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Review

The Use of Digital Technologies in Endodontic Diagnosis and Restorative Planning

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Abstract

Endodontics and restorative dentistry are integral components of oral healthcare, working collaboratively to preserve and restore tooth health and functionality. The interdependence between these two fields is particularly evident in cases where endodontic therapy precedes restorative interventions. Recent years have witnessed significant advancements in endodontics and restorative dentistry, primarily fueled by the incorporation of cutting-edge digital technologies. The integration of digital technologies has brought about a paradigm shift in the practices of dental professionals, fundamentally altering the way diagnoses are made, treatment plans are formulated, and interventions are executed. This shift is characterized by heightened precision, increased efficiency, and a more patient-centric approach, collectively elevating the standard of dental services. This study undertakes a comprehensive review of the current state of digital technologies in endodontic diagnosis and restorative planning, recognizing their transformative potential in modern dental practices. Commencing on February 25th, 2024, a meticulous examination of current academic literature, utilizing diverse databases such as PubMed, Web of Science, and Cochrane was conducted. The search strategy employed various medical terminologies and manual searches on Google Scholar to identify pertinent research terms. The study emphasizes the rapid evolution and integration of digital technologies in dentistry, presenting novel opportunities to enhance diagnostic precision and streamline treatment planning in both endodontics and restorative dentistry. The review underscores that the integration of digital technologies, encompassing digital radiography, electronic apex locators, digital impressions, computer-aided designing and manufacturing technology, teledentistry, and augmented reality/virtual reality, has ushered in a new era of precision, efficiency, and collaboration in endodontic diagnosis and restorative planning. These technologies collectively enhance diagnostic accuracy, streamline treatment planning, and improve communication among dental professionals, reaffirming the pivotal role of technology in achieving optimal outcomes in both fields.

Keywords: *digital technology, endodontics, restorative dentistry, diagnosis, treatment planning*

Introduction

Endodontics and restorative dentistry play pivotal roles in preserving and restoring the health and functionality of teeth, thereby contributing significantly to overall oral health. Endodontics, the branch of dentistry that focuses on the diagnosis and treatment of dental pulp and periapical tissues, is instrumental in saving teeth that may otherwise be lost due to irreversible damage or infection (1). The primary objective of endodontic procedures, such as root canal therapy, is to eliminate infection, alleviate pain, and maintain the structural integrity of the tooth. The significance of endodontics becomes evident in its ability to address conditions like deep dental caries, trauma, and pulpitis, which, if left untreated, can lead to severe infections and compromise the vitality of the affected tooth (2). By meticulously cleaning and shaping the root canals, endodontists can remove diseased tissue, disinfect the canal system, and subsequently seal it to prevent re-infection. This allows patients to retain their natural dentition, preventing the need for extraction and supporting overall oral function (1). Restorative dentistry, on the other hand, complements endodontics by focusing on the rehabilitation of damaged or missing teeth. Its significance lies in the restoration of both form and function, ensuring that patients can bite, chew, and speak comfortably (3). Restorative procedures encompass a wide range of treatments, including dental fillings, crowns, bridges, and implants. Dental caries, fractures, and wear can compromise the structural integrity of teeth, and restorative dentistry steps in to rebuild and reinforce them (4). The symbiotic relationship between endodontics and restorative dentistry is evident in cases where endodontic therapy precedes the placement of restorations. Following root canal treatment, teeth may undergo restoration with crowns or other prosthetic devices to ensure long-term functionality. This integration of disciplines emphasizes the comprehensive nature of dental care, addressing not only immediate concerns but also considering long-term outcomes for patients (5).

