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Digitalization in Periodontics: Unlocking Potential and Possibilities

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ABSTRACT

The field of periodontics has undergone a transformative evolution with the integration of digital technologies. This abstract explores the impact of digitalization on periodontics, focusing on key aspects such as diagnostics, treatment planning, and patient engagement. Digital imaging, including digital radiography and intraoral scanners, has revolutionized the precision and efficiency of periodontal diagnostics. Computer-Aided Design and Manufacturing (CAD/CAM) technologies have enhanced treatment planning, allowing for customized and accurate solutions in periodontal interventions. Teledentistry has emerged as a valuable tool, facilitating remote consultations and increasing accessibility to periodontal care. Electronic Health Records (EHRs) streamline patient management, improving communication among healthcare providers. Precision dentistry, guided by advanced software, ensures optimal outcomes in periodontal surgeries. The incorporation of augmented and virtual reality in periodontal education enhances the learning experience for students and professionals. Digital platforms, such as websites and mobile apps, play a pivotal role in patient engagement and education, empowering individuals to actively participate in their periodontal health. As digitalization continues to advance, periodontics stands at the forefront of innovation, offering a more efficient, precise, and patient-centric approach to the prevention and treatment of periodontal diseases.

Keywords: *Teledentistry, Electronic health records, Artificial Intelligence, 3D printing, Digital Imaging, Periodontal disease*

INTRODUCTION

In the dynamic landscape of contemporary dentistry, the integration of digital technologies has ushered in a new era of precision, efficiency, and patient-centered care. This paradigm shift is particularly pronounced in the specialized field of periodontology, where the application of digital tools has transformed traditional approaches to diagnosis, treatment planning, and patient education and engagement. Digital periodontology harnesses a spectrum of cutting-edge technologies to enhance the accuracy and effectiveness of periodontal diagnostics. Traditional diagnostic methods, often reliant on analog approaches, are being superseded by digital imaging modalities such as digital radiography and intraoral scanners. These technologies provide clinicians with real-time insights, reducing the margin for error and improving diagnostic precision.1 Dental conditions including periodontitis and dental caries are among the most common in the world, generating significant subjective and financial burdens on patients and healthcare systems.2

Periodontal disease is an infection-driven inflammatory disease resulting from an interplay of microbial infection and host response to the microbial challenge and can be influenced by several environmental, acquired, and genetic risk factors.3 Traditional methods of diagnosing periodontal conditions often relied on visual and tactile assessments, which had limitations in terms of accuracy and early detection. However, with the advent of

digital technology, dental professionals now have access to advanced tools and techniques that enhance the precision and efficiency of periodontal disease diagnosis.
The integration of digital technology in the field of periodontics has elevated the standard of care in dentistry and enhanced diagnostic capabilities, contributing to more personalized and effective treatment strategies for individuals with periodontal concerns. This review explores the impact of digitalization in periodontics, focusing on key areas where technology has reshaped traditional practices.4

Teledentistry:
Teledentistry is an online dental care service that allows patients and dentists to meet in real-time, safely, without being at the same location, and is generated from interactive tools, telecommunications, and dentistry combinations. Instead of directly speaking with patients face-to-face, teledentistry uses information technology to enable remote dental care, advice, education, or treatment. The first study on teledentistry was conducted in 1994 by the US Army as part of the US Army's Total Dental Access Project.5 The term Teledentistry was defined by Cook et al. in 1997, as "the practice of diagnosing and providing treatment advice over a distance using video-conferencing technology".6
There are 3 primary ways in which it can be used as a service modality which include the following7:
i) consultations between dentists; for instance, a general dentist and a specialist dentist could share patient records and pictures, then have a review and a discussion about treatment planning;
ii) a real-time face-to-face videoconference consultation between a general dentist or specialist and a patient or family member in a remote, distant location;
iii) remote patient monitoring, gathering data in real-time, and sending them to the dentist in a remote location for examination and action as required.

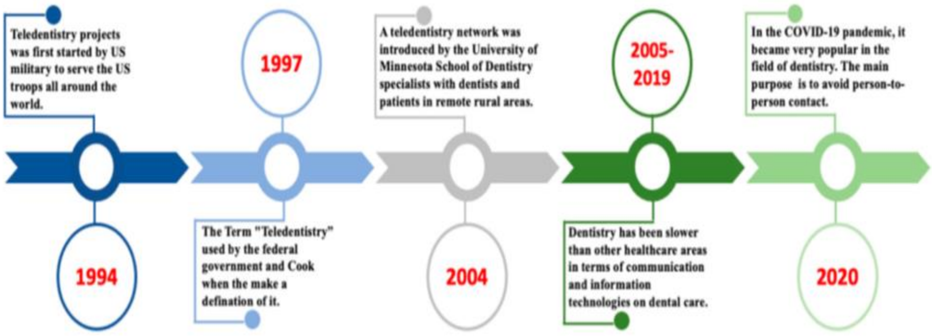

Figure 15: Timeline of teledentistry evolution.5

Electronic Health Records (EHRs)
EHRs refer to digital records that contain comprehensive patient information, treatment history, radiographs, and other pertinent dental data. Several benefits come with implementing electronic health records (EHRs) in dental practices, from better patient care and less administrative work to increased data security and practice efficiency. The transition of dental clinics from maintaining paper data to electronic health records has simplified patient management. EHRs make it easier for dental practitioners to store, retrieve, and share data efficiently. The process of digitizing dental information improves communication, reduces paperwork, and contributes to a more organized and comprehensive approach to patient care.8

