Review Article

Digitalization in Prosthodontics: Changing Needs Based on Modern Demands

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ABSTRACT

The impact of digitalization on general dental practice influences number of parameters like clinical aspects, student training, patient motivation, laboratory procedures, practice management and dental research. The availability of software has also augmented the role of chairside computers by successfully integrating clinical features with corresponding administrative functions. Digitalized dentistry (DD) also includes important aspects of clinical features, patients, and treatment procedures in addition to financial and management procedures. Various dental procedures have found its implementations such as digital radiographs, CAD/CAM technology, digital shade matching, prosthesis fabrication, rapid prototyping and stereolithography for maxillofacial prosthesis as well as digital face bows, virtual articulators and many others to mention.

Key words: CAD/CAM, digital, dentistry, impressions, rapid prototyping

INTRODUCTION

Digitalization include steps like analysis of potential impact, review of current state with the desired impact, then approach to close the gap and finally implementation and validity.[1] Itturns existing products or services into digital variants adding advantage over tangible products. It has been continuously evolving since years to change society and made the human life easier by saving time, effort, fuel, cost and thereby improving quality.[2]

The advent of digital technologies has aided dentists' efforts to ensure that the patient will receive best possible treatment under the most comfortable circumstances. It has lot of options for preserving as well as providing next to natural oral health and aesthetics with an enhanced approach, reduced treatment time, better

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quality assurance and minimized error potential.[1-3]

A variety of dental restorative aspects including diagnosis, rehabilitation, and maintenance of patients with complex clinical conditions have been dramatically improved through the digitalized techniques compared with conventional procedures used in past.[4]

MATERIALS AND METHODS

An electronic search on digitalization and dental literature was conducted through Google scholar, PubMed, Hinari, Cochrane to obtain all the relevant information on impact of digitalization on dental services. Only English based literature published from January 1990 to January 2020 was considered for this review. Keywords used for the search were CAD/CAM, digital dentistry, rapid prototyping.

Aspects of Dentistry being influenced by Digitalization

Digitalized dentistry (DD) include important aspects of clinical features, patients, and treatment procedures in addition to financial and management procedures.(Fig.1)

Digitalization influences number of parameters like clinical aspects, student training, patient motivation, laboratory procedures, practice management and dental research.The availability of software has also augmented the role of chairside computers by successfully integrating clinical features with corresponding administrative functions and financial management.

Digitization has been implemented in many dental procedures including digital radiographs aiding in diagnosis, CAD/CAM technology, digital shade matching,