In recent years, endodontics and restorative dentistry have witnessed remarkable advances, largely driven by the integration of cutting-edge digital technologies. Digital innovations have revolutionized diagnostic and treatment modalities, enhancing precision, efficiency, and patient outcomes. The use of digital technologies in endodontics and restorative dentistry has brought about a transformative shift in the way dental professionals diagnose, plan, and execute treatments. This paradigm shift is characterized by increased precision, efficiency, and patient-centric care, ultimately elevating the overall quality of dental services (6). In endodontics, digital technologies have revolutionized diagnostic imaging. This enhances the accuracy of diagnosing conditions such as dental caries, periapical lesions, and intricate root canal anatomy. Moreover, the precision provided by these digital imaging tools facilitates more accurate treatment planning, leading to improved outcomes in root canal therapy and surgical interventions (7). Additionally, specialized endodontic software aids in visualizing internal tooth anatomy, assisting practitioners in navigating complex root canal systems and optimizing treatment strategies (8). Augmented Reality (AR) and Virtual Reality (VR) are emerging as educational tools in restorative dentistry. These technologies provide immersive experiences for training and simulating complex restorative procedures in a virtual environment (9). Dental professionals can enhance their skills and expertise in a risk-free setting, ultimately benefiting patient outcomes. The significance of digital technologies in both endodontics and restorative dentistry lies in their collective impact on improving diagnostic accuracy, treatment planning, and execution. These technologies promote a more patient-friendly experience, reduce the invasiveness of procedures, and contribute to the overall success and longevity of dental interventions (6). As digital tools continue to evolve, the dental landscape is likely to witness further advancements, solidifying the role of technology in shaping the future of endodontics and restorative dentistry. As digital technologies continue to evolve, the future holds the promise of even more sophisticated tools and techniques, further advancing the fields of endodontics and restorative dentistry.

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This study aims to conduct a comprehensive review of the current state of digital technologies in endodontic diagnosis and restorative planning, recognizing their transformative impact on contemporary dental practices. The rationale for this review stems from the rapid evolution and integration of digital technologies in dentistry, presenting novel opportunities to enhance diagnostic precision and streamline treatment planning in endodontics and restorative dentistry. The review also aims to evaluate the efficacy of these digital imaging techniques in diagnosing endodontic pathologies, such as dental caries and periapical lesions, as well as in visualizing intricate root canal anatomies. Additionally, the study will explore the current evidence regarding the accuracy and reliability of electronic apex locators in determining root canal lengths, assess the capabilities of endodontic software in treatment planning, and evaluate the feasibility and effectiveness of teledentistry in remote consultations and collaborative decision-making. By critically reviewing the existing literature, this study aims to provide insights into the current state of digital technologies in endodontics and restorative dentistry, identify gaps in knowledge, and offer directions for future research and clinical implementation. The overarching goal is to contribute to the evidence-based understanding of how digital technologies can optimize diagnosis and treatment planning, ultimately informing dental professionals about the most effective and innovative approaches in contemporary practice.

Review

Recent years have seen substantial advancements in endodontics and restorative dentistry, driven by the integration of state-of-the-art digital technologies. These innovations have transformed diagnostic and treatment approaches, improving precision and patient outcomes. The collective impact of digital technologies improves diagnostic accuracy, treatment planning, and execution, promoting a patient-friendly experience and contributing to the success and longevity of dental interventions (10).

Digital Radiography

The utilization of digital technologies in endodontic diagnosis and restorative planning, particularly in the realm of digital radiography, marks a significant advancement in contemporary dentistry. Digital radiography has revolutionized the imaging landscape, replacing traditional X-ray films with electronic sensors or phosphor plates, thereby transforming the process of capturing and interpreting dental images (11). Digital intraoral radiography, a key component, provides immediate and high-quality images while minimizing radiation exposure. This is crucial in endodontic diagnosis, allowing for a detailed assessment of dental caries, periapical lesions, and root canal anatomy. Research indicates that the enhanced clarity and resolution of digital images aid practitioners in identifying intricate structures within the tooth, contributing to accurate treatment planning (12).

Moreover, Cone Beam Computed Tomography (CBCT) is a digital radiographic technique that has become integral in endodontics. CBCT provides three-dimensional images, offering an unparalleled view of the tooth and surrounding structures. According to the literature, this technology is particularly advantageous in cases requiring detailed assessment, such as complex root canal morphologies or surgical endodontic procedures. The precise imaging capabilities of CBCT contribute to more accurate diagnoses and tailored treatment strategies (13). The integration of digital radiography in endodontics and restorative dentistry underscores the importance of technological advancements in shaping contemporary dental practices. The benefits include reduced radiation exposure, immediate image availability, and improved diagnostic accuracy (11). As digital radiography continues to evolve, it is poised to further streamline the diagnostic and planning phases, contributing to more efficient and patient-centered dental care. The ongoing developments in digital technologies reaffirm their indispensable role in advancing the fields of endodontics and restorative dentistry.

