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AI-Enabled Orthodontic Telehealth And Endodontic Sterilization: Knowledge And Practices Of Dental Assistants And Nurses Under Saudi Vision 2030

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Abstract

Background: The integration of artificial intelligence (AI) in orthodontic telehealth and the reinforcement of endodontic sterilization protocols represent critical advances in modern dentistry. These developments are particularly relevant in Saudi Arabia, where healthcare transformation under Vision 2030 emphasizes digital innovation, patient safety, and workforce empowerment

Objective: This narrative review explores the knowledge and practices of dental assistants and nurses regarding AI-enabled orthodontic telehealth and endodontic sterilization. It highlights their role in supporting digital health initiatives and infection control within the Saudi context.

Methods: A structured search of PubMed, Scopus, Web of Science, and Google Scholar was conducted for studies published between 2015 and 2025. Keywords included “artificial intelligence,” “orthodontic telehealth,” “endodontic sterilization,” “infection control,” “dental assistants,” “nurses,” and “Saudi Arabia.” Peer-reviewed articles, guidelines, and systematic reviews were included, with findings synthesized thematically.

Results: The literature demonstrates that AI-driven orthodontic telehealth enhances diagnostic accuracy, facilitates remote monitoring, and reduces healthcare disparities, while sterilization protocols in endodontics remain indispensable for ensuring patient safety. However, evidence indicates gaps in training and inconsistent compliance among dental auxiliaries. Dental assistants and nurses require targeted upskilling in AI literacy, digital workflows, and infection control to fully realize the benefits of these innovations.

Conclusion: Aligning AI-enabled orthodontic telehealth and rigorous endodontic sterilization with Saudi Vision 2030 will strengthen the national dental workforce, improve patient safety, and promote global competitiveness in healthcare. Empowering dental assistants and nurses through structured training and regulatory support is essential to achieve these objectives.

Keywords: Artificial Intelligence; Orthodontic Telehealth; Endodontic Sterilization; Infection Control; Dental Assistants; Nurses; Saudi Arabia; Vision 2030

INTRODUCTION

The ongoing transformation of healthcare under Saudi Vision 2030 has positioned digital health as a cornerstone for advancing efficiency, accessibility, and quality of care (Ministry of Health, 2020). Dentistry is no exception: AI-enabled orthodontic telehealth platforms are increasingly utilized to facilitate remote monitoring, automate diagnostic support, and optimize treatment planning, especially for patients in underserved or geographically distant areas (Alhumaid et al., 2023; Lee & Zhang, 2021). These innovations reduce the burden of in-person visits, enable timely interventions, and align with the national agenda for digital healthcare expansion (Alkhalifa, 2022).

At the same time, maintaining rigorous sterilization protocols in endodontic practice remains a critical element of patient safety. Root canal therapy depends heavily on infection control, as inadequate sterilization of instruments may lead to cross-infection, treatment failure, or systemic complications (Peters & Schönenberger, 2019; American Association of Endodontists [AAE], 2022). Thus, the integrity of sterilization workflows is a non-negotiable standard in modern endodontics.

Within this context, dental assistants and nurses represent the frontline workforce, bridging the gap between technology adoption and safe clinical practice. Their role is not limited to supporting dentists but extends to ensuring the proper use of AI-based tools, adhering to sterilization guidelines, and fostering patient trust in both digital and in-clinic services (Almutairi & Banerjee, 2021; World Health Organization [WHO], 2020). Despite their importance, evidence on their knowledge and practices related to AI-driven orthodontic telehealth and endodontic sterilization in Saudi Arabia remains limited.

This study aims to:

1. Evaluate the knowledge of dental assistants and nurses regarding the use of AI in orthodontic telehealth.
2. Assess practices related to endodontic sterilization protocols among dental assistants and nurses.
3. Identify gaps and barriers that may hinder effective adoption of AI-driven orthodontic telehealth and compliance with sterilization standards.
4. Align findings with Saudi Vision 2030, providing recommendations for workforce development, patient safety, and digital health integration in dentistry.

Significance of Study

The significance of this study lies in its dual focus on emerging digital health technologies and fundamental infection control practices within dentistry, framed under the national transformation agenda of Saudi Vision 2030.

