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Review Article

The Scope and Futuristic Approach of Digitalization in Prosthodontics

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ABSTRACT:
Dentistry can be dated back to eighteenth century, and the dental equipment consisted of hand driven and later water driven motors. From then there has been a long journey to achieve the contemporary paraphernalia. With the passing years and the endless growth in research, emerged a gamut of options in dentistry. The impact of digital technology in prosthodontics is immense, let it be in the clinical and lab procedures like use of CAD-CAM technology, stereolithograph, rapid prototyping, use of virtual articulators and digital facebows, digital radiographs or in the field of training, education and research by the use of virtual patient programs, dental software, optoelectronic recording of jaw motion, retention testing device, audiovisual aids, the list will remain endless.
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INTRODUCTION

Dentistry can be dated back to eighteenth century, and the dental equipment consisted of hand driven and later water driven motors[1]. From then there has been a long journey to achieve the contemporary paraphernalia. With the passing years and the endless growth in research, emerged a gamut of options in dentistry. The contemporary dental practice has endless options for preserving oral health and provides next to natural aesthetics with an enhanced approach, reduced treatment time, minimized error potential and better quality assurance. These reasons rightly explain present day dentistry being called the **Golden Age of Dentistry**.[1]

The digital technology has immense influence over the clinical aspect, diagnosis and treatment panning, laboratory procedures, training of students, patients motivation, practice management and not the least dental research.[1] Digitalization has become a part and parcel of contemporary prosthodontics with the probability of most of the procedures being based on the digital techniques in the near future.[2]

OBJECTIVE

The impact of digital technology in prosthodontics is immense, let it be in the clinical and lab procedures like use of CAD-CAM technology, stereolithograph, rapid prototyping, use of virtual articulators and digital facebows, digital radiographs or in the field of training , education and research by the use of virtual patient programs, dental software, optoelectronic recording of jaw motion, retention testing device, audiovisual aids, the list will remain endless. A review has been written with contemporary references considering the pros and cons of various technological progresses.[2,3]

AID IN DIAGNOSIS

Role of digitalization in diagnosis includes digital radiographs, photographs, T-scans, jaw tracking devices, virtual articulators, diagnostic wax-ups and stents.

Digital radiographs: includes Radiovisiography (RVG)- intraoral periapical radiographs, panoramic radiographs, TMJ radiographs, cephalometric radiographs, computed tomography , cone beam computed tomography and Magnetic resonance imaging [4]

Dental photographs: aid for patient education and aesthetic treatment planning. to visualise post treatment effect, variation of tooth size and form etc, easier to store, can be viewed at various angulations and easily measured and could be of great help to examine the age changes like occlusal vertical dimension, tooth colour and facial changes.[5]

T-scan: Systems like Tekscan(T scan) and Matscan permit a precise study of occlusalcontacts and the forces created; examining even slightest of occlusal interferences, significant in full mouth rehabilitation and implant protected occlusion (IPO). The patient's bite record is transferred to a computing system which can make an actual simulation of the patient occlusion on a monitor, assuming the different situations possible during centric, eccentric and functional movements. This provides both qualitative and quantitative assessment of occlusion.[6]

Jaw tracking devices: Jaw tracking devices (K7 Diagnostics) would be helpful in studying jaw movements and hence occlusion which may be a micro-trauma for temporomandibulardisorder. [7]

Virtual articluators: They offer dynamic visualization of the occlusal surface, the occlusal profile of the teeth can be designed with increased or decreased cusps to eliminate occlusal interferences of the dynamic pattern. The data set of newly designed and improved occlusal surfaces can be transferred to a milling machine, producing real crowns and fixed restoration with that particular, optimized functional occlusion.[8]

Virtual diagnostic wax-up: A computer generated, powerful and realistic, diagnostic wax-ups equipped with software technology include the patient smile and secure the order for the final prostheses, represent an efficient planning and promotion tool for dentists, saves time and costs by eliminating cumbersome manual reproduction of the diagnostic design.[9]

AID IN PATIENT EDUCATION AND MOTIVATION

Softwares like XCPT, Dentrix and BiteFX can be used for a better understanding of treatment plans portrayed in a visually convincing way.[10]