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Digital Impressions and CAD/CAM technology

The incorporation of digital technologies, specifically digital impressions, has significantly transformed endodontic diagnosis and restorative planning in dentistry. Digital impressions have emerged as a cornerstone in modern dental practices, replacing conventional, cumbersome impression materials with advanced intraoral scanners that capture precise 3D models of the teeth (14). According to the research evidence, the accuracy and detail provided by intraoral scanners contribute to a comprehensive understanding of the tooth's anatomy, aiding in the diagnosis of conditions such as dental caries and periapical lesions. This technology facilitates a more efficient and patient-friendly experience, as it eliminates the discomfort associated with traditional impression materials while delivering immediate digital images (15).

In the realm of endodontics, CAD/CAM technology contributes to the restorative phase following root canal treatment. After endodontic therapy, intraoral scanners capture digital impressions, creating precise 3D models of the tooth. These digital models are then utilized in the CAD/CAM workflow to design and manufacture customized restorations, such as crowns and inlays. The ability to digitally design restorations allows for meticulous planning, ensuring optimal fit, function, and aesthetics (16, 17). Additionally, CAD/CAM facilitates same-day dentistry, as restorations can be milled chairside, reducing the time between diagnosis and treatment completion (18).

Restorative planning is further streamlined by CAD/CAM technology in cases where tooth preparation is required. The digital impressions obtained with intraoral scanners aid in designing restorations that precisely fit the prepared tooth structure. Literature suggests that CAD/CAM systems ensure a seamless transition from diagnosis to treatment planning, promoting a more efficient and patient-centered approach (16). In restorative dentistry, CAD/CAM extends its impact beyond individual tooth restorations to the fabrication of bridges and implant-supported prosthetics. The digital design capabilities allow for the creation of complex restorations with intricate anatomical details, ensuring optimal form and function (19). The benefits of CAD/CAM technology also extend to communication between dental professionals and dental laboratories. Digital files can be easily shared, fostering collaboration and enabling precise fabrication of restorations. This digital workflow enhances the overall accuracy of the restoration process, minimizing errors associated with traditional methods (16).

Electronic Apex Locators

Electronic Apex Locators (EALs) have emerged as indispensable tools in the realm of endodontic diagnosis, playing a crucial role in facilitating precision and accuracy during root canal procedures. These digital technologies have significantly enhanced the process of determining the length of root canals, revolutionizing the way dental professionals approach endodontic treatments (20). In endodontic diagnosis, EALs contribute to the accurate localization of the apical foramen, allowing practitioners to determine the precise working length of the root canal (21). Traditional radiographic methods, while valuable, can present limitations such as distortion and superimposition, making it challenging to achieve pinpoint accuracy. EALs, on the other hand, provide real-time feedback by measuring the impedance or resistance changes in the root canal, enabling precise identification of the apical constriction. Research indicates that this not only enhances diagnostic accuracy but also aids in avoiding over-instrumentation, reducing the risk of procedural errors (22). Moreover, according to the evidence, EALs have a profound impact on restorative planning following endodontic treatment. By accurately determining the root canal length, dental professionals can ensure that restorations are precisely positioned at the apex, promoting a sealed and biologically effective closure. This is crucial for the success of restorations, particularly when considering factors such as post-placement and core build-up materials (21). The use of EALs aligns with the contemporary trend of minimally invasive dentistry, as it allows for more conservative approaches in root canal treatment. The ability to

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precisely identify the apex contributes to the preservation of tooth structure, reducing unnecessary removal of healthy dentin.

