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Recent Advances in The Digital Technology of Prosthodontics - A Review Article

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Abstract

Digital technologies in the field of prosthodontics have posed to be one of the most important reasons to enhance the quality of treatment. The procedures starting from diagnosis till patient review has digitalized options. Digitalized prosthodontics is presently a most promising one in accordance with accuracy. This article emphasizes the advantages, disadvantages and uses of digital technologies which have contributed for amplification of treatment in prosthodontics.

Keywords: Digital workflow, Digital technology, Digital smile.

Introduction

The workflow in prosthodontics has been gradually changing with the advent of digitalization, which has an endless scope. The conventional methods have been enhanced greatly by digital methods [1]. It has revolutionized and become well established in the field of prosthodontics. Some of the areas of digital technology are Digital radiography, Intraoral imaging, Computer-aided design/computer-aided manufacturing (CAD/CAM), Shade matching, Digital smile designing, Virtual articulators and digital facebows, Laser, Occlusion and Temporomandibular joint (TMJ) analysis and diagnosis, extra oral and intraoral photography, Practice and patient record management that includes digital patient education [2]. In this article recent advances in digital prosthodontics are described.

Evolution and Types

Beeswax was the first ever impression material used. Then zinc oxide eugenol based impression materials were used followed by reversible hydrocolloids (agar-agar, impression compound) succeeded by irreversible hydrocolloids(Alginate, impression plaster). Polysulfide and polyether was used in 1953 and late 1960s respectively. Later Polyvinyl siloxane gained credibility owing to its remarkable dimensional stability. Dentistry witnessed a shift towards digital technology during mid-twentieth century where digital impressions were preferred over conventional ones [3].

Digital Radiography

Radiovisiography

In dentistry the boon of digitalization came in 1987 with first digital radiography system called Radiovisiography (RVG), a multicomponent system. It was introduced by Dr. Francis Mouyen and the charge-coupled device (image

sensor) was created by an engineer Paul Suni. The greater contrast resolution of RVG facilitates a clear view of infinitesimal details of carious lesions, and in the evaluation of the extent of alveolar bone loss constituting the periodontium. The operator records the images from the oral structures with the help of an intraoral camera, and then transfer to the computer for interpretation. In RVG, the radiation exposure is reduced [4].

Digital Panoramic Radiography

Charge-Coupled Devive (CCD) based Digital panoramic radiographs had merits such as 40-70% reduction in radiation dosage and immediate image display when compared to conventional panoramic radiograph [5].

Computed Tomography Scan

Computed Tomography (CT Scans) are used in prosthodontics to determine the site aptness for implant rehabilitation. It reveals the combination of structure and quality of the bone, soft tissues including nerves, blood vessels, foramen and sinuses. Efficient contrast resolution provided makes it suitable for evaluation of surgical as well as prosthetic phases of implant placement [6].

Cone Beam Computed Tomography (CBCT)

CBCT imaging is an advanced imaging modality that provides excellent volumetric imaging of the dental hard tissues and osseous structures in 3D with less radiation which overcomes the shortfall of CT Scan [7].

Principle

In CBCT, the region of interest is focused in the field of view for the cone beam. Solitary rotatory motion of 200 degree obtains a volumetric data set which the scanning software fetches and reconstructs, giving rise to the digital volume computed of 3D voxels of anatomical data that can be handled with SIDEXIS software. CBCT is most commonly used in prosthodontics . It is used to assess the quantity and quality of bone in edentulous rigdes and implant cases, implant site evaluation, accurate measurements and accurate planning of implant in relation to vital structures and surgical guide [8].

