ISSN: 2581-5989
PubMed - National Library of Medicine - ID: 101738774

International Journal of Dental Science and Innovative Research (IJDSIR)

IJDSIR : Dental Publication Service

Available Online at: www.ijdsir.com

Volume – 7, Issue – 3, May – 2024, Page No. : 46 - 52

An insight into the digital evolution in Periodontics - A Narrative Review

[1]Dr. Pranisha P.K, Postgraduate Student, DAPM RV Dental College, Bangalore

[2]Dr. Apoorva S.M, Reader, DAPM RV, Dental College, Bangalore

[3]Dr. Suchetha A, Professor and HOD, Department, DAPM RV Dental College, Bangalore

[4]Dr. Darshan B. M, Reader, Department of Periodontics, DAPM RV, Dental College, Bangalore

Corresponding Author: Dr. Pranisha P.K, Postgraduate Student, DAPM RV Dental College, Bangalore.

Citation of this Article: Dr. Pranisha P. K, Dr. Apoorva S.M, Dr. Suchetha. A, Dr. Darshan B.M, "An insight into the digital evolution in Periodontics - A Narrative Review", IJDSIR- May – 2024, Volume –7, Issue - 3, P. No. 46 – 52.

Type of Publication: Review Article

Conflicts of Interest: Nil

Abstract

In this emerging era of digital revolution, where our day-to-day life is being improved, digital revolution has set foot in the field of dentistry as well. These technologies have refined the dental professional to operate in a smarter, adaptable and convenient way. Over the past few years, several developments have been observed which have enabled the general dentistry to become better. In this so-called digital age, there has been a rapid progress in the field of Periodontics also, both in clinical aspects as well as research. The purpose of this article is to narrate digital advancements in diagnosis and treatment planning in the field of Periodontics. This article throws light on digitization in the field of Periodontics such as three-dimensional advancement in periodontal probing, Digital imaging, Photo acoustic imaging, Optical coherence tomography, three-dimensional Bio-printing, Digital implant planning and digital implant surgery etc.

Keywords: Digital Dentistry, Digital Imaging, Narrative Review, Periodontics, T-scan, 3D-bioprinting.

Introduction

The wave of digital revolution has greatly impacted our daily life that has become an inevitable component. Digitalization is conquering every possible aspect making our lives much easier and more effortless. Dentistry has also evolved in its course with the digitalization which has significantly improved dental professionals in their practice and management. Digital technologies and newer equipments are superior when compared to the conventional procedures. The precision and ease of use of these computing devices have made practice more efficient with reduced errors. Virtual planning has paved the way for a better patient communication, more precise esthetic and functional rehabilitations, and more predictable treatment outcomes. Computer software's can improve clinical evaluation and treatment plan through analysis and simulation. Right from diagnosis to treatment plan, digitization has created a remarkable progress. Handling and evaluating patient data have become extremely simple due to advances in computing speed and user interfaces.[1] In periodontology, diagnosis is an integral step towards management of the disease. The digital techniques can offer much more accuracy in the diagnosis of periodontal disease.[2]Technological advancements are allowing medical/ dental professionals to adopt more conservative treatment modalities, such as minimally invasive periodontal therapy, which improves patient acceptance and comfort.[1]For the purpose of evaluating pathogenic abnormalities and implantology, digital radiography and modern diagnostic tools have proven to be highly efficacious and accurate. Various other advances include3D advancement in periodontal probing, T-scan, Bio-printing, Digital imaging, 3D assisted implant surgeryetc.[3]

3D Advancement in periodontal probing

Conventionally probing depths are clinically assessed using periodontal probe, a calibrated thin metallic instrument. The probe is placed into the pocket or gingival sulcus for recording the pocket depth.[4]Even now, periodontal charting is most commonly performed using the first-generation probes. Using these instruments has several drawbacks, the most frequently mentioned being that the approach is not standardized, there can be large intra and inter-examiner variances while probing.[5] A pressure-sensitive probe has been developed to get over the limitations and variables that affect probing method. This type of probes can exert a constant pressure while recording the pocket's depth. Because the instruments of the second generation are sensitive to pressure, the uniformity of probing pressure can be enhanced. These probes were developed in response to scientific literature showing that standardized probing pressure is necessary, and should not exceed 0.2 N/mm^2.[6]The third generation of periodontal probes combines automated measurements, controlled force delivery, and digital data capture. Digital measurements of the depth of the periodontal pocket are stored by the system. Such periodontal probes require digitalization in order to be used, but they do not offer 3D disease information.[2] 4th generation probes are three dimensional probes intended to record sequential probing along the gingival sulcus. They represent an effort to expand the linear probing system to serial probing system.[6]5th generation probes are the ultrasonographic probes which uses a narrow, high-frequency (10–15 MHz) ultrasonic wave. This wave is sent into the gingival sulcus/periodontal pocket, which then identifies the echoes of the wave that is returning.[7]The cementoenamel junction is a fixed point that can serve as a mapping system for measuring and recording the depth of periodontal pocket using an ultrasound probe non-invasively.[8]