Patient Engagement and Education

Digital platforms, including websites, mobile apps, and social media, are powerful tools for patient engagement and education. Dentists can use these platforms to disseminate information about oral health, treatment options, and post-operative care. Interactive content and virtual simulations contribute to a more informed and empowered patient base.9

Digital Imaging and Diagnostics

Digital radiography has replaced conventional X-rays, offering benefits such as reduced radiation exposure, immediate image availability, and enhanced diagnostic capabilities. Intraoral scanners have become essential tools, providing high-resolution 3D images of the oral cavity. These digital diagnostics not only aid in accurate diagnosis but also streamline the communication of information between dental professionals. A modern alternative to conventional film-based radiography that involves recording radiographs using digital sensors that create high-quality images with minimal radiation exposure. Digital storage of the pictures makes it simple to share them with other dental and medical specialists for collaborative diagnosis, planning, and follow-up.1 Disadvantages of IOPA or bitewing radiographs include overlapping anatomical structures, lack of 3D details, and under or overestimation of the bone defects, complicating the determination of bone defects, in particular the intrabony lesions.10

- Digital radiography: Two digital radiographic methods: One uses solid-state detectors and other photostimulable phosphors.

The direct method: Solid-state detectors are based either on charge-coupled device technology (CCD) or on complementary metal oxide semiconductor technology (CMOS). The key feature is the immediate availability of the image which results in considerable time saving.11

The Indirect Method: This digital imaging system is based on photostimulable phosphor (PSP) also called storage phosphor. offer an indirect approach to digital image acquisition. The exposed PSP plates are scanned in an external laser scanner, which generates the digital image data for storage and display on the computer. The plates are then erased and can be reused.12

Advantages and disadvantages of digital radiography11,12

Advantages - There are numerous ways to alter the final image, including changing its brightness, contrast, inversion, and grayscale. Accurate measurement can be ensured through the calibration of magnified pictures through computer software applications.

Disadvantages - Cost of devices, learning to use the concept, thickness, and rigidity of the sensor, lack of standardization, and infection control.

- Digital Subtraction Radiography (DSR)10,13

Digitalization of intraoral radiographs significantly reduced the radiation exposure and made digital subtraction radiography (DSR) possible for follow-up of lesions. By removing the unaltered anatomic structures from the image, this approach makes it easier to visualize even small changes in bone density, both qualitatively and quantitatively. The development of digital subtraction radiography (DSR) aims to improve the depiction of changes in minerals over time The application of substraction radiography in dentistry was facilitated by the development of microcomputers, allowing conventional radiographs to be digitized and subtracted. A uniform difference picture is created by registering two images of the same item and subtracting the image intensities of the corresponding pixels.

Advantages of DSR

- detects small osseous lesions
- improved overall contrast and trabecular marrow spaces can be visualized with enhancement of low- and high-density images.

Disadvantages of DSR

- Cannot give an objective description
- Presence of high standardization of x-rays, no reduction in exposure, costly and time-consuming process
- Needs identical projection alignment during exposure of sequential radiographs.

- **Cone-Beam Computed Tomography (CBCT):**

CBCT uses a 2D area detector mounted on a rotating gantry that rotates 360 degrees around the head in conjunction with an ionizing radiation source in the shape of a cone. In one scan, several sequential pictures are generated. To create fundamental images that are subsequently utilized to reconstruct 3D views, several exposures are done at predetermined intervals. Evaluation of the jaw bones, implant placement, TMJ evaluation, diseases in the bone and soft tissue, periodontal evaluation, endodontic evaluation, alveolar ridge resorption, etc. are among the conditions for which it is advised.13

3D advancement in periodontal probing

Periodontal pockets are clinically assessed using a calibrated thin metal instrument called a periodontal probe, inserted into the gingival sulcus or pocket, and advanced to the base of the pocket until resistance is met by the first intact collagen fibers.14 The third-generation periodontal probe integrates digital data collection, controlled force application, and automated measurements. The system stores digital recordings of the periodontal pocket depth readings. Using such periodontal probes necessitates digitization, however the probes do not provide 3D disease information.10 The fourth generation of periodontal probes, known as the ultrasonographic periodontal probe, uses images and maps the upper boundary of the periodontal ligament and its variation over time to show whether periodontitis is present. The ultrasonic image is constructed, and periodontal pocket depth measurements are estimated using computer software that interprets the data and provides 3-D information about the disease.10,14

T Scan system in Periodontics:

T-Scan is a computerized occlusal analysis system used in dentistry to evaluate occlusal force and analyze the distribution of forces on individual teeth during biting and chewing. The T-Scan system typically involves placing a thin, sensor-equipped device between the patient's teeth. T-scan measures the length of the bite, the force of the tooth contact, and the timing of the tooth contact in order to assess the occlusal contact data.15 Sreelakshmi CK et al16., showed that using T-Scan III, how occlusal loading forces, occlusal contact variability, and their correction were managed in cases of periodontitis.