Optical Impression

Nowadays, in market many oral scanner systems are currently available for digital impression. They are environment friendly whereas the conventional material's disposal contributed to the pollution. There are various systems to produce models from the digital files. They are CEREC System, Lava C.O. S System, iTero System, E4D System and TRIOS System which works on the principles of Triangulation of light, Active wavefront sampling, parallel confocal imaging, optical coherence tomography with confocal microscopy and ultrafast optical sectioning with confocal microscopy respectively. They capture digital pictures of the prepared teeth and with the help of a software converts it into a virtual model where the desired prosthesis can be designed and eventually milled accordingly. Chair side Economical Restoration of Esthetic Ceramics(CEREC) is the first intraoral digital impression. CEREC AC Bluecam use blue LED diode as its light source to capture images. It captures one quadrant of the digital impression within a minute. It is esthetically pleasing since it uses porcelain material [9]. The Lava C.O.S System use LED as its light source. iTero System captures the intraoral surfaces and contours by using the red laser as a light source. It is an open system in the treatment of retains, alignets, FPDs, crowns and implant. Red laser is the light source for the E4D System. It traps image from every angle. The CEREC AC Bluecam and Omnicam, E4D System function as a “Single- visit treatment”. The TRIOS System works based on the principle of ultimate speed optical sectioning and confocal microscopy. LASER is the light source for this system. For making digital impression, the tooth preparation is completed, then the tissues are retracted to see the tooth

margins. The scanners utilize sequences of images or video to capture the structure of prepared tooth.

Digital Shade Matching

Digital shade matching systems presents improved esthetic efficiency. Accuracy is at its zenith for shade selection of prostheses. The recent advances of digital imaging and shade matching are colorimeters, spectrophotometer, digital cameras as filter colorimeter and spectroradiometer [10].

Colorimeters

It filters the light in the red, green and blue areas of the visual color spectrum. Colorimeter is less accurate than the spectrophotometer [11].

Spectrophotometers

It is a device that measures the spectral reflectant of a body, photometer is a device used for measuring light intensity. A spectrophotometer measures the reflectance for each wavelength and allows calculating values. There are several very high-quality & reliable clinical spectrophotometers available, E.g., The VITA Easy shade Compact and Crystal Eye. It is used to determine an overall tooth shades. Digital camera is the newest devices used for dental shade matching, and it is based on the RgB color model. The camera obtains red, blue and green data that are used to produce the color image. Digital cameras are an approaching digital shade selection [12]. Nowadays, digital cameras are preferred due to ease of use.

There are some currently available devices are:

1. Shofu's shade chromameter
2. The VITA Easy shade
3. The shade scan
4. Shade rite dental vision system
5. The spectroshade
6. Clear match system.

Digital Smile Designing

It is a multi-use tool that can assist the restorative team throughout treatment. It is improving the dental teams to understand the esthetic issue and it increases the patient acceptance of the final result. Placing the reference lines and other shapes over extra and intraoral oral digital photography widens the dental teams diagnostic vision. It helps to evaluate the limitations, risk factors, treatment outcomes and esthetic principles of a given case. The softwares available for smile design are Smile Design Pro, Planmeca Romexis Smile Design, and DSD App by Coachman. In DSD, Photoshop CS6 and Keynote was not created specifically but used by the dentists and dental professionals. Cara smile design software is a brand-new one which has a variety of hues which facilitates forethought of esthetics concerned with teeth as well as gingival margin [13].

Computer – Aided Design / Computer - Aided Manufacturing

It was intervened in dentistry during the 1980s. It utilizes the digital photography which aids in spotting of the defects present in teeth for which prosthesis has to be made. The first CAD/CAM devices are CEREC and Procera. The CEREC was introduced for chairside technique, one-visit procedure for fixed restorations mostly inlays and onlays. During the chair side procedure of CAD/CAM, digital images of the prepared tooth are taken with a digital intraoral camera. Through this digital image the dentist will design the adequate restoration directly on computer screen using CAD software and then the same is milled using CAM technology. Procera is a non-chairside CAD/CAM device. In this, the models are sent to laboratory after scanning for miling purpose. Aesthetic inlays, onlays, veneers, crowns, partial and complete dentures, surgical stent for implant placement and prosthesis are fabricated using these techniques [14]. This technology uses Zirconia ceramics which have an edge of

superior aesthetics by putting an end to metal based prosthesis. They are exceptional in physical and mechanical properties. It has two forms, one of which is completely synthesized and arduous to process it. Whereas the other one is partially synthesized and easier to process [15]. In implant dentistry CAD/CAM is used to design the required components. Dentures made by this technology exhibit a great degree of confinement to the oral structures. In maxillofacial prostheses it ensures colour compatibility [16]. Recent advance of CAD/CAM is normally it is an "subtractive method," but recently it is an "additive" method such as rapid prototyping and selective laser sintering technologies.