Diamond probe/ Perio 2000

This device encompasses a probe with an ability to identify compounds with volatile sulphur in periodontal pockets. Although it resembles a typical periodontal probe, its tip has a unique micro-sensor that detects Clinical Attachment Level (CAL), Probing Pocket Depth (PPD), bleeding on probing and levels of sulfide in this system.[9]The system outputs three different sorts of information when the sensor-integrated probe tip comes and contacts the sulfides in the gingival crevicular fluid: a sulfide level, an auditory tone, and a four-color light bar.[35]

Digital Imaging in Periodontics

Intraoral radiographs are frequently utilized to detect loss of alveolar bone linked to periodontal disease. A variety of factors can impact the quality of an X-ray-sensitive film. Poor exposure, excessive or insufficient development, and inadequate fixing can result in a radiograph that is not very useful for diagnosis.[10]Various digital intraoral radiographic methods which are majorly in use are CCDs, (Charged Couple Devices)and PSP.[11,12] Advantages of digital imaging includes telediagnosis, rapid image transfers, electronic record of patient, better image quality, adjustment in contrast and brightness of image, less radiation exposure, time saving, eliminates need for film and developing chemicals etc.[36]

Subtraction radiography

A well-established technique called subtraction radiography which has been in use in medicine, has been added to the list of techniques for diagnosing periodontal disease. The process of converting serial radiographs into digital images is necessary for this approach. The digital images that were acquired in serial fashion can then be superimposed, and the resulting composite can be seen on a video screen. One can identify variations in bone density and volume by observing lighter regions (indicating bone gain) or darker regions (indicating bone loss).[37]

However, intraoral radiography remains basically a two-dimensional (2D) imaging technique due to a lack of expertise regarding the 3D defect component of infra-bony abnormalities. Axial slices surrounding the point of interest are provided by conventional CT, which solves this problem but has a number of drawbacks'.[13,14,15]The superimposition of teeth frequently hides periodontal bone defects in 2D images and a two-dimensional picture cannot detect bone loss. A three-dimensional (3D) model of the target region can be created using Cone Beam Computed Tomography (CBCT) software, and the CBCT technique produces a 3D volumetric picture in the coronal, transaxial, and sagittal planes without any magnification.[16] For the identification of intrabony defects, furcation involvements, and destructions of the buccal/lingual bone, CBCT provides the 3D images that are required. Although there are clear advantages to using CBCT applications in Periodontics, considering the need of the examination and possible risks, it should only be utilized when it is indicated.[17]

Perioscopy

Introduced in 2000, perioscopy is a lesser invasive technique based on the principles of medical endoscopy**.** A small periodontal endoscope is called a perioscope. It visualises the subgingival surface of the root, the tooth surface, and the calculus when it is placed into the periodontal pocket.[18]A 1-mm fiber-optic bundle featuring lighting, irrigation, and a digital display makes up the system. In one randomized controlled experiment, the perioscopy device was reported to produce a statistically significant calculus clearance using this endoscope for sub-gingival scaling; however, this effect was restricted to interproximal areas deeper than 6 mm.[19]Using a periscope during periodontal therapy has enhanced significantly the subgingival calculus removal. To help with the subgingival tissue imaging and diagnosis and treatment aspect of periodontal disease, a periodontal endoscope with fiber optics was developed.[20]The potential of periodontal endoscopy in order to visualise subgingival calculus seems fairly promising, given that it is a clinically available technology designed for exploration in the gingival sulcus. With the perioscope, we may precisely identify and demarcate any anatomical irregularities or abberrations on the root surface, such as furcations and line angles, which could potentially jeopardize the maintenance of periodontal health following treatment. The prolonged treatment duration and the operator's high learning curve are the key drawbacks.[21]While the majority of patients can be treated deprived of anesthesia, a small percentage of patient feels discomfort without anesthesia and hence, requires the same level of anesthesia as traditional surgical periodontal treatments.[22]