3D bioprinting

3D printing is correctly described as additive manufacturing or rapid prototyping is generally used to describe a manufacturing approach that builds objects one layer at a time, adding multiple layers to form an object. The 3D printer uses a powder or liquid resin that is gradually constructed from an image on a layer-by-layer basis. All 3D printers also use 3D CAD software that measures thousands of cross-sections of each product to determine precisely how each layer is to be constructed. A small layer of liquid resin is dispensed by the 3D printer, and each layer is hardened in the desired cross-section pattern using an ultraviolet laser that is controlled by a computer. A chemical bath is used at the end of the operation to remove any leftover soft resin. The intricate hierarchical structure of periodontal tissues necessitates the use of multiphasic biomaterial constructs that can replicate the structural integrity of the bone-ligament contact.17 Applications in the field of periodontics include guided implant placement, scaffolds, educational models, sinus and bone augmentation, and socket preservation. Improved alveolar ridge preservation, enhanced regenerative capabilities, increased reduction in pocket depth and bony fill, easier implant placement in complicated cases with more accuracy and less time required with better results, and a valuable tool for training and education using simulated models were all demonstrated.18

3D assisted Implant surgery

When traditional procedures are implicated, the clinical outcome is often uncertain and relies heavily on the expertise and experience of the clinician. Computer-assisted implant surgery (CAIS) has become an integral part of modern implantology, offering a more accurate, predictable, and minimally invasive approach to dental implant placement. CAIS uses advanced imaging, computer software, and navigational tools to enhance the precision and success of implant surgeries.10 CAIS currently consists of three different technologies: static, dynamic, and robotic. Static relies on prefabricated guides to guide osteotomy and implant placement; dynamic is based on real-time tracking of the drill's position, and robotic includes implant placement by an autonomous robotic arm.19

Digital smile designing (DSD)

The goal of the DSD concept is to assist clinicians by enhancing the aesthetic visualization of the patient's concern, providing insight into a potential solution thereby educating and motivating them about the benefits of the treatment and increasing the case acceptance. Digital smile design enables us to create and project the new smile design by attaining a simulation and previsualization of the final outcome of the proposed treatment. Patients participate in the digital designing process of their smile, which allows for customization of the smile to match each patient's unique needs preferences, and psychological traits. This emotional connection with the patient boosts their confidence in the process and improves their acceptance of the planned treatment.20 DSD is described as a multipurpose conceptual tool that can support diagnostic vision, improve communication, and enhance treatment predictability, by allowing careful analysis of the patient's facial and dental characteristics that may have gone unnoticed by clinical, photographic, or diagnostic cast-based evaluation procedures.21 The efficacy of using DSD approaches and whether or not DSD is improving patient comfort and treatment outcomes were assessed in a study by Gabriele Cervino et al., that involved reviewing 24 articles on DSD. The authors concluded that this tool provides the clinician as well as the patient vital information, such that patients can observe their rehabilitations even before they start which may serve crucial medico-legal purposes.22

Artificial intelligence (AI)

AI is increasingly being integrated into dental education and training which provide immersive learning experiences for dental students and professionals, enhancing their understanding of complex procedures and improving clinical skills. The goal of artificial intelligence (AI) is to create computer programs that can use machines to simulate human behavior. When developing an AI-based tool, both the input ‘A’ and the required output ‘B’ are provided; the AI approach then tunes the tool to leverage the link between input and output, which can then be used on new (unseen) data sets, typically with remarkable performance.23 The AI model utilized was built on the foundation of a 'conventional neural network' (CNN) and trained with photos to fine-tune the system using the transfer learning method.10 Evidence suggests that

AI can help in the diagnosis and treatment planning of periodontal disease by reducing subjectivity, detecting periodontal bone loss, and classifying periodontal infections. However, additional research is required to standardize AI algorithms and confirm their therapeutic utility.24

CONCLUSION

In conclusion, the digitalization of periodontics represents a significant leap forward in the delivery of periodontal healthcare. From advanced diagnostics and precision dentistry to remote consultations and patient education, digital technologies are reshaping traditional practices and improving overall outcomes. Embracing these innovations ensures that periodontal treatment remains at the forefront of healthcare, providing efficient, patient-centered, and technologically advanced solutions for the benefit of both practitioners and those seeking quality periodontal as well as overall oral care.

Declaration by Authors

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