IOSR Journal of Dental and Medical Sciences (IOSR-JDMS)
e-ISSN: 2279-0853, p-ISSN: 2279-0861.Volume 19, Issue 11 Ser.9 (November. 2020), PP 52-56
www.iosrjournals.org

Digital Revolution in Periodontology

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Abstract
Change towards the digital era is an irreversible global trend. With technology developing at a faster pace, the Digital Revolution has now fully entered the world of dentistry and has become more user-friendly allowing dental professionals to work in smarter ways than before. Diagnostic precision reduces errors and 3D planning for therapies opens the way toward a novel, minimally invasive dentistry that uses compatible and aesthetic materials. Virtual planning ensures predictable aesthetic and functional rehabilitation, painless postoperative recovery, and better communication with patients, thus meeting their expectations. Digital techniques are always superior and will surely become the future of dentistry. So, the need of the hour is to incorporate more digitization into our practice for the comfort of both dentist as well as the patient. The purpose of this article is to explore around the application of digital dentistry in diagnosis and treatment of periodontal disease.

Keywords: *AI Technology, Conventional neural network, T Scan, Digital Imaging, Compudent, 3D Bioprinting.*

Date of Submission: 10-11-2020 Date of Acceptance: 25-11-2020

I. Introduction

Dentistry has evolved from a very long time. In 1723 Fauchard was accepted as being the Father of Modern Dentistry because his book was the first to define an extensive framework for the practice of dentistry. Things are not same at present as it was in ancient and medieval period. Technologies tend to develop day by day, which makes our everyday life easier and comfortable. Similar technology development has been incorporated in dentistry. In the world of changing trends everything has become digital which makes work simple, precise and accurate. Hence incorporation of digitized technologies becomes the need of the hour in dentistry too. Digitization improves efficiency and reduces time. Initially, we start with digitizing patient records, storing radiographs and clinical photographs for ease of storage and quick viewing, reduced time improves efficiency. The second most utilization of digitization could be for better patient management [1]. Live videos, three-dimensional animations, voice-activated software, and virtual consultations will help to built better rapport with patients as well as educate and motivate them. Digital radiography and advanced diagnostic aids such as computed tomography and Dentascans has increased effectiveness and accuracy and can be very useful in implantology and assessing pathological abnormalities. The other advances include laser, AI technology, 3D Bioprinting, computer assisted anaesthetic delivery, and much more.Periodontitis is an inflammatory disease of the periodontal tissue or the supporting tissues of the teeth [2,3]. Periodontitis is caused by the formation of bacterial biofilms on teeth, root surfaces and periodontal pocket. The biofilm triggers host- derived immune and inflammatory reaction to the pocket [4]. When we focus light on periodontology, diagnosis is integral step towards treatment of the disease. Diagnosis of periodontal disease starts with probing depth, attachment loss, bleeding on probing and moving further with radiographs. Studies have shown conventional methods results in errors, precision in reading is required which can be achieved by digital methods which help in diagnosis of periodontal disease. Hence the article will enlighten the use of digital technology in diagnosis and treatment of periodontal disease. Let us get enlightened with the advanced digital methods which have made the work easier and accurate.

3D advancement in periodontal probing

The Periodontal pocket is measured using a calibrated metal instrument, periodontal probe. As it is a conventional method manual periodontal probing includes many drawbacks as the pressure applied by the clinician may vary during each session and person, this can lead to overestimation or underestimation of periodontal probing depth. Constant force periodontal probes which are the first pressure-sensitive probe were designed to provide uniform and continuous pressure during examination of periodontal pocket depth and minimize variations [5]. However, the lack of tactile sensitivity is another drawback. This is because the tip of

the probe can penetrate the junctional epithelium at the site of inflammation [6]. The third generation periodontal probe combines automated measurements, 'controlled force application' and digitized data capturing. Digital recordings of the periodontal pocket depth measurements is saved in the system. Digitization becomes essential while using such periodontal probes but these probes don't give 3D information about the disease [7,8,9,10]. Ultrasonography periodontal probing is the method for periodontal ultrasonic diagnostics involving the projection of maximum frequency arrow ultrasonic beam to periodontal pockets. The periodontal ligament reflects the echoes of the ultrasound waves which is captured by the transducer positioned within the handpiece which is transferred to the system for evaluation. The ultrasonic image is built and the software converts data for estimating periodontal pocket depth [11,12,13] However, this approach is challenging, as the interpretation requires visualization and analysis of an echo wave. Endoscopic capillaroscopy is versatile endoscopes that utilize fibre optics to visualize distant inaccessible internal structures. Optical fibre technology may obtain higher resolution picture of the periodontal pocket microcirculation.