Optical Coherence Tomography (OCT)

Optical coherence tomography, a non-invasive method of studying the dental microstructure, can also be used to evaluate periodontal tissues. It provides a tissue "optical biopsy" at a depth of two to three millimeters. Huang et al. (1991) proposed OCT as a biologic imaging method. Important anatomic features are visible in dental OCT pictures in-vivo, which are useful for diagnosing both hard and soft oral tissues. OCT allows for the high-resolution visualization of periodontal tissue shape, sulcular depth, and attachment of connective tissue. Therefore, before significant bone loss happens, it can detect active periodontal disease.[23] Optical coherence tomography is an imaging technique where a low coherence infrared light is used to capture micrometer resolution in three- dimensional 3D image from within optical scattering media. It provides sections of tissues in non-invasive manner**.** With OCT, one can create 3D images by reconstructing high-resolution cross-sections of both soft and hard tissues, including subgingival calculus.[24]

Laser Fluorescence

Subgingival calculus is detected by laser fluorescence using root surface chemicals that are stimulated to produce distinctive emission frequencies.25 Metabolite porphyrins are produced as an intermediate bio product during the heme production process. Porphyromonas gingival is and Prevotella intermedia are examples of the oral periodontopathic bacteria that synthesise porphyrins. Porphyrins are abundant in calculus, particularly in the subgingival region, where P. gingival is and P. intermedia play a role in periodontal disease. The biofilm of the subgingival pocket frequently contains these periodonto pathogens. A 655nm diode laser is used in laser fluorescence as the excitation source to detect subgingival calculus. A high-pass filter filters out ambient light (daylight and operating lights) and reflected light, letting in only near-infrared light (>680nm). The emissions are then measured using a photo detector. The detection of SGC using bacterial auto fluorescence can be used for both periodontal diagnosis and treatment.[34]

Photo Acoustic Imaging (PA)

It is a hybrid method of imaging in biomedical field that blends the sharp contrast optical imaging with high resolution ultrasound imaging. By permitting contrast based on optical absorption, it expands the use of ultrasonic technology. The idea behind traditional ultrasonography is "sound in, sound out," whereas photoacoustic imaging replaces this with "light in, sound out.[26]While photoacoustic imaging has demonstrated benefits in the treatment of periodontal disease, more posterior teeth, or molars, cannot be imaged due to the size of typical photoacoustic transducers. In a clinical study by Fu L et al, clinical "hockey stick" transducer was used which was modified to work with photoacoustic (PA) technology with an integrated fiber bundle.[27]

T-Scan

T-scan is a relatively recent computerized method that enables semi-quantitative and qualitative interpretation of tooth contact data. T-Scan measures the force of relative occlusion, biting surface area, and tooth contact time. When identifying strong occlusal contacts in teeth that are mobile, T-Scan could be a helpful tool.[28]Premature occlusal contacts are commonly detected in patients with chronic periodontitis and are significantly correlated with its severity. In order to look into the occlusal elements that affect the teeth, tools such as pressure indicator paste, waxes, and articulation paper marks are used. However, these methods have some limitations they cannot detect simultaneous tooth interactions or quantify force and time concurrently. The usage of articulating paper marks does not produce a scientific relationship between the force applied, the surface area, the depth of colour or the sequence of contact times.[2]

3D Bio printing

Periodontology is a different branch of dentistry that makes use of three-dimensional (3D)printing, with a focus on regenerative periodontology for research and 3D printed strategies for aesthetic gingival correction.[29]A manufacturing process known as 3D printing creates objects by layer by layer addition to create the finished product. This technique is frequently called as rapid prototyping or additive manufacturing.[30]3D printing provides scaffolding of issues in bone grafting procedures. Bio-resorbable scaffolds for periodontal restoration, procedures for sinus and bone augmentation, socket preservation, direct implant insertion, and peri-implantitis management are all made possible by 3D printing. The goal of 3D printed scaffolds is to facilitate the regeneration of bone, periodontal ligament, cementum, and establishment of linkage between them.[2]