Endodontic Software

Endodontic software has emerged as a pivotal component in the integration of digital technologies for endodontic diagnosis and restorative planning, offering advanced tools to enhance precision, visualization, and treatment planning in contemporary dentistry. This software plays a crucial role in transforming the way dental professionals approach complex endodontic cases and subsequent restorative procedures. In endodontic diagnosis, specialized endodontic software facilitates a detailed analysis of internal tooth anatomy, aiding practitioners in visualizing and navigating intricate root canal systems (23). Research suggests that the software provides three-dimensional reconstructions of the tooth, allowing for a comprehensive understanding of root canal morphology and potential challenges. This level of visualization is particularly beneficial in cases with aberrant canal configurations or anatomical variations, enabling practitioners to formulate optimal treatment strategies (24). Moreover, endodontic software contributes to treatment planning by offering simulation tools that allow practitioners to virtually plan and execute root canal procedures. The ability to simulate various treatment scenarios enhances preoperative strategizing, reducing the likelihood of unexpected challenges during actual procedures. Additionally, research indicates that the software assists in optimizing instrument selection and placement, fostering a more precise and efficient treatment process (25).

In restorative planning, endodontic software aids in seamless communication between endodontists and restorative dentists. Digital files generated by the software can be easily shared, allowing for collaborative decision-making and ensuring that restorations are tailored to the specifics of each case. This facilitates a more coordinated and integrated approach between endodontic and restorative phases, ultimately leading to improved outcomes for the patient (23). The significance of endodontic software lies in its ability to provide a comprehensive digital workflow that enhances diagnostic accuracy, treatment visualization, and collaborative efforts among dental professionals. As these technologies continue to evolve, endodontic software is poised to become an even more integral part of endodontic and restorative practices, contributing to a more streamlined, efficient, and patient-centered approach in the field of dentistry.

Teledentistry and Digital Treatment Records

Teledentistry, coupled with digital dental records, represents a revolutionary integration of digital technologies in endodontic diagnosis and restorative planning, transforming the way dental care is delivered and managed. Teledentistry allows for remote consultations, enabling endodontists and restorative dentists to collaborate efficiently, irrespective of geographical distances. This is particularly valuable in complex endodontic cases where specialists' input is essential for optimal treatment planning (26). Through teledentistry platforms, digital images and records can be securely shared and discussed, facilitating a more collaborative and interdisciplinary approach to patient care. The use of digital dental records is paramount in this context, as it streamlines the management of patient information, treatment plans, and follow-up procedures. According to the research, electronic health records enhance accessibility, ensuring that crucial patient data is readily available to both endodontists and restorative dentists involved in the case. This seamless exchange of information contributes to more informed decision-making, reducing the risk of miscommunication and improving the continuity of care (27).

Teledentistry, in conjunction with digital dental records, also enhances patient communication and engagement. Dental professionals can remotely consult with patients, discuss treatment options, address concerns, and provide education on post-endodontic and restorative care. This not only contributes to a more patient-centered approach but also fosters better understanding and compliance (28). Furthermore, digital dental records contribute

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to the efficiency of restorative planning. Access to comprehensive patient histories, treatment plans, and diagnostic images allows restorative dentists to make informed decisions when designing and fabricating restorations following endodontic procedures. This integration of information reduces redundancies, streamlines workflows, and improves the overall quality of restorative outcomes (29). The combined use of teledentistry and digital dental records in endodontic diagnosis and restorative planning exemplifies the potential of digital technologies to enhance communication, collaboration, and efficiency in dental care.

Augmented Reality (AR) and Virtual Reality (VR)

Augmented Reality (AR) and Virtual Reality (VR) are emerging as transformative elements in endodontic diagnosis and restorative planning, offering innovative tools that provide enhanced visualization, education, and simulation capabilities in dentistry. In endodontics, these technologies provide practitioners with immersive experiences for detailed visualization of root canal systems and dental anatomy (30). AR overlays digital information onto the real-world view, aiding in real-time visualization during procedures. VR, on the other hand, creates fully immersive virtual environments, allowing practitioners to explore and navigate virtual tooth structures in three dimensions. This level of visualization is particularly beneficial for understanding complex root canal morphologies and planning intricate endodontic procedures (9).