Digital Facebow and Virtual Articulators

Virtual facebows record the terminal hinge axis and transfers it to a virtual articulator where the digitalized casts are analyzed in terms of static and dynamic jaw relation thereby simulating real patient data [17] .The major drawback of mechanical was its inability to simulate dynamic conditions of the occlusion in the mouth which was overcome by virtual articulators .They are otherwise known as 'software articulators'. Ability to kinematically design prostheses has made them more reliable [18].

Types

Completely adjustable

Completely adjustable articulators posses Jaw motion analyzer (JMA) that records precise movement paths of mandible and was designed by Kordaass and Gaertner in Griefswald university of Germany.

Mathematically simulated

Mathematically simulated articulators are fully adjustable three-dimensional virtual articulators based on mathematical simulation of articular movements, offering possibilities such as curved Benett movement which makes them more versatile compared to mechanical articulators, E.g., Szentpetery's virtual articulators and Stratos 200.

Recent advances

3D virtual articulator system D-Isny was developed by Zebris Company which has an advantage of analyzing masticatory movements including force and frequency at points of contact [19].

Digital occlusion

The drawbacks of intraoral scanners are that they are unable to replicate patient's biting or performing functional movements in real time. T-scan which was produced by Dr. William Maness has helped dentists in precise occlusion analyzes by identifying imbalances in patient's bite. When this occlusal data is incorporated into a digital impression, precise image of patient's bite along with force measurements is analyzed [20]. It is referred as Digital Impression Overlay(DIO). It has improved efficiency in placing implant by planning the placement in an attempt to avoid non-axial forces biomechanically thereby eliminating peri-implant bone loss and place them in aesthetically acceptable position.

Digital Photography

Digital photographs are of prime importance as they have raised the treatment standards, especially in cosmetic dentistry. They have helped to assess frontal and lateral profile, gonial angle, curve of Wilson, curve of Spee and golden proportion. It has eliminated shading errors. They have become critical for the evaluation of treatment outcomes and has helped dentists to detect and rectify errors [21]. They serve as legal document proof and, paves the way for digital smile designing and have become fundamental for maintaining patient records [22].

Lasers

Laser has diverse use in the field of prosthodontics. They have become an integral part of treatment for patients who are apprehensive with complex medical histories, and for ones, especially with potential bleeding problems and for whom adverse effects of anesthesia are prone to occur.

Laser has enabled us to maintain a painless, bloodless and clean surgical field. Minimal postoperative swelling and discomfort is experienced by the patient [23]. In removable prosthodontics, soft tissue lasers excise the soft tissue hyperplasia while tuberosity reduction is done. Erbium lasers are used for tori reduction. They are also used for excision of soft tissue lesions such as epulis fissurata resulted from a chronic trauma by a sharp denture flange. Modification in residual ridge during preprosthetic phase is done to aid for eliminating any hindrance for retention, stability and support of the prostheses. During fixed prosthodontic procedures Argon laser has provided excellent hemostasis and coagulation. Gingival retraction by using retraction cord and haemostatic agents before making an impression during crown and bridge procedure are replaced by laser troughing using Nd:YAG laser. Laser re-contouring of soft and bony tissue for the formation of ovate pontic sites are done. Argon laser is used for contouring of gingival tissues around the laminates [24].