AID IN CLINICAL PRACTICE

A further development in the CAD/CAM technologies used in dentistry is the transition from closed to open access systems. Whereas in the past the digitizing, designing and manufacturing came as a closed system (e.g. CEREC®), more and more the technology is being opened up and the component part of a CAD/CAM system can be purchased separately. This creates much greater flexibility in that data can be acquired from a range of sources (intra-oral scanner, contact or laser model digitizer, CT, MRI)[11]

AID IN TREATMENT AND ASSOCIATED LABORATORY

The manufacturing can be done by broadly two methods

1. ***Subtractive manufacturing***: CAD/CAM in dentistry is primarily based around the process of subtractive manufacturing. The technology most people will be familiar with is computer numerically controlled machining, which is based on processes in which power-driven machine tools, such as saws, lathes, milling machines, and drill presses, are used with a sharp cutting tool to mechanically cut the material to achieve the desired geometry with all the steps controlled by a computer program. These technologies have achieved a high degree of sophistication with new technologies such as **electrical discharge machining, electrochemical machining, electron beam machining, photochemical machining, and ultrasonic machining**[12] that come under subtractive machining.
2. ***Additive manufacturing***: The process of joining materials to make objects from 3D model data, usually layer upon layer, as opposed to subtractive manufacturing methodologies.

In principle the process works by taking a 3D computerfile and creating a series of cross-sectional slices. Each slice is then printed one on top of the other to create the 3D objects. **One attractive feature of this process is that there is no waste.** Traditionally additive manufacturing processes started to be used in the 1980s to manufacture prototypes, models and casting patterns. Thus it has its **origins in rapid prototyping (RP)**, which the name is given to the rapid production of models using additive layer manufacturing. Today additive manufacturing describes technologies that can be used anywhere throughout the product life cycle from pre-production (i.e. rapid prototyping) to full scale production (also known as rapid manufacturing) and even for tooling applications or post production customization.

Thus additive manufacturing is transitioning from rapid prototyping models to manufacturing real parts for use as final products. The equipment is becoming competitive with traditional manufacturing techniques in terms of price, speed, reliability and cost of use.

There is already a huge array of additive manufacturing technologies that we can use and these include:

- Stereolithography (SLA)
- Fused deposition modeling (FDM)
- Laser powder forming
- Inkjet printing

STEREOLITHOGRAPHY (SLA)

The term "stereolithography" was first introduced in 1986 by Charles W. Hull, who defined it as a method for making solid objects by successively printing thin layers of an ultraviolet curable material one on top of the other. SLA is now routinely used to produce surgical guides for the placement of dental implants. Its use is gradually being extended to include the manufacture of temporary crowns and bridges and resin models for loss wax casting. [13]

FUSED DEPOSITION MODELING (FDM)

There are a number of techniques that come under the umbrella of fused deposition modeling. Fused filament fabrication (FFF) is an additive manufacturing technology commonly used for modeling, prototyping, and production applications. The technology was developed by S. Scott Crump in the late 1980s and was commercialized in 1990. A reservoir of material is extruded through a nozzle and put down in layers to create a 3D structure. The bioplotter uses this approach and is capable of printing in multiple materials to build up a 3D structure.

The main application of the bioplotteris in the modeling of scaffolds for tissue engineering and organ printing. It has ability to use a wide range of materials, including ceramic pastes (HAP and TCP) for creating porous bone scaffolds, bioresorbable polymers such polycarpolactone and/or poly-l-lactide for drug delivery and agar, gelatine, chitosan, collagen, alginate and fibrin as carriers for cells that are used in organ printing.[14]

LASER POWDER FORMING TECHNIQUES

Laser based additive manufacturing, such as selective laser melting (SLM) and selective laser sintering (SLS), is accomplished by directing a high power laser using mirrors at a substrate consisting of a fine layer of powder. Where the beam hits the powder it creates a melt pool and the powder particles fuse together. This technology is in wide use around the world due to its ability to make very complex geometries directly from digital CAD data. When processing polymers and ceramic the industry generally refers to this as selective laser sintering whereas for metals the terms used are SLM or DMLS (direct metal laser sintering). A range of metal powders can be used that include steel, titanium, titanium alloys, and Co/Cr alloys. The technology is beginning to find wide acceptance for the construction of implants such as bone analogs, orthopaedic and dental implants with porous surface features for bone ingrowth, dental crowns and bridges and partial denture frameworks.[15]

