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DIGITAL DENTISTRY - A REVIEW

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Digital dentistry may be defined in a broad scope as any dental technology or device that incorporates digital or computer-controlled components in contrast to that of mechanical or electrical alone. Digital dentistry refers to the use of dental technologies or devices to carry out dental procedures rather than using mechanical or electrical tools. The use of digital dentistry can make carrying out dental procedures more efficient than using mechanical tools, both for restorative as diagnostic purposes. 'Godfather' of Digital Dentistry is the French professor François Duret, who invented dental CAD/CAM in 1973.

The major limitation of most areas of digital dentistry is cost. To adopt new technology often requires a higher capital investment, especially at the “innovator” or “early adopter” stage. Despite this, if the new technology meets the above criteria to be considered an advantage, then return on investment can be high if properly implemented. Some areas of digital dentistry lack one or more of these characteristics and could easily be improved by adopting or integrating technology from other industries, or eliminating attempts to improve older, outdated technology and implementing newer, disruptive technology. Digital imaging takes about one-fourth to one-sixth the exposure time that a traditional dental X-ray machine does; therefore the patient is subjected to less radiation during the exposure of a radiograph. The amount of energy used by the flat sensor device to generate the image is 65 percent of the total X-ray radiation emitted. As a result, the patient is exposed to only a minute amount ,approximately one-tenth of the radiation dose of conventional X-rays.

Implementation of computers into each operatory and throughout the practice is the first and most frequent adoption of digital dentistry. The future in this area will reveal technologies and methods of communication already available in other industries, such as voice-activated and/or touch-screen computer and software instruction, live video and rapid recall of photos and educational components, 3-D video presentation with and without monitors or tablets, and off-site live consultation and education.

CAD/CAM was first applied to dentistry in the early 1970s, when French dentist Dr. Francois Duret introduced CAD/CAM concepts into dental applications in his thesis, “Optical Impression.” In 1984, Duret invented and patented a CAD/CAM device. Swiss dentist Dr. Werner Mormann and electrical engineer Dr. Marco Brandestini developed the concept for what would become CEREC 1, the first commercially available digital impressioning system, which was introduced in 1985.1 CEREC 1 combined a 3-dimensional (3D) digital scanner with a milling unit to create dental restorations from commercially available blocks of ceramic material in a single appointment. CEREC 1 was designed for the fabrication of ceramic inlays and onlays.

ALL CAD/CAM SYSTEMS CONSIST OF THREE COMPONENTS:

1. Adigitalisation tool/scanner that transforms geometry into digital data that can be processed by the computer.

2. Software that processes data and, depending on the application, produces a data set for the product to be fabricated.

A production technology that transforms the data set into the desired product.The fundamental principle of this system's concept was to capture electronically a preparation's image and then use software to interpolate the information and create a digital model. A virtual restoration design was then suggested and, after user-defined parameters were set, the restoration design was milled from a ceramic block and seated, all in one appointment. Subsequent software and hardware upgrades with the introduction of the CEREC 2, CEREC 3, and CEREC 3D systems (Sirona) focused primarily on improvements in user-friendliness, accuracy, material, and milling options.

