judgment when used as a substitute rather than as a supportive tool. Phenomena such as automation bias and automation complacency show that professionals

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may place excessive trust in automated systems, accepting incorrect recommendations or reducing their critical vigilance when faced with algorithmic outputs perceived as reliable (Parasuraman; Riley, 1997; Goddard; Roudsari; Wyatt, 2012; Lyell; Coiera, 2017). Thus, the issue lies not only in the technical capacity of artificial intelligence, but also in the way it is integrated into the clinical process.

The ethical discussion becomes even more relevant when considering that responsibility for care remains linked to the professional who establishes the clinical relationship with the patient. Even when systems are regulated, validated, or commercially disseminated, the final decision still requires human interpretation, prudence, transparent communication, and professional responsibility. The literature on bioethics and digital health has emphasized that the implementation of artificial intelligence in healthcare must preserve autonomy, beneficence, non-maleficence, justice, transparency, and accountability (Beauchamp; Childress, 2019; Char; Shah; Magnus, 2018; World Health Organization, 2021; UNESCO, 2021). In dentistry, these principles are particularly important because clinical decision-making takes place within a fiduciary relationship, in which the patient places trust not only in the technical competence of the dental professional, but also in his or her capacity for judgment, listening, and care.

Given this scenario, it becomes necessary to shift the debate from professional replacement to the paradigm of augmented intelligence. From this perspective, artificial intelligence should not be understood as a new form of autonomous clinical intelligence, but as an instrument capable of expanding the analytical capacity of the dental professional while preserving the centrality of human judgment. Technology may assist in organizing information, recognizing patterns, and reducing specific technical uncertainties, but it does not replace clinical deliberation, ethical responsibility, or the humanization of care (Topol, 2019b; Miller, 2019; Amann *et al*., 2020).

Thus, this article aims to critically discuss the incorporation of artificial intelligence in contemporary dentistry based on four central axes: clinical efficiency, human judgment, professional responsibility, and humanized care. It is based on the premise that the future of digital dentistry will not depend solely on the sophistication of algorithms, but on the profession's ability to integrate them in a critical, ethical, and patient-centered manner. Artificial intelligence may expand information processing and support specific diagnostic and therapeutic stages; however, the task of interpreting, deciding, communicating, and

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caring in the face of the uncertainty that characterizes clinical practice remains the responsibility of the dental professional.

METHODOLOGY

This study is characterized as a narrative literature review with a critical and reflective approach. The bibliographic search was conducted in the first semester of 2026 and included publications related to artificial intelligence, digital dentistry, diagnostic imaging, clinical decision-making, automation bias, explainable artificial intelligence, bioethics, professional responsibility, governance of health technologies, and patient-centered care. The databases PubMed/MEDLINE, Scopus, Web of Science, Cochrane Library, SciELO, and Google Scholar were consulted, in addition to institutional and normative documents published by recognized international organizations and professional entities.

Controlled descriptors and free-text terms were used in Portuguese and English, including combinations of “artificial intelligence”, “dentistry”, “clinical judgment”, “clinical decision-making”, “automation bias”, “explainable artificial intelligence”, “professional responsibility”, “bioethics”, and “patient-centered care”. Original articles, reviews, conceptual studies, institutional documents, international guidelines, regulatory frameworks, and classic works relevant to the proposed discussion were included. Studies exclusively focused on algorithmic architecture without direct relation to clinical practice, opinion texts without scientific support, and commercial materials used solely for product promotion were excluded.

The final selection of references considered conceptual relevance, timeliness, methodological quality, pertinence to the central theme, and capacity to critically support the axes of the article. The methodological design was guided by transparency principles applicable to narrative reviews, inspired by the SANRA tool (*Scale for the Assessment of Narrative Review Articles*), proposed to assist authors, reviewers, and editors in assessing the quality of narrative reviews (Baethge; Goldbeck-Wood; Mertens, 2019). SANRA was not applied as a formal scoring instrument, but was used as a reference to clarify the relevance of the topic, the objectives of the review, the search strategy, the criteria for source selection, and the coherence of the scientific reasoning.