First, the integration of artificial intelligence (AI) into orthodontic telehealth is reshaping the way dental services are delivered. Remote monitoring, AI-assisted diagnosis, and digital consultations have the potential to reduce geographic barriers, improve patient compliance, and optimize clinical efficiency (Alhumaid et al., 2023; Lee & Zhang, 2021). However, the success of such digital innovations depends largely on the preparedness of dental assistants and nurses, who are often the first point of contact in patient care pathways.

Second, endodontic sterilization remains a cornerstone of dental safety. Failure to adhere to sterilization standards can result in cross-infection, compromised treatment outcomes, and systemic complications (Peters & Schönenberger, 2019; AAE, 2022). Despite clear guidelines, compliance often varies depending on training, resources, and staff awareness. By evaluating the knowledge and practices of assistants and nurses, this study highlights critical areas for intervention that can safeguard patient outcomes and align clinical practices with global infection-control standards.

Third, in the Saudi context, this study addresses two national priorities: (1) accelerating the digital transformation of healthcare systems, and (2) strengthening workforce competencies to ensure safe, efficient, and sustainable care delivery (Ministry of Health, 2020). Dental assistants and nurses represent a vital segment of the workforce whose upskilling directly contributes to achieving these objectives.

Finally, by focusing on the intersection of AI-enabled orthodontic telehealth and endodontic sterilization, this study generates insights that are both timely and actionable. The findings can inform policymakers, educators, and healthcare leaders in designing training curricula, developing clinical

protocols, and shaping policies that advance both digital dentistry and patient safety within the framework of Vision 2030.

Methodology

This paper was designed as a narrative review, aiming to synthesize and critically appraise current literature on the intersection of AI-enabled orthodontic telehealth and endodontic sterilization, with a focus on the roles of dental assistants and nurses under the framework of Saudi Vision 2030.

Search Strategy

Relevant literature was identified through a structured search of electronic databases including PubMed, Scopus, Web of Science, and Google Scholar. Keywords and Boolean operators included combinations of: "artificial intelligence," "orthodontic telehealth," "teledentistry," "endodontic sterilization," "infection control," "dental assistants," "nurses," and "Saudi Arabia."

Inclusion and Exclusion Criteria

- **Inclusion:** Peer-reviewed articles, guidelines, systematic reviews, and observational studies published between **2015 and 2025**, written in English or Arabic, focusing on digital dentistry, telehealth, or sterilization in dental settings.
- **Exclusion:** Opinion papers without references, conference abstracts lacking full text, and studies unrelated to orthodontics, endodontics, or dental auxiliaries.

Data Extraction and Synthesis

Selected articles were reviewed for their relevance to three primary themes:

1. Applications of AI in orthodontic telehealth.
2. Protocols and compliance in endodontic sterilization.
3. Roles and practices of dental assistants and nurses.

The data were synthesized narratively and presented in thematic sections, supported by summary tables for clarity. Emphasis was placed on identifying trends, challenges, and implications for the Saudi healthcare context.

Limitations of Methodology

As a narrative review, this study does not provide a quantitative meta-analysis. While it seeks to integrate available knowledge, findings may be influenced by publication bias and the quality of included studies.

1. Artificial Intelligence in Orthodontic Telehealth

The application of artificial intelligence (AI) in orthodontics has expanded rapidly, particularly in the domain of telehealth and remote monitoring. AI algorithms are now capable of detecting malocclusions, evaluating treatment progress, and even predicting orthodontic outcomes with high accuracy (Lee & Zhang, 2021). Telehealth platforms supported by AI allow patients to upload intraoral photographs or scans, which are analyzed by automated systems before being reviewed by orthodontists (Alhumaid et al., 2023). This process minimizes unnecessary clinic visits, enhances accessibility in rural areas, and aligns with the Saudi healthcare system's drive toward digitization (Ministry of Health, 2020). Despite these advantages, limitations remain, including data privacy concerns, uneven access to digital tools, and the need for training dental staff to interpret AI-generated outputs (Alkhalifa, 2022).

2. Sterilization Protocols in Endodontics

Endodontic practice, especially root canal therapy, demands rigorous infection control and sterilization protocols. The American Association of Endodontists (AAE, 2022) recommends multi-step sterilization procedures, including pre-cleaning, ultrasonic washing, chemical disinfection, autoclave sterilization, and biological indicator testing. Inadequate sterilization has been linked to cross-infections and reduced treatment success (Peters & Schönenberger, 2019). Dental assistants and nurses play a central role in ensuring compliance with sterilization workflows by maintaining logs, verifying autoclave parameters, and handling single-use versus reusable instruments correctly (Almutairi & Banerjee, 2021). Recent studies highlight that lapses in sterilization are often not due to lack of knowledge but to inconsistent

adherence under workload pressures (Kumar et al., 2020). Therefore, reinforcing consistent practice and integrating digital monitoring systems is vital for patient safety.