Utilization of AI Technology in detection of dental plaque

The term "artificial intelligence" (AI) was coined in the 1950s and refers to the concept of creating device which has the capability of performing tasks that are usually performed by humans. 'Dental plaque' comprises of bacterial masses on dental surfaces; these mass typically occurs on the gingival margins and interproximal areas [14]. Usually, 'dental plaque' is identified by practitioner using an explorer or by means of disclosing agents [15,16]. All these evaluation methods becomes uncomfortable and time consuming for the clinician. Consequently it is important to establish a cost effective and convenient method for detecting plaque, according to the studies, in order to compare the effectiveness of artificial intelligence in the detection of plaque. The 'AI model' used was developed on a the basis of 'conventional neural network' (CNN) and trained using images to fine-tune the system based on transfer learning method. Photographs of primary teeth were taken using intraoral camera after this disclosing agent was applied and photographs of the discoloured teeth were taken. Areas with plaque were marked on natural teeth and discoloured teeth. The adopted plaque detection model then gathered the features of 'dental plaque' from these images. The 'dental plaque' observed by the 'AI model' was compared to the actual dental plaque areas to enable the 'AI model' to compare the results and learn from its errors [17]. When observation was made in detecting the plaque by the clinician and AI model, better and accurate results were obtained from the AI model. This would become more helpful in prevention of accumulation of plaque and progression of periodontitis.

T Scan system in Periodontics

The periodontium has its own adaptive capacity to the occlusal forces which is exerted on the tooth. The occlusal trauma is not to be considered as an etiological factor for periodontitis, its presence may exacerbate the severity of the disease [18]. Occlusal adjustments are recommended for the teeth with premature contacts and interferences. Premature occlusal contacts are commonly detected in patients with chronic periodontitis and are significantly correlated with its severity. Articulation paper marks, waxes, pressure indicator paste, etc. are used to examine occlusal factors acting on the teeth. However, the limitations of these methods are they do not detect simultaneous contact nor do they quantify time and force. There is no scientific relation between the depth of the colour, its surface area, the amount of force, or the sequence of contact times resulting from the use of articulation paper marks [19]. Recently, 'T scan' has been commonly used as a reliable and easy to use diagnostic method for occlusal contact analysis using paper thin disposable sensors. It has been emerged as an effective diagnostic method for evaluation of proper occlusal pattern and resulted in high quality treatment. The system has undergone substantial update to enter the advanced version of the T Scan III system (version 7.0). The T scan makes the quantity of measurable contact data by recording variables such as bite duration, time, and intensity of tooth contact and saves data on the hard disc that can be played over time based video for data analysis. The difference in electrical resistance is transformed into photos on the screen. The program works in two ways: time analysis and force analysis. Time analysis mode includes details on the position and duration of contacts displaying on the previous screen with the first, second and third or more contacts in various colours. The force analysis mode demonstrates the position of occlusion and their relative intensity in five separate colours. The occlusal forces in T-Scan are only seen in relative force values rather than absolute values as applied forces will shift with variations in muscular forces and intercuspation. Therefore, by calculating relative strength level over the elapsed period on the various cusps and fossae contact that hit too early may be easily identified with too much or too little occlusal force. T scan III analyses the order of occlusal contacts while at same time calculates changes in the percentage of force of the same contacts from the moment the teeth begin contact to the maximum intercuspation [20].

Digital Imaging system

The latest diagnostic approach to intraoral radiography has identified a variety of shortcomings in its efficacy. IOPA or bitewings can under or overestimate the quantity of bone defects caused by projection errors. The key disadvantages of IOPA is the overlapping anatomical structures and lack of 3D details. This also hinders a real difference between the buccal and lingual plates and complicates the determination of bone defects, in particular the infrabony lesions, often referred to as craters, and furcation involvements. Digitalization of intraoral radiographs greatly decreased the exposure of radiation and rendered digital subtraction radiography (DSR) which is feasible for follow-up of lesion [21,22,23]. However, intraoral radiography remains fundamentally a two-dimensional (2D) imaging technique with a lack of knowledge on the 3D defect aspect of infrabony defects. Conventional CT addresses this issue by providing axial slices around the point of interest, but has significant disadvantages [24,25,26].