Recent advances

1. Fabrication of restorations from porcelain and other materials are done using casts that are scanned by laser, by linking it to computerized milling equipment.
2. Welding of broken clasp is done using laser which eliminates the need for investment and soldering alloy .
3. In maxillofacial prostheses for Laser holographic imaging [25].

Digital management of patient records

Comprehensive and accurate records are fundamental for good dental practice. Maintaining patients dental records is crucial as it has legal implication and forensic application. It comprises the documents relating history of presenting illness, clinical examination, provisional and final diagnosis, treatment rendered, tablets prescribed and prognosis. Presently, the best dental softwares which serve for these purposes are Dentrix, Ascend, Eaglesoft, Denticon, Curve-dental, ACE dental, Dentimax and i-Dentalsoft are being used by the dentists worldwide [26].

Digital patient education

Patient education can make a significant difference in maintaining good rapport with the patients. It helps patient in understanding of the importance of oral health. Digitalized educational aids can provide patients with information to assist them in wanting what they actually need.3D videos and multimedia presentations helps in superior level of understanding. It is a step ahead of charts and posters used for patient education [27]. Softwares available are Consult-Pro chair side, CAESY (XCPT), Bite FX, GURU (Schein).

Table 1

No.	Digital technology	Advantages	Disadvantages	Uses
1	**Digital X-Rays**			
	Orthopantomogram (OPG)	Wide range of coverage.	Fine anatomic details are not reproduced because of distortion of the geometry.	Provides information about the structures and pathologies of lower face.
	Radiovisiography(RVG)	-Radiation is minimal. -Instant image production.	Sensor is small and thick.	Used to produce intraoral periapical radiographs.
	Computed tomography (CT)	-Painless -Prevents superimpositions.	-High radiation.	Issue 3D images of soft tissues.
	Cone beam computed Tomography (CBCT)	-Lower effective radiation doses. -Easier image acquisition.	-Radiation scatter -Artifacts	3D images of hard tissues.
2	Optical impression	-Accuracy of impression. -Prevention of sensitivity to impression material.	-Lack of familiarity among dentists.	Digital scanning of the teeth.
3	Virtual articulator	-Simulate the actual patient data. -Static as well as dynamic occlusion relations are recorded well.	-Difficult to adapt to the technical aid initially.	For virtually mounting digital casts.
4	Digital Shade selection	-Light source used is constant. -Exact evaluation of selected shade.	Complexity of thee equipment.	Appropriate teeth shade matching.
5	Digital photograph	-Immediate accessibility -Good resolution	- Heavy	Patient education, diagnosis and treatment planning.
6	Fabrication-CAD/CAM Milling	-Error is less. -One visit fixed restorative procedure.	-Soft tissue management is critical. -High learning curve.	For designing and fabrication of dental restorations.
7	Lasers	- Excellent hemostasis. -Better post-operative healing.	- Ocular injury. -Chances for pulpal damage.	-Excising soft tissue hyperplasia during tuberosity reduction. -Bone and soft tissue recontouring. -For removing inflamed granulation tissue in case of peri-implantitis.

Conclusion

Digital era in prosthodontics has made the workflow easier and has been proven to be the best concerning qualitative treatment. Many complicated procedures have been brought to a single click. When, it is utilized with adequate knowledge it would redefine the practice of contemporary prosthodontics. Recent advances in digitization options have substantially improved patient's smile to a harmonious one for which a prosthodontist strive. Excellent integrated approach has been made possible,

right from diagnosing to a perfect treatment planning. It is effective and at the same time minimizes discrepancies to a greater extent. The scope for digitization in prosthodontics is continuously facing new horizons. Lots of researches are being conducted in this particular area to scale down manual errors. It is predicted that many of the dentists would adopt this computer-aided technologies in the impending future. Time-consuming and labor-intensive steps are replaced, that serves the dentist to focus efficiently on the important aspects of the procedure. One of the major hurdles of digitization is the adaptation for hardware and software takes time. Notwithstanding its downside, digital technology owes the best to the profession by creating a virtual environment.

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