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The selected texts were analyzed through critical reading and narrative synthesis, with no intention of performing a meta-analysis or quantitative synthesis. The information was organized into four analytical categories: a) clinical efficiency and applications of artificial intelligence in dentistry; b) human judgment, clinical reasoning, and management of uncertainty; c) professional responsibility, transparency, and risks associated with the uncritical use of automated systems; and d) humanized care, fiduciary relationship, and patient centrality.

DEVELOPMENT

Dental artificial intelligence and clinical efficiency

The incorporation of artificial intelligence into dentistry should be understood within the broader context of the digital transformation of clinical practice. Even before the dissemination of intelligent systems, technologies such as intraoral scanners, CAD/CAM systems, cone-beam computed tomography, virtual planning, three-dimensional printing, and digital integration of clinical data had already been changing the way information is acquired, processed, and incorporated into dental care (Van Noort, 2012; Joda; Brägger; Gallucci, 2015; Mangano *et al*., 2017).

Within this scenario, artificial intelligence (AI) represents an additional stage in the digitalization of dentistry, as it is not limited to recording or organizing information. Its main contribution lies in its ability to recognize patterns, correlate large volumes of data, and support clinical interpretation in specific tasks. Systems based on machine learning and deep learning have been used for caries detection, periodontal assessment, identification of periapical lesions, radiographic interpretation, cone-beam computed tomography analysis, orthodontic planning, implant dentistry, and clinical decision support (Schwendicke; Samek; Krois, 2020; Chen; Stanley; Att, 2020; Thurzo *et al*., 2022).

The clinical efficiency provided by AI largely derives from its ability to perform repetitive and standardized tasks with speed, consistency, and high processing capacity. In imaging exams, for example, algorithms can assist in the triage of radiographic alterations, highlight regions of interest, suggest diagnostic classifications, and reduce perceptual failures associated with fatigue, cognitive overload, or interobserver variability (Schwendicke; Samek; Krois, 2020; Lee *et al*., 2025).

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Beyond the academic field, artificial intelligence has already reached regulated and commercial application in dentistry, especially in solutions aimed at dental image analysis. The existence of systems authorized by regulatory agencies for clinical use indicates that these technologies are already part of the reality of dental offices, clinics, and diagnostic centers. Thus, the central question is no longer whether AI will be incorporated into dentistry, but how it should be incorporated in a critical, safe, and ethically responsible manner (Shujaat *et al*., 2025).

However, clinical efficiency should not be confused with clinical sufficiency. The ability of an algorithm to identify patterns in images or suggest diagnostic classifications does not correspond to the entirety of the clinical process. Dental practice involves anamnesis, physical examination, listening to the patient, analysis of systemic factors, risk assessment, individual preferences, and responsibility for therapeutic decision-making. Moreover, algorithmic performance depends on the quality of the data used for system development, training, and validation, and may present limitations when transferred to heterogeneous clinical environments (Thurzo *et al*., 2022; Lee *et al*., 2025).

Therefore, artificial intelligence should be understood as a tool capable of increasing clinical efficiency in dentistry, especially in tasks related to pattern recognition, information triage, and diagnostic support. Its value, however, depends on integration with human judgment. When used as an auxiliary instrument, it may contribute to more informed decisions and more organized workflows; when interpreted as a substitute for clinical deliberation, it may produce a false sense of security and inappropriately displace professional responsibility.

Clinical judgment, automation bias, and calibrated trust

The incorporation of artificial intelligence makes it necessary to revisit a fundamental question: what characterizes clinical judgment? At first glance, part of dental practice may appear to be based on pattern recognition. The dental professional observes images, identifies morphological alterations, correlates clinical signs, and formulates diagnostic hypotheses. In this respect, AI shows relevant performance, since algorithms can recognize statistical regularities in large volumes of data. However, reducing clinical judgment to pattern recognition excessively simplifies the nature of decision-making in healthcare.

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Clinical judgment involves the integration of information from multiple sources: anamnesis, physical examination, complementary exams, medical history, systemic conditions, functional factors, psychosocial context, patient expectations, therapeutic possibilities, and biological limits. This integration requires clinical reasoning, professional experience, prudence, communication, and the ability to weigh risks and benefits in situations that are often incomplete or ambiguous (Croskerry, 2009; Norman; Eva, 2010).