The educational potential of AR and VR in restorative dentistry is also substantial. These technologies offer interactive learning experiences, allowing dental professionals to engage in simulated restorative procedures. Practitioners can virtually design and manipulate restorations, improving their skills in a risk-free environment (30). AR can be employed chairside, overlaying digital information onto the patient's real-time view during restorative procedures, aiding in precise tooth preparation and restoration placement (31). Moreover, AR and VR contribute to patient education and communication. By using these technologies, practitioners can visually demonstrate treatment plans, show patients virtual representations of their oral conditions, and explain proposed restorative procedures. Evidence suggests that this enhances patient understanding, leading to improved communication, and ultimately, increased treatment acceptance (32). The integration of AR and VR in endodontic diagnosis and restorative planning fosters a more collaborative approach among dental professionals. Virtual models and simulations can be easily shared, enabling multidisciplinary teams to collaboratively plan and execute complex treatments (31, 32). This interconnected approach enhances the overall quality of care and facilitates a more streamlined workflow. As AR and VR technologies continue to evolve, their application in endodontics and restorative dentistry holds tremendous promise. These innovations not only provide advanced visualization and educational tools but also contribute to improved patient communication, making them valuable assets in shaping the future of comprehensive and patient-centric dental care (9).

Conclusion

The integration of digital technologies, such as digital radiography, electronic apex locators, digital impressions, CAD/CAM technology, teledentistry, and augmented reality/virtual reality, has ushered in a new era of precision, efficiency, and collaboration in endodontic diagnosis and restorative planning. These technologies collectively enhance diagnostic accuracy, streamline treatment planning, and improve communication among dental professionals. The ongoing advancements reaffirm the pivotal role of technology in achieving optimal outcomes in endodontics and restorative dentistry.

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Conflict of interest

There is no conflict of interest

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Data availability

Data that support the findings of this study are embedded within the manuscript.

Author contribution

All authors contributed to conceptualizing, data drafting, collection and final writing of the manuscript.

References

1. Torabinejad M, Fouad AF, Shabahang S. Endodontics e-book: Principles and practice: Elsevier Health Sciences; 2020.

2. Walton RE, Torabinejad M, Bakland LK. Endodontics. Principles and Practice (10th ed) St Louis, Missouri: Elsevier. 2009.

3. Caiafa A, Visser L. Restorative dentistry. Wiggs's Veterinary Dentistry: Principles and Practice. 2019:357-86.

4. Walmsley AD, Walsh TF, Lumley P, Burke FT, Shortall A, Hayes-Hall R, et al. Restorative Dentistry: Elsevier Health Sciences; 2007.

5. Gopikrishna V. Conservative Dentistry. J Conserv Dent.

6. Rekow ED. Digital dentistry: The new state of the art—Is it disruptive or destructive? Dental Materials. 2020;36(1):9-24.

7. Gaudin A, Pérez F, Galicia J. Digital technology in endodontics. Digital Restorative Dentistry: A Guide to Materials, Equipment, and Clinical Procedures. 2019:229-47.

8. Masri R, Driscoll CF. Clinical applications of digital dental technology: Wiley Online Library; 2015.

9. Huang T-K, Yang C-H, Hsieh Y-H, Wang J-C, Hung C-C. Augmented reality (AR) and virtual reality (VR) applied in dentistry. The Kaohsiung journal of medical sciences. 2018;34(4):243-8.

10. Haidar ZS. Digital Dentistry: Past, Present, and Future. Digital Medicine and Healthcare Technology. 2023.

11. Dhir P, David CM, Keerthi G, Sharma V, Girdhar V. Digital imaging in Dentistry: An overview. International Journal of Medical and Dental Sciences. 2014:524-32.

12. Farida A, Maryam E, Ali M, Ehsan M, Sajad Y, Soraya K. A comparison between conventional and digital radiography in root canal working length determination. Indian Journal of Dental Research. 2013;24(2):229-33.

13. Kamburoğlu K. Use of dentomaxillofacial cone beam computed tomography in dentistry. World journal of radiology. 2015;7(6):128.