Digital implant planning and guided implant surgery

A more accurate diagnosis and early identification of possible issues are made possible by three-dimensional imaging of anatomical structures and enhanced evaluation of the volume and quality of accessible bone. This allows for high levels of predictability in surgical planning.[31]The actual workflow for producing surgical guides is quite complex, because several patient appointments and waiting periods are necessary to prepare the prosthetic setup, do the radiological examination, produce the surgical guide and finally place the implant. This is not only time consuming for the patient, but it is also work intensive and generates cost. Various options are being developed to optimize this workflow.[32]A digital workflow including computer-aided design (CAD), computer-aided manufacturing (CAM), and digital data processing and acquisition is used for preoperative implant planning in guided implant surgery. Implants are positioned using specialized software systems that develop the prosthetic setup virtually in relation to the individual anatomy and the configuration to generate the best implant position.[33]

Conclusion

Digital progress has aided in every technical breakthrough, ranging from communication to business and healthcare. This pattern, as it exists today and will continue to do so, will never end. It is crucial for the advancement of our profession, our practices, our patient care, and our duty to humanity to comprehend the current state and advantages of developing technology in dentistry. It directly helps medical professionals, patients, the community, businesses, and the global community. Even though there are plethora of digital advancements in microbiological and research aspects, however, the present article covers little advancement which is relevant clinically and diagnostically.

References

1. Kulkarni MR. Digitization in Periodontics. Digitization in Dentistry: Clinical Applications. Springer 1st ed., chapter 11.2021,p.305-33.
2. Ravishankar PL, Rajarajeswari S. Digital Revolution in Periodontology. IOSR J Dent. Med. Sci, vol.19,no.11,2020,p.52-56
3. Laine ML, Moustakis V, Koumakis L, Potamias G, Loos BG. Modeling susceptibility to periodontitis. J Dent Res, vol.92, no.1, 2013, p.45-50

4. Elashiry M, Meghil MM, Arce RM, Cutler CW. From manual periodontal probing to digital 3-D imaging to endoscopic capillaroscopy: recent advances in periodontal disease diagnosis. J Periodontal Res, vol.54,no.1.2019,p.1-9.
5. Armitage GC. Periodontal diagnoses and classification of periodontal diseases. Periodontol 2000, vol.34,no.1,2004, p.9-21.
6. Ramachandra SS, Mehta DS, M Sandesh Nagarajappa, M Baliga Vidya, M Amarnath Janardhan. Periodontal probing systems: a review of available equipment. Compend Contin Educ Dent, vol.32, no.2, 2011, p.71-77.
7. Lynch JE, Hinders MK, McCombs GB. Clinical comparison of an ultrasonographic periodontal probe to manual and controlled-force probing. Measurement, vol.39, no.5,2006, p.429-39.
8. Bains VK, Mohan R, Bains R. Application of ultrasound in periodontics: Part II. J Indian Soc Periodontol, vol.12, no.3,2008, p.55-61
9. Fazal I,Pasha AK, Irfana K,Cochikunnel C, Joseph R. A. Perio Tools: A Journey from Inaccuracy to Precision- A Mini Review. Saudi J Oral Dent Res, vol .7,no.3, 2022, p.79-85.
10. Khocht A, Janal M, Harasty L, Chang KM. Comparison of direct digital and conventional intraoral radiographs in detecting alveolar bone loss.J Am Dent Assoc, vol.134,no.11,2003,p.1468-75.
11. Jeffcoat MK, Reddy MS. Advances in measurements of periodontal bone and attachment loss. Monogr Oral Sci. S Karger A G 1st edition, chapter 4,2000, p.56–72
12. Cury PR, Araujo NS, Bowie J, Sallum EA, Jeffcoat MK. Comparison between subtraction radiography and conventional radiographic interpretation during long-term evaluation of periodontal therapy in Class II furcation defects. J Periodontol,vol.75,no.8,2004, p.1145–1149.
13. Sukovic P. Cone beam computed radiography in craniofacial imaging. Orthod Craniofac Res 2003, vol.6,no.1,2003,p.31–36
14. Ludlow JB, Davies-Ludlow LE, Brooks SL, Howerton WB. Dosimetry of 3 CBCT devices for oral and maxillofacial radiology: CB Mercuray, NewTom 3G and i-CAT. Dentomaxillofac Radiol, vol.35, no.4, 2006, p.219–226.
15. Scarfe WC, Farman AG, Sukovic P. Clinical applications of cone beam computed tomography in dental practice. J Can Dent Associ 2006; vol.72, no.1,2006, p.75–80.
16. Naznin.S, LogaranjiniA. Recent Advances in Diagnostic and Treatment Modality Related Periodontal Infection. Int J Sci Res,vol.9, no.11, 2020, p.596-599.
17. Acar B, Kamburoğlu K. Use of cone beam computed tomography in periodontology. World J of Radiol,vol.6,no.5,2014, p.139.
18. Kamath DG, Nayak SU. Detection, removal and prevention of calculus: Literature Review. The Saudi Dent J, vol.26, no.1, 2014, p.7-13.
19. Geisinger ML, Mealey BL, Schoolfeld J, Mellonig JT. The effectiveness of subgingival scaling and root planing: an evaluation of therapy with and without the use of the periodontal endoscope. J Periodontol,vol .78,2007, p.22–8.
20. Rathod AD, Jaiswal PG, Masurkar DA. Enhanced Periodontal Debridement with Periodontal Endoscopy (Perioscopy) for Diagnosis and Treatment in Periodontal Therapy. J Clin Diagn Res, vol.16, no.8, 2022, p.13-16.