Uncertainty is a constitutive dimension of clinical practice. In dentistry, many decisions do not present themselves as choices between true and false, but rather as deliberations within a field of probabilities. The interpretation of a radiographic image, the maintenance of a tooth with a doubtful prognosis, the indication of implants, or the choice between monitoring and intervening requires weighing possible alternatives, rather than the simple automatic application of protocols. In this sense, clinical judgment does not consist merely of eliminating uncertainty, but of managing it responsibly (Simpkin; Schwartzstein, 2016).

This ability differentiates clinical reasoning from algorithmic inference. AI systems operate based on patterns present in the data used for their training and validation. When applied to situations like those represented in training datasets, they may offer high performance. However, in the face of atypical scenarios, incomplete information, overlapping clinical conditions, or patients not adequately represented in the data, their results may become less reliable. It is up to the clinician to recognize these zones of indeterminacy and decide when to accept, question, or relativize an automated recommendation.

The literature on clinical reasoning shows that decision-making involves both intuitive and analytical processes. Fast thinking, based on pattern recognition and accumulated experience, may be efficient in familiar situations, but it is also subject to cognitive biases. Reflective thinking allows hypotheses to be reviewed, alternatives to be considered, and errors in judgment to be reduced (Kahneman, 2011; Croskerry, 2009). AI may function as a second layer of analysis, drawing attention to findings that might otherwise go unnoticed; however, when received as a decision-making authority, it may weaken precisely the reflective component of clinical judgment.

At this point, relevant cognitive risks emerge, such as automation bias and automation complacency. Automation bias occurs when professionals place excessive trust

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in automated recommendations, accepting results without sufficient critical verification. Automation complacency manifests when professionals reduce their active vigilance because they consider the system reliable enough to monitor or interpret certain information. Both phenomena are particularly concerning in clinical contexts, in which decisions involve uncertainty, professional responsibility, and direct consequences for the patient (Parasuraman; Riley, 1997; Goddard; Roudsari; Wyatt, 2012; Lyell; Coiera, 2017).

In dental practice, the risk lies not only in the possibility that the algorithm may err, but also in the professional failing to perceive that the algorithm can err. When an automated recommendation is received as an objective conclusion rather than as auxiliary information, a silent transfer of the decision-making burden to the machine may occur. This transfer may weaken professional autonomy, reduce clinical investigation, and compromise the responsibility of the dental professional toward the patient (Gaube *et al*., 2021; Asan; Bayrak; Choudhury, 2020).

Calibrated trust therefore emerges as an essential competence. Trusting an intelligent system appropriately means recognizing its usefulness without ignoring its limitations. A system should be considered reliable when it operates within its validated domain, with adequate data and in tasks for which it has demonstrated consistent performance. However, it should be questioned when its recommendations diverge from the clinical picture, when there are signs not captured by the algorithm, or when the case departs from the patterns on which the system was trained (Hoff; Bashir, 2015).

Thus, the challenge is not to choose between trusting or distrusting artificial intelligence, but to learn how to trust it appropriately. Excessive trust may transform AI into an undue authority; absolute distrust may prevent the use of its potential benefits. Between these extremes, calibrated trust allows artificial intelligence to be used as a supportive instrument, while maintaining human judgment as the final instance of interpretation, decision-making, and responsibility.

Explainability, professional responsibility, and humanized care

The discussion on artificial intelligence in dentistry cannot be limited to algorithmic performance. In clinical contexts, it is as important to know whether a system produces an adequate response as it is to understand how that response was generated, which data influenced the recommendation, and to what extent the professional can

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interpret it critically. This need makes explainable artificial intelligence, or *Explainable Artificial Intelligence* (XAI), a central issue for the safe integration of AI into dental practice.

Explainable artificial intelligence refers to a set of approaches aimed at making algorithmic systems more understandable, interpretable, and auditable. In healthcare, this requirement is particularly important because clinical decisions cannot be based solely on opaque outputs, even when they are statistically accurate. When a system indicates a possible carious lesion, bone loss, periapical lesion, or tomographic alteration, the dental professional must have at least a minimal understanding of which elements contributed to that indication, in order to confront it with the clinical examination, the patient's history, and his or her own professional reasoning (Amann *et al*., 2020; Antoniadi *et al*., 2021).