1…Intra-oral mapping technology is one of the most exciting new areas in dentistry since three-dimensional scanning of the mouth is required in a large number of procedures in dentistry such as restorative dentistry and orthodontics. The main advantages in the employment of those devices are: high fidelity models,creation of 3D archives and surgery simulation and a process simplification. Existing devices are driven by several noncontact optical technologies such as confocal microscopy, optical coherence tomography, photogrammetry, active and passive stereovision and triangulation, interferometry and phase shift principles. The “die” is virtually cut on the virtual model, and the finish line is delineated by the dentist directly on the image of the die on the monitor screen. Then, a CAD system, called “biogeneric”, provides a proposal of an idealized restoration and the dentist can make adjustments to the proposed design using a number of simple and intuitive on-screen tools. Once the dentist is satisfied with the restoration, he can mount a block of ceramic or composite material of the desired shade in the milling unit and proceeds with fabrication of the physical restoration. In conofocal imaging technique the imaging process is based on illuminating the target surface with three differently-coloured illumination beams (one of red, green or blue light) combinable to provide white light, capturing a monochromatic image of the target portion of teeth, corresponding to each illuminating radiation, and combining the monochromatic images to create a full colour image. A system uses Optical radiation scattered from surfaces and subsurface regions of illuminated objects is received by a detector array. Electrical signals are generated by a detector array in response to the received radiation. A processor receives the electrical signals and calculates three-dimensional position information of object surfaces based on changes in the relative phase of the emitted optical radiation and the received optical radiation scattered by the surfaces. Future improvements will use algorithms based on thousands of patient radiographs that accurately diagnose caries and make suggestions for the dentist. The potential for complete conversion to extraoral imaging only is a serious possibility for the future. Diode lasers are one of the lowest costing areas of digital dentistry to adopt, as well as one of the easiest. Advantages of excellent hemostasis, universal use around all restorations, simplified surgical procedures, and an expanding use in a plethora of dental procedures make this area of digital dentistry highly desirable. The current trend is small, portable, cordless, low-cost diode lasers…1.

2..Surgical guide for implants are fabricated using the conventional impression technique by taking a impression with alginate or polyvinyl and pouring up the stone model-two time-intensive steps. After the model sets, the lab places a denture tooth or teeth in the edentulous area and a vacuform tray is made by heating a thermoplastic material and adapting it down over a model with a special vacuum machine.Fortunately, with a digital scanner, once the intraoral scan is performed, the digital file is sent to the lab where a virtual tooth is added and a guide is fabricated and sent back to the office. No model is made, eliminating additional costs.To place a standard abutment, digital scanner is used to scan the actual abutment. Fabrication of a custom abutment which would require a fixture level impression. With analog dentistry, a fixture level impression coping is placed. With digital dentistry, we have the ability to place a scanning body, which is the digital equivalent of a fixture level impression coping. Guided surgery enables us to do this and place our implants precisely based upon final prosthetic restorations limited by bone morphology. Impressions are made, models poured , and case planed, this is send along with a CBCT scan to a guided surgery facility. Guides are fabricated and implants placed. We can now shorten the process by using the intraoral scanner to scan our patients instead of using the analog model technique. This STL file is then merged with the DICOM file of the cone beam scan into the implant-planning software to plan our cases.….23...The introduction of computer-aided design and computeraided manufacturing (CAD/CAM) technology into complete denture fabrication has eliminated polymerization shrinkage in the definitive denture. The use of CAD/CAM record bases for complete denture fabrication can provide a better-fitting denture with fewer postprocessingocclusal errors. Computer-aided design and computer-aided manufacturing (CAD/CAM) technology has recently expanded into the area of complete dentures.The bases are milled from prepolymerized acrylic resin cylinders that are highly condensed and less porous than conventional denture acrylic resin.…3. 4…Full digital impressions of both the maxillary and mandibular arches are taken, as well as a digital bite registration.Taking the digital impressions prior to extraction allows for a heightened level of accuracy, as it avoided the difficulties often associated with scanning an edentulous arch. These intraoral images are saved in the STL file format, and are easily utilized in the laboratory for CAD/CAM design, production and case reparation. With the denture

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production tool selected in the program, the laboratory specialist began to digitally design the prostheses. Various options control the opacity of the overlaid 3-D images in the design software, which permitted the designer to view the pre-extraction and post-extraction digital models as a single. With the pre-extraction files in view, the occlusal plane is set by placing markers at three distinct points of odigital 3-D printing technology with traditional denture fabrication techniques. The appliance can be milled directly from a block of acrylic, or a physical model can be printed with a 3-D printer and used to create a traditional mold that is then invested and processed.…4 .