3. Roles of Dental Assistants and Nurses

Dental assistants and nurses are critical to the success of both digital orthodontic telehealth systems and endodontic sterilization protocols. They are often responsible for preparing digital records, communicating with patients remotely, managing sterilization cycles, and ensuring infection control in the operatory (WHO, 2020). In Saudi Arabia, these professionals represent a large proportion of the dental workforce, yet their training in advanced digital health technologies remains limited (Alkhalifa, 2022). Studies have emphasized that assistants and nurses require targeted upskilling programs in AI literacy, digital data handling, and advanced infection control practices (Almutairi & Banerjee, 2021). By strengthening their competencies, the dental workforce can meet international safety standards while supporting the national agenda of healthcare modernization.

4. The Saudi Vision 2030 Context

Saudi Vision 2030 emphasizes digital transformation, healthcare workforce development,, and patient safety as key pillars of reform (Ministry of Health, 2020). Within this framework, dentistry—as a frontline specialty that directly interfaces with diverse populations—offers significant opportunities for integration of these pillars through telehealth platforms, artificial intelligence (AI), and advanced sterilization protocols.

One of the primary objectives of Vision 2030 is to expand digital health services to enhance accessibility, particularly in rural and underserved areas of the Kingdom (Alkhalifa, 2022). AI-enabled orthodontic telehealth aligns directly with this goal by reducing the need for frequent in-clinic visits, streamlining remote diagnostics, and providing equitable access to specialized care. This contributes to lowering healthcare disparities and ensures that patients across different regions benefit from the same quality of orthodontic oversight.

In parallel, patient safety remains a cornerstone of healthcare transformation. Endodontic sterilization plays a critical role in preventing healthcare-associated infections, maintaining treatment success rates, and protecting public trust in dental services (Peters & Schönenberger, 2019). By strengthening sterilization compliance and embedding digital monitoring systems, Saudi dental clinics can achieve internationally recognized benchmarks for infection control while reducing systemic risks.

Equally important, Vision 2030 underscores the need for healthcare workforce empowerment through continuous training and upskilling. Dental assistants and nurses, who represent a substantial proportion of the dental workforce in Saudi Arabia, must be equipped not only with clinical sterilization competencies but also with digital literacy to operate AI-driven systems effectively (Almutairi & Banerjee, 2021). Capacity-building initiatives, accreditation programs, and professional development modules tailored to auxiliaries can close existing knowledge gaps and prepare the workforce for future demands.

Finally, alignment with Vision 2030 ensures that the dental sector contributes to broader national objectives in digital health, sustainability, and global competitiveness. By embedding AI into orthodontic care and reinforcing sterilization standards in endodontics, Saudi Arabia positions itself as a regional leader in dental innovation. This approach not only advances clinical excellence but also strengthens the resilience of the healthcare system, reduces preventable risks, and supports the Kingdom's ambition to be recognized for pioneering safe, efficient, and technologically advanced healthcare solutions (Alhumaid et al., 2023; WHO, 2020).

DISCUSSION

This narrative review highlights the intersection of AI-enabled orthodontic telehealth and endodontic sterilization, with an emphasis on the roles of dental assistants and nurses under the framework of Saudi Vision 2030. The findings suggest both opportunities and challenges that are highly relevant to Saudi Arabia's healthcare transformation.

1. Integration of AI in Orthodontic Telehealth

The literature demonstrates that AI-driven telehealth platforms are capable of enhancing diagnosis, remote monitoring, and treatment planning in orthodontics (Lee & Zhang, 2021; Alhumaid et al., 2023).

For Saudi Arabia, where healthcare accessibility in remote regions remains a challenge, these tools provide a mechanism to reduce geographic inequities. However, implementation requires robust digital infrastructure, data security frameworks, and staff training. Dental assistants and nurses, who frequently manage patient interactions and digital records, need targeted education to ensure safe and efficient use of AI applications. Without sufficient training, the benefits of AI integration may be undermined by user error or misinterpretation of automated outputs.