Explainability contributes to reducing opacity, favoring calibrated trust, supporting clinical auditing, and preserving the critical role of the dental professional. However, it should not be treated as a definitive solution to all problems related to AI in healthcare. Visually convincing explanations may produce a false sense of understanding, especially when the professional lacks adequate training to interpret the limits of the model. Therefore, explainability must be associated with clinical validation, critical assessment, professional training, and appropriate governance (Rudin, 2019; Ghassemi; Oakden-Rayner; Beam, 2021).

The ethical and regulatory dimension reinforces this need. International documents on AI in healthcare emphasize principles such as human supervision, transparency, safety, equity, data protection, accountability, and preservation of autonomy. In dentistry, these principles are relevant because clinical decisions may involve irreversible interventions and aesthetic, functional, emotional, and financial impacts. Regulatory approval of a system, however important, does not eliminate the need for professional interpretation in the concrete clinical case (World Health Organization, 2021; UNESCO, 2021; European Parliament and Council of the European Union, 2024).

Professional responsibility remains a central axis. Even when an AI system assists in diagnosis or planning, the dental professional remains the one who establishes the clinical relationship, interprets findings, communicates alternatives, and assumes therapeutic decision-making before the patient. An algorithmic recommendation may participate in the decision-making process, but it does not possess moral responsibility,

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does not establish a fiduciary relationship, and does not answer to the patient (Char; Shah; Magnus, 2018; Price; Gerke; Cohen, 2019; Gerke; Minssen; Cohen, 2020; Naik *et al*., 2022). This responsibility includes transparency in the use of technology, data protection, attention to equity, and informed consent. Algorithms trained on insufficiently diverse datasets may show unequal performance across population groups, reproducing health disparities. In addition, radiographic images, tomographic scans, clinical photographs, digital models, and therapeutic records require adequate protection, legitimate purpose, and secure storage. Algorithmic efficiency cannot be achieved at the expense of the patient's informational vulnerability (World Health Organization, 2021; Beauchamp; Childress, 2019).

Humanized care represents the axis that articulates these elements. AI may contribute to reorganizing clinical workflows, reducing repetitive tasks, and allowing greater attention to listening, communication, and shared deliberation. However, this possibility is not automatic. If technology reduces the patient to data, images, and probabilities, it may favor distancing and mechanization of the clinical relationship. If used as a supportive tool, subordinated to clinical judgment, it may contribute to better-founded decisions and greater transparency in care (Topol, 2019a; Sassi *et al*., 2025).

The preservation of humanized care depends directly on professional education. Digital dentistry requires a dental professional capable of understanding the basic logic of intelligent systems, critically interpreting their results, recognizing limitations, identifying risks of bias, and integrating algorithmic recommendations into clinical reasoning. This competence is not limited to the operational use of software; it involves digital literacy, critical thinking, applied ethics, clinical communication, and the ability to make decisions in scenarios of uncertainty (Schwendicke *et al*., 2023; Harte *et al*., 2025; Mun *et al*., 2025).

Therefore, digital dentistry should not move toward the replacement of clinical practice by automation, but toward a clinical practice expanded by technology and guided by human responsibility. Professional education must prepare the dental professional to act as a critical interpreter of artificial intelligence, a guardian of the fiduciary relationship, and an ethical mediator between data, evidence, and patient values. On this horizon, true innovation will not consist merely in adopting more intelligent systems, but in building a dental practice capable of remaining human amid technological sophistication.

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The main axes discussed can be summarized in Chart 1, highlighting the potential of artificial intelligence, its associated risks, and the preserved role of the dental professional in clinical decision-making.