5… 3D digital edentulous model may be made for model analysis. Three points are selected on the contacting plane of the upper occlusal trim and lower occlusal rim in the 3D digital edentulous model. The selection of these 3 points determined the occlusal plane for the digital edentulous model. Artificial teeth are arranged ,the teeth can be moved in the sagittal, horizontal, and coronal planes during the modeling using 3Shape Dental System 2013. The length, width, and height of dentition could be adjusted, and the localization of the dentition could be modified accordingly to match the arch shapes of the individuals. For each individual tooth, modification/adjustment can be made for the whole tooth or the local regions of the tooth.Artificial teeth are arranged in the 3D virtual models to match the particular shapes of the patient's arches.Forocclusal adjustment adjustment the CAD software can mimic the movements of occlusion, laterotrusion, pro/retrusion, and side shift. During the virtual occlusal adjustment, the contacting points are recorded using different color for each single movement .Those interfering points are removed using the function of virtual grinding . The design of virtual 3D complete dentures is finished after completing this step of occlusal adjustment…5.

6…The CAM technology could be classified into 2 types: additive manufacturing and subtractive manufacturing. The subtractive manufacturing relies on the computerized numerical control (CNC) machining.The desired geometry is obtained by physical removing the extra materials via machining (ie, cutting/milling) according to the digital model. The subtractive manufacturing has been extensively used to fabricate fixed prosthesis, such as inlays, onlays, veneers, crowns, and fixed bridges. Various materials such as composite resin, ceramic, titanium, and precious and nonprecious metals could be processed using subtractive manufacturing.…6.7…The very first system that was introduced in digital radiography in dentistry was Radio-visio-graphy (RVG, formerly Trex-trophy Radiology Inc., Marietta, GA) by Trophy in France in 1987. Digital radiography refers to a method of capturing a radiographic image using a solid-state technology sensor, breaking it into electronic pieces, and presenting and storing the image using a computer. There are three types of digital radiography systems available for use in dental imaging: (1) CCD-Charge-Coupled Device (direct system); (2) CMOS-Complementary Metal Oxide Semiconductor (direct system); and (3) PSP-photo-stimulable phosphor (indirect system). One of the most commonly cited positive features of digital radiography is the radiation dose reduction up to 80%, when compared with conventional plain film radiography. It is estimated that the dose reduction for intraoral digital imaging is in the range of 50%[3]-60%] when compared to E-speed film and for extraoral digital imaging, 50%-70%, when compared to film-screen combinations. Other obvious benefits include the short processing time, i.e., the ability to view the image more quickly, the elimination of the darkroom, processing chemicals and the errors associated with improper darkroom maintenance, chemical handling, solution replenishment and replacement, etc. It allows manipulation of the image produced such as contrast, density, sharpness and image orientation, without any additional radiation exposure to the patient or the operator.Digital subtraction radiography (DSR) is a technique used to determine qualitative changes that occur between two images taken at different points in time. Subtraction method was introduced by B.G. Zeides des Plantes in the 1920s. The first image is the baseline image and the second image shows the changes that have occurred since the time the first image was taken. DSR cancels out the complex anatomic background against which this change occurs. In order for DSR to be diagnostically useful, it is crucial that the baseline projection geometry and image intensities be reproduced. Dove et al reported that angulation errors should be limited to two degrees. DSR helps to detect the alveolar bone changes of 1%-5% per unit volume and of crestal bone height change of 0.78 mm. Parsell et al in 1998 found that digital subtraction radiography with or without enhancement improved the likelihood of a correct cancellous defect diagnosis when compared to other methods to detect oral cancellous bone lesions. Computed tomography is considered the gold standard imaging technique to assess injuries of the maxillofacial skeleton region. It is an excellent tool for detecting complex facial fractures, like those involving the frontal sinus, naso-ethmoidal region], and the orbits. CT helps in defining the displacements of fractures prior to surgical reduction and fixation. It helps to indentify multiple extra root canals which when missed can lead to endodontic treatment failure. Chronic apical periodontitis can be seen with the CT scan in early and established stages. It aids in detecting vertical root fracture or split teeth which cannot be detected on periapical radio graphs.…7. 8… The introduction of video-based computer-assisted image analysis systems for the evaluation of standardized dental radiographs offered increased diagnostic accuracy in the détéction of subtle density changes over Interpretation of conventional radiographs. Digital subtraction images measure the density differences stored in digital format. The assessment of alveolar bone density changes due to progression of disease or healing following therapy can also be made. The application of digital image analysis methods offers objective, quantitative and non-invasive ways to obtain additional diagnostic information from standardized radiographs in clinical trials.…8