21. Chang JJ, Chen C, Chang J, Koka S, Jokerst JV. A narrative review of imaging tools for imaging subgingival calculus. Front Oral Maxillofac Med, no.5, 2023, p.1-25.
22. Ganesh PR, Karthikeyan R, Malathi K. Perio-Scopy: A New Paradigm in Periodontal Therapy. Int J Dent Med Res, vol.1, no.6, 2015, p.168-71.
23. Canjau S, Todea C. Minimally-invasive diagnostic approaches in periodontics: laser Doppler imaging and optical coherence tomography. Clin Dent Rev, vol.5, no.1, 2021, p.11.
24. Mualla SK. Fluorescence and dentistry. J Dent Med Sci, vol.15, no.3, 2016, p.65-75.
25. Krause F, Braun A, Frentzen M. The possibility of detecting subgingival calculus by laser-fluorescence in vitro. Lasers Med Sci, vol.18, 2003, p.32-5.
26. Moore C, Bai Y, Hariri A, Sanchez JB, Lin CY, Koka S et al. Photoacoustic imaging for monitoring periodontal health: A first human study. Photoacoustics,vol.12, 2018, p.67-74.
27. Fu L, Ling C, Jin Z, Luo J, Palma-Chavez J. A more compact photoacoustic imaging system to detect periodontitis. MedRxiv, 2021,p.2021-11.
28. Nguyen K, Rincon JC, Bickel M. Association of strong premature contacts and tooth mobility using T-Scan. Aus Dent J, vol.52, no.S4, 2007, p.S49-50.
29. Takkella BK, Anusha NV, Sujanamulk B, Naffizuddin M, Jammalamadugu RK, Pinjari H et al. Perspective of 3D printing in dentistry—Exploring the new horizon. Trends Immunother, vol.7, no.1, 2023, p.2133.
30. Sonika S, Nalini HE, Devi RR. Quintessential commence of three-dimensional printing in periodontal regeneration-A review. The Saudi Dent J, vol.35, no.7, 2023, p.876-82.
31. Weber HP, Cano J, Bonino F. Digital implant surgery. Clinical applications of digital dental technology. Willey-Blackwell 2nd edition 2015,chapter 7,2015, p.139-66.
32. Schubert O, Schweiger J, Stimmelmayr M, Nold E, Guth JF. Digital implant planning and guided implant surgery–workflow and reliability. Br Dent J, vol..226,no.2,2019, p.101-8.
33. Flügge T, Kramer J, Nelson K, Nahles S, Kernen F. Digital implantology—a review of virtual planning software for guided implant surgery. Part II: Prosthetic set-up and virtual implant planning. BMC oral health, vol.22, no.1,2022,p.1-1.
34. Badran Z, Demoersman J, Struillou X, Boutigny H, Weiss P, Soueidan A. Laser-induced fluorescence for subgingival calculus detection: scientific rational and clinical application in periodontology. Photomed. Laser Surg, vol.29, no.9, 2011, p.593-6.
35. Zhou H,McCombsGB,Darby ML, Marinak, K.Sulphur by-product: The relationship between volatile sulphur compounds and dental plaque-induced gingivitis. J. Contemp. Dent. Pract, vol.5, no.2, 2004, p.27–39.
36. White SC, Yoon DC, Tetradis S. Digital radiography in dentistry: what it should do for you. J Calif Dent Assoc, vol.27, no.12, 1999, p.942-52.
37. Grondahl HG, Grondahl K. Subtraction radiography for the diagnosis of periodontal bone lesions. Oral Surg. Oral Med. Oral Path, vol.55,no.2, 1983, p.208-13.