Chart 1 – Critical integration of artificial intelligence in dentistry

Analytical axis	Potential of AI	Main risk	Role of the dental professional
Clinical efficiency	Recognizing patterns, organizing data, and supporting diagnosis	Confusing technical efficiency with clinical sufficiency	Integrating findings with clinical examination and the patient's context
Clinical judgment	Reducing specific technical uncertainties	Transforming algorithmic probability into clinical certainty	Interpreting information, weighing risks, and deciding under uncertainty
Automation bias	Offering fast and standardized recommendations	Accepting automated recommendations without critical verification	Maintaining vigilance, questioning discrepancies, and clinically validating findings
Explainability	Making recommendations more transparent and auditable	Producing a false sense of understanding or security	Assessing whether the explanation is clinically plausible and relevant
Professional responsibility	Supporting documentation, analysis, and clinical decision-making	Diluting or displacing responsibility for care	Preserving accountability and final professional decision-making
Humanized care	Freeing time for listening, communication, and shared deliberation	Reducing the patient to data, images, or probabilities	Maintaining the bond, clear communication, and patient-centered care

Source: Prepared by the authors (2026).

DISCUSSION

This critical narrative review analyzed the incorporation of artificial intelligence in dentistry based on four interdependent axes: clinical efficiency, human judgment,

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professional responsibility, and humanized care. Its main contribution is to shift the debate from the mere assessment of algorithmic performance to a broader reflection on the place AI should occupy in contemporary dental practice. Although the literature demonstrates relevant advances in pattern recognition, interpretation of imaging exams, and support for therapeutic planning, the analysis developed in this article indicates that these technologies should be understood within a model of augmented intelligence, in which AI expands the analytical capacity of the dental professional without replacing his or her clinical responsibility (Schwendicke; Samek; Krois, 2020; Chen; Stanley; Att, 2020; Topol, 2019b).

This point is relevant because much of the enthusiasm surrounding artificial intelligence in healthcare derives from its ability to process large volumes of data and identify statistical regularities with speed and precision. In dentistry, this potential is evident in areas such as radiology, periodontology, implant dentistry, orthodontics, and digital planning. However, technical efficiency should not be confused with clinical sufficiency. An algorithm may recognize a radiographic alteration, estimate probabilities, or suggest diagnostic classifications, but it does not, by itself, integrate anamnesis, clinical examination, patient values, biological limitations, prognosis, functional impact, and ethical responsibility. Thus, AI may qualify specific stages of care, but it does not replace the complexity of clinical judgment (Thurzo *et al*., 2022; Lee *et al*., 2025).

The discussion of clinical judgment therefore remains central to understanding the limits of automation in dentistry. Clinical practice cannot be reduced to pattern identification, even though this component is relevant. It involves contextual reasoning, hypothesis formulation, critical review of information, communication of uncertainties, and decision-making in frequently ambiguous scenarios. In many situations, the dental professional does not decide between correct or incorrect alternatives, but among possibilities that require weighing risks, benefits, prognosis, biological cost, and patient expectations. From this perspective, uncertainty is not a failure of clinical practice, but a condition inherent to healthcare (Croskerry, 2009; Norman; Eva, 2010; Simpkin; Schwartzstein, 2016).

AI may contribute to reducing specific technical uncertainties, especially when it assists in detecting subtle findings, comparing images, triaging exams, and organizing clinical information. However, it may also produce an illusion of certainty when its results

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are received as final conclusions. This risk is particularly important in relation to automation bias and automation complacency, phenomena in which professionals may place excessive trust in automated systems or reduce their critical vigilance when faced with algorithmic recommendations perceived as reliable (Parasuraman; Riley, 1997; Goddard; Roudsari; Wyatt, 2012; Lyell; Coiera, 2017).

In dental practice, the problem lies not only in the possibility of algorithmic failure, but also in the cognitive relationship established between the professional and the system. When AI is treated as a decision-making authority, clinical judgment tends to be displaced to a secondary position, weakening professional autonomy and responsibility toward the patient (Gaube *et al*., 2021; Asan; Bayrak; Choudhury, 2020). For this reason, calibrated trust emerges as an essential competence: appropriately trusting an intelligent system means recognizing its usefulness without ignoring its limitations, validation context, and domain of application (Hoff; Bashir, 2015).