INKJET PRINTING TECHNOLOGIES

Inkjet printers are capable of printing at a very high resolution by ejecting extremely small ink drops. Inkjet printing works by propelling individual small droplets of "ink" toward a substrate. It has a wide range of dental applications such as reproduction of dental models, orthodontic bracket guides, and surgical guides for implant placement, mouth guards, sleep apnea appliances and even try-in veneers. A particular feature of this technology is that it can print an object using two materials with quite distinctively different properties. Thus it would be possible to produce a mouth guard with hard and soft regions and it can make them with different colors.[16]

DIGITAL IMPRESSIONS AND CAD/CAM

Precision and accuracy of master impressions are critical to the overall excellence and marginal fit of definitive fixed restorations. CAD/CAM offers clinicians, patients and laboratory technician's methods that are reproducible and accurate, and allows for user and patient friendly clinical procedures. CAD/CAM systems are available that either digitally scan and create fixed restorations chairside or that capture chairside digital impressions that are then sent to a laboratory. In-office CAD/CAM allows clinicians to provide same-visit indirect fixed restorations that are accurate and esthetically pleasing. Chairside digital impression making allows for the creation of accurate models that can then be used for either traditional or CAD/CAM fabrication of restorations, and involves less chairside time. In the case of image verification and model milling in the manufacturer's facility, standardized quality control procedures also benefit the final product. The current in-office systems with chairside milling are the **CEREC** (Sirona) and **E4D** (D4D Technologies) machines. Chairside digital impression systems with transfer of images to a laboratory or manufacturing facility include the **iTero, CEREC and Lava C.O.S. systems.**

ADVANTAGES

1. Digital scans take less time than conventional impressions, including the bite registrations and save the material handling and expense. Indicated for patients who have a tendency to gag while making an impression thus ensuring more comfort.
2. In addition to the speed of image acquisition compared to traditional techniques, once the imaging technique has been learned, the digital images will be accurate for the laboratory and the need for repeat impressions at the request of the lab will not occur, saving material and clinician effort.
3. Scanning takes three to four minutes, compared to almost double this for a traditional impression and bite registration technique. There are no material restrictions either, resulting in less risk of either clinic or laboratory errors, with no risk of errors due to distortion of impression or bite registration materials.

4. The accuracy of scanning the occlusion and occlusal surfaces helps to reduce the time required for minor occlusal adjustments at the seating appointment.

With advancing technology, these digital impression concepts will eliminate the need to handle/ manipulate materials, also reducing the chances of error which can be encountered from the initiation of making an impression to obtaining a cast to fabricate the prosthesis and asking the patient to try it. This is certainly more conservative and minimally invasive in its approach in terms of clinician and patient acceptability.[17]

SUMMARY

Advances in digital imaging, computer aided design, internet communication, digital manufacturing and new materials have undoubtedly simplified the diagnostic process and improved treatment outcomes. Digital technology has impact over the patient motivation, practice management and clinical treatment procedures. Be it digital radiographs aiding in diagnosis, CAD-CAM ceramics for better aesthetics and function with a smaller number of appointments.[1] Digitization started to influence dental fraternity with the form of audio-visual aids in both teaching and patient education. It has become part and parcel of contemporary prosthodontics with the probability of most of the procedures being based on digital techniques in near future. Let us think of X-rays or photographs, making impressions, recording jaw movements or fabricating prosthesis, educating and training new dentists or patient motivation for practice build up, all has become digital.

Additionally, complete dentures fabricated by CAD/CAM technology appear to be more amenable to clinical use than complete dentures fabricated with rapid prototyping technology. Rapid prototyping and stereolithography used mainly for maxillofacial prosthesis fabrication[18] and implant surgery [19] provide high level of predictability, more convenience and even a smaller number of sittings. Also, patient care and communication can be enhanced substantially by using several new technologies.[2]

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