14. Runkel C, Güth J-F, Erdelt K, Keul C. Digital impressions in dentistry—accuracy of impression digitalisation by desktop scanners. Clinical oral investigations. 2020;24:1249-57.

15. Seelbach P, Brueckel C, Wöstmann B. Accuracy of digital and conventional impression techniques and workflow. Clinical oral investigations. 2013;17:1759-64.

16. Escobar PM, Kishen A, Lopes FC, Borges CC, Kegler EG, Sousa-Neto MD. A CAD/CAM-based strategy for concurrent endodontic and restorative treatment. Restorative dentistry & endodontics. 2019;44(3).

17. Susic I, Travar M, Susic M, editors. The application of CAD/CAM technology in Dentistry. IOP Conference Series: Materials Science and Engineering; 2017: IOP Publishing.

18. Nayak A, Jain PK, Kankar P, Jain N. Computer-aided design–based guided endodontic: a novel approach for root canal access cavity preparation. Proceedings of the Institution of Mechanical Engineers, Part H: Journal of Engineering in Medicine. 2018;232(8):787-95.

19. Abdullah AO, Muhammed FK, Zheng B, Liu Y. An Overview of Computer Aided Design/Computer Aided Manufacturing (CAD/CAM) in Restorative Dentistry. Journal of Dental Materials & Techniques. 2018;7(1).

20. Khadse A, Shenoi P, Kokane V, Khode R, Sonarkar S. Electronic apex locators-an overview. Indian Journal of Conservative and Endodontics. 2017;2(2):35-40.

http://dx.doi.org/10.52533/JOHS.2024.40301

21. Tsesis I, Blazer T, Ben-Izhack G, Taschieri S, Del Fabbro M, Corbella S, et al. The precision of electronic apex locators in working length determination: a systematic review and meta-analysis of the literature. Journal of endodontics. 2015;41(11):1818-23.

22. Shirazi Z, Al-Jadaa A, Saleh AR. Electronic Apex Locators and their Implications in Contemporary Clinical Practice: A Review. The Open Dentistry Journal. 2023;17(1).

23. Van Der Meer WJ, Vissink A, Ng YL, Gulabivala K. 3D Computer aided treatment planning in endodontics. Journal of dentistry. 2016;45:67-72.

24. Decurcio DA, Bueno MR, Silva JA, Loureiro MAZ, Sousa-Neto MD, Estrela C. Digital planning on guided endodontics technology. Brazilian Dental Journal. 2021;32:23-33.

25. Ribeiro D, Reis E, Marques JA, Falacho RI, Palma PJ. Guided Endodontics: Static vs. Dynamic Computer-Aided Techniques—A Literature Review. Journal of Personalized Medicine. 2022;12(9):1516.

26. Daniel SJ, Kumar S. Teledentistry: a key component in access to care. Journal of evidence based dental practice. 2014;14:201-8.

27. Joda T, Bornstein MM, Jung RE, Ferrari M, Waltimo T, Zitzmann NU. Recent trends and future direction of dental research in the digital era. International journal of environmental research and public health. 2020;17(6):1987.

28. Torres-Pereira CC, Morosini IdAC, Possebon RS, Giovanini AF, Bortoluzzi MC, Leao JC, et al. Teledentistry: distant diagnosis of oral disease using e-mails. Telemedicine and e-Health. 2013;19(2):117-21.

29. Khan SA, Omar H. Teledentistry in practice: literature review. Telemedicine and e-Health. 2013;19(7):565-7.

30. Fahim S, Maqsood A, Das G, Ahmed N, Saquib S, Lal A, et al. Augmented reality and virtual reality in dentistry: highlights from the current research. Applied Sciences. 2022;12(8):3719.

31. Carpegna G, Scotti N, Alovisi M, Comba A, Berutti E, Pasqualini D. Endodontic microsurgery virtual reality simulation and digital workflow process in a teaching environment. European Journal of Dental Education. 2023.

32. Dzyuba N, Jandu J, Yates J, Kushnerev E. Virtual and augmented reality in dental education: The good, the bad and the better. European Journal of Dental Education. 2022.

http://dx.doi.org/10.52533/JOHS.2024.40301