Explainable artificial intelligence contributes to this calibrated trust, but it does not solve all challenges in isolation. Systems capable of presenting heat maps, regions of interest, confidence levels, or interpretable justifications may help professionals better understand algorithmic recommendations. However, visually convincing explanations do not necessarily guarantee real understanding of the model's functioning or the clinical validity of the inference. Therefore, explainability must be associated with clinical validation, professional education, data governance, and the preservation of human judgment as the final instance of decision-making (Rudin, 2019; Amann *et al*., 2020; Ghassemi; Oakden-Rayner; Beam, 2021).

The ethical and regulatory dimension reinforces this conclusion. International documents on AI in healthcare emphasize principles such as human supervision, transparency, safety, equity, data protection, accountability, and preservation of autonomy. These principles are particularly relevant in dentistry, since clinical decisions may involve irreversible interventions and aesthetic, functional, emotional, and financial impacts for the patient. Regulatory approval of a system, however important, does not eliminate the need for professional interpretation in the concrete clinical case (World Health Organization, 2021; UNESCO, 2021; European Parliament and Council of the European Union, 2024).

In this sense, responsibility for AI-mediated decisions should be understood in an expanded manner, involving developers, manufacturers, institutions, regulators, and

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professionals. However, in the direct clinical relationship, the dental professional remains the agent responsible for integrating information, communicating alternatives, clarifying uncertainties, and conducting therapeutic decision-making. An algorithmic recommendation may participate in the decision-making process, but it does not possess moral responsibility, does not establish a fiduciary relationship, and does not answer to the patient (Char; Shah; Magnus, 2018; Price; Gerke; Cohen, 2019; Gerke; Minssen; Cohen, 2020; Naik *et al*., 2022).

Humanized care represents another decisive axis. The promise that artificial intelligence may make clinical practice more human depends on how it is incorporated. If technology reduces the patient to data, images, and probabilities, it may favor distancing and mechanization of the clinical relationship. On the other hand, if it is used to reduce repetitive tasks, organize information, and support better-founded decisions, it may free time and attention for listening, communication, and shared deliberation (Topol, 2019a; Sassi *et al*., 2025).

Professional education therefore becomes a strategic element for the safe integration of artificial intelligence into dentistry. The dental professional of the future should not be merely an operator of software, but a critical interpreter of intelligent systems. This requires competencies in digital literacy, basic understanding of machine learning, recognition of algorithmic biases, interpretation of results, communication of uncertainties, applied ethics, and patient-centered decision-making (Schwendicke *et al*., 2023; Harte *et al*., 2025; Mun *et al*., 2025).

As a limitation, this narrative review did not aim to perform a meta-analysis, quantify the performance of specific systems, or statistically compare AI tools used in different areas of dentistry. Its contribution lies in the critical integration of clinical evidence, ethical frameworks, regulatory discussions, and concepts related to professional judgment. Future research should evaluate how artificial intelligence systems influence dental decisions in real-world scenarios, including diagnostic errors, adherence to recommendations, communication with patients, informed consent, equity, professional education, and distribution of responsibility.

Thus, artificial intelligence should be understood as one of the most relevant transformations in contemporary dentistry, but its value will depend less on the promise of replacing human decisions and more on its capacity to expand clinical practice responsibly.

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Algorithmic efficiency may qualify diagnosis and planning; explainability may promote transparency; regulation may establish safety parameters; and professional education may reduce cognitive risks. However, clinical decision-making will continue to require judgment, prudence, communication, and ethical commitment.

CONCLUSION

Artificial intelligence represents a relevant transformation in contemporary dentistry, with the potential to enhance clinical efficiency, qualify information analysis, and support diagnostic and therapeutic decisions. However, its value should not be measured solely by its ability to recognize patterns or process large volumes of data, but by the way it is integrated into dental care.

The findings of this critical narrative review indicate that AI should be understood as an instrument of augmented intelligence, rather than as a substitute for clinical judgment. Dental decision-making remains dependent on contextual interpretation, management of uncertainty, communication with the patient, and the ethical responsibility of the dental professional.

The safe adoption of AI requires calibrated trust, explainability, human supervision, data governance, adequate professional education, and clarity regarding responsibility for clinical acts mediated by technology. It is concluded that the future of digital dentistry will not be defined only by the sophistication of intelligent systems, but by the profession's ability to integrate them in a critical, ethical, and humanized manner.

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