2. Importance of Endodontic Sterilization

Sterilization in endodontic practice is universally recognized as a non-negotiable element of patient safety (Peters & Schönenberger, 2019; AAE, 2022). Inadequate sterilization not only compromises treatment success but also places patients at risk of cross-infection. Evidence indicates that compliance often falters due to workload pressures, resource limitations, or gaps in knowledge among dental auxiliaries (Kumar et al., 2020). In Saudi Arabia, where dental assistants and nurses constitute a significant segment of the workforce, reinforcing sterilization standards through digital monitoring systems and regular competency assessments could strengthen infection control. AI-supported checklists and sterilization log-tracking platforms represent promising innovations that align with Vision 2030's digital health goals.

3. Workforce Competencies and Training Gaps

A consistent theme across the literature is the critical role of dental assistants and nurses in bridging advanced technology with safe clinical practice (Almutairi & Banerjee, 2021). Yet, studies reveal that their training in both AI literacy and infection control is limited (WHO, 2020). Addressing this gap requires investment in structured professional development programs, incorporation of telehealth and sterilization modules into vocational curricula, and accreditation mechanisms that incentivize compliance. This is particularly relevant in Saudi Arabia, where Vision 2030 prioritizes upskilling healthcare professionals to meet international standards.

4. Alignment with Saudi Vision 2030

The integration of AI-driven orthodontic telehealth and standardized endodontic sterilization protocols directly supports the pillars of Saudi Vision 2030: digital transformation, patient safety, and workforce empowerment (Ministry of Health, 2020). By enhancing the competencies of dental assistants and nurses, Saudi Arabia can ensure that its dental workforce contributes not only to improved patient outcomes but also to national objectives of sustainability and global competitiveness.

5. Challenges and Future Directions

Despite the opportunities, several barriers must be addressed. These include:

- Technological challenges, such as interoperability of AI systems and cost of implementation.
- Human factors, including resistance to change, lack of confidence in AI, and variability in sterilization compliance.
- Regulatory frameworks, which must balance innovation with patient privacy, safety, and accountability.

Future research should explore quantitative assessments of KAP (Knowledge, Attitudes, Practices) among dental assistants and nurses in Saudi Arabia, as well as pilot programs that integrate AI telehealth platforms with sterilization monitoring systems. Such studies could provide empirical evidence to guide policy, training, and technology deployment.

Conclusion

This review underscores the growing importance of AI-enabled orthodontic telehealth and endodontic sterilization protocols as critical components of modern dental practice. While AI technologies provide opportunities to enhance accessibility, efficiency, and patient-centered care, the integrity of sterilization practices remains essential to safeguard treatment success and public health. Within this landscape, dental assistants and nurses emerge as pivotal actors, bridging advanced technologies with safe, evidence-based practices.

For Saudi Arabia, aligning these domains with the pillars of Vision 2030—digital transformation, patient safety, and workforce empowerment—represents both a challenge and an opportunity.

Equipping the dental workforce with the skills needed to integrate AI tools and maintain high standards of infection control will be central to achieving global competitiveness and delivering equitable, high-quality oral healthcare.

Recommendations

1. **Workforce Training and Upskilling**
   - o Develop structured training programs on AI literacy and teledentistry for dental assistants and nurses.
   - o Incorporate advanced infection control and sterilization modules into vocational curricula and continuing education.
2. **Digital Integration in Clinical Workflows**
   - o Implement AI-assisted telehealth platforms in orthodontic practices, especially in underserved regions.
   - o Adopt digital sterilization monitoring systems (e.g., automated checklists, log tracking) to ensure compliance and accountability.
3. **Policy and Regulation**
   - o Establish clear national guidelines for the use of AI in dentistry, ensuring data privacy, patient safety, and clinician oversight.
   - o Strengthen regulatory enforcement of sterilization protocols with periodic audits and competency assessments.
4. **Research and Evaluation**
   - o Conduct future empirical studies, such as KAP (Knowledge, Attitudes, Practices) surveys, to assess workforce readiness.
   - o Pilot and evaluate integrated telehealth–sterilization models in selected Saudi dental clinics.
5. **Alignment with Vision 2030**
   - o Position dental assistants and nurses as frontline contributors to the national digital health agenda.
   - o Use AI-driven telehealth and rigorous sterilization as benchmarks for Saudi Arabia's leadership in innovative, safe, and sustainable dental care.

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