Computerized Local anaesthetic delivery

Periodontal procedures involve injection of local anaesthetic solution to prevent pain during clinical situations like Scaling and Root Planning, flap surgery with localized defects and in the harvesting of the free mucosal grafts from the palate [27]. During such therapeutic procedures administration of local anesthesia becomes painful which induces fear inside patients, appropriate local anaesthetic technique is necessary to reduce fear and anxiety during such treatments. Computer controlled local anaesthetic system was introduced in 1997. It was initially referred to as Wand. Subsequent models were later released on the market namely wand plus and compudent [28]. It consists of a base unit, hand piece and foot pedal. The hand piece is an ultra light pen like handle in which the traditional anaesthetic cartridge is mounted. It has got a base unit which contains microprocessor which controls a piston that incorporates local anaesthetics by pushing the local anaesthetic plunger up into the cartridge. The solution is pushed through the micropore tube of a handpiece operated by a computer control device. Upon activation of foot pedal, rate of injection can be controlled. There are three modes of flow rate available namely slow, fast and turbo speed. It is used as a good option to administer small amounts of anaesthetic solution continuously during needle placement, which instantly anaesthetizes the tissue. The system has got increased tactile sensation due to light weight handpiece. It is non threatening to patient due to reduced force required for needle insertion and this makes the patient more comfortable.

Digital smile designing

The digital smile design (DSD) is a software based system which has been recently introduced in the field of dentistry. It is a precise and efficient method for aesthetic rehabilitation as it allows the clinician to visualize and estimate discrepancy of orofacial and dentogingival tissues. It employs digital editing software along with digital photography to provide digital simulations. Digital smile design (DSD) is extremely user friendly as it simplifies and demonstrates various steps involved in treatment planning. It also confirms patient expectations thus resulting in greater treatment acceptance. These simulations can provide various treatment possibilities and projected outcomes to patients seeking aesthetic correction [29]. The information gathered from the photographs is fed into the software which develops an aesthetic treatment scheme. Once aesthetic evaluations are done, provisional restorations or wax mock-up will provide the patient and the clinician with the preview of result [30]. Digital imaging and designing lets patient envision the desired final outcome before beginning treatment, which increases the predictability of treatment [31,32]. The practitioner could answer the concerns of patients by digitally presenting the final result, and informing them about the benefits of the treatment. It improves clinician evaluation and treatment plan through cosmetic simulation of patients issue by digital analysis of gingival, facial and dental parameters, which can examine the smile and the face in a systematic manner [33].

3d bioprinting

3D printing is the term used to portray added substance fabricating approach that constructs material layer by layer. It utilizes data from CAD programming which estimates a large number of cross segments to fabricate the specific reproduction of every item [34]. 3D printing provides tissue scaffolding in bone grafting procedures [35]. 3D printing involves bio-resorbable scaffold for periodontal reconstruction, sinus and bone augmentations procedures, socket preservation, , direct implant installation, maintenance of peri implantitis. The goal of 3D printed scaffolds is to facilitate the regeneration of bone, PDL, cementum, and establishment of linkage between them [36]. Recent advancements in technology have made the use of 3D-printed scaffolding to retain socket and conserve the dimension of the extraction socket. The combined 3D printed scaffold reduces chance of inflammation and also improved osteogenesis [37]. Medications has been developed 3D printing techniques, their integration into periodontics may help in producing specific medicines. These medications would be dose dependent, precise, safer and effective [38].

3D assisted Implant surgery

Replacement of missing teeth must provide patient with cosmetic, functional and biomechanical criteria for natural dentition, in particular for chewing. When conventional procedures are implicated, the clinical outcome is often uncertain, as it relies heavily on the expertise and experience of practitioner. Advancements in computer-assisted surgery have contributed to the concept of successful procedures in Implantology. The guided approaches are typically focused on 3D reconstruction of patient's anatomy data from either Computed Tomography (CT) or Cone-Beam Computed Tomography (CBCT) [39]. Digital planning processes include digital drill guide models, which are usually created by stereo-lithography. Relevant 3D image-based system programmes for the planning of implant surgery, have recently been developed and clinically approved by several manufacturers [40].

II. Conclusion

Digital development that has contributed to all the technological advancements from communication to industry and healthcare. This pattern will never stop, as it is now and in future. Understanding the present degree and benefits of emerging technology in day to day dentistry is essential to the evolution of our discipline, our practices, our care and service to humanity. It has direct benefits for clinicians, patients, the community, business and the world as a whole.

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Dr. Noveena Dhanalakshmi S, et. al. "Digital Revolution in Periodontology." *IOSR Journal of Dental and Medical Sciences (IOSR-JDMS)*, 19(11), 2020, pp. 52-56.