9…Subtraction radiography permits reduction of structured noise from sequentially obtained images containing changes of diagnostic interest. It is particularly well suited for the detection of small periodontal changes, because the teeth provide stable bases for standardization of projection geometry from one exposure to the next and because structured noise is prevalent in unprocessed images of the periodontium. …9

10…Current digital radiographic methods are practical for use by physical anthropologists and can provide information on bone mass variations among populations. Such information can be used to suggest and evaluate potential etiologic agents of alveolar bone loss. Moreover, these methods can be adapted to the quantitative measurement of image features (other than alveolar bone) that are of interest in anthropologic studies. Digital subtraction radiography is proposed as a potential diagnostic tool for implant research and patient monitoring. Examples of the application of this technique are given observing peri-implant density changes during the early healing phase and during ligature-induced peri-implantitis in an animal model. Additional cases document the loss of peri-implant bone density associated with an infection and increase in density caused by remodeling after functional loading of an implant with a single crown. Digital subtraction radiography might be one of the most sensitive noninvasive methods for assessing subtle density changes in peri-implant tissues, providing additional diagnostic information on im plant tissue integration and maintenance.…10

REFERENCES:

1. A Comparative Analysis Of Intraoral 3d Digital Scanners For Restorative Dentistry.SLogozzo, G Franceschini, A Kilpelä, M Caponi, L Governi, L Blois. The Internet Journal of Medical Technology. 2008 Volume 5 Number 1.
2. Using digital impressions for implants. June 25, 2015 Bart Silverman, DMD.
3. Denture fabrication -(J Prosthet Dent 2015;114:493-497).
4. Patzelt SB, Vonau S, Stampf S, Att W. Assessing the feasibility and accuracy of digitizing edentulous jaws. J Am Dent Assoc. 2013 Aug;144(8):914-20.
5. Design and fabrication of complete dentures using CAD/CAM technology. Medicine (Baltimore). 2017 Jan; 96(1): e5435. Published online 2017 Jan 10. doi: 10.1097/MD.0000000000005435 PMCID: PMC5228646.Weili Han, MM,aYanfeng Li, MD, a,Yue Zhang, MM, a Yuan lv, MM,a Ying Zhang, MM,a Ping Hu, MM,aHuanyue Liu, MM,aZhengMa,a and Yi Shen, MMb.
6. Bidra AS, Taylor TD, Agar JR. Computer-aided technology for fabricating complete dentures: systematic review of historical background, current status, and future perspectives. J Prosthet Dentistry 2013;109:361–6.
7. World J Radiol. 2014 Oct 28; 6(10): 794–807. Recent advances in imaging technologies in dentistry. Naseem Shah, Nikhil Bansal, and Ajay Logani.
8. Digital imaging in periodontal radiography - A review. Journal of clinical Periodontology. Volume 15, Issue 9 .October 1988 ,Pages 551–557. Authors-Urs Bragger.
9. Subtraction radiography for the diagnosis of periodontal bone lesions. Oral Surgery, Oral Medicine, Oral Pathology.Volume 55, Issue 2, February 1983, Pages 208-213.Hans-Göran ,Gröndahl, KerstinGröndahl.
10. Image-based quantification of alveolar bone. Volume 37, Issue Supplement S19 ,1994. Pages 155–176.American journal of physical anthropology. C.F Hildebolt, TQ Bartlett, M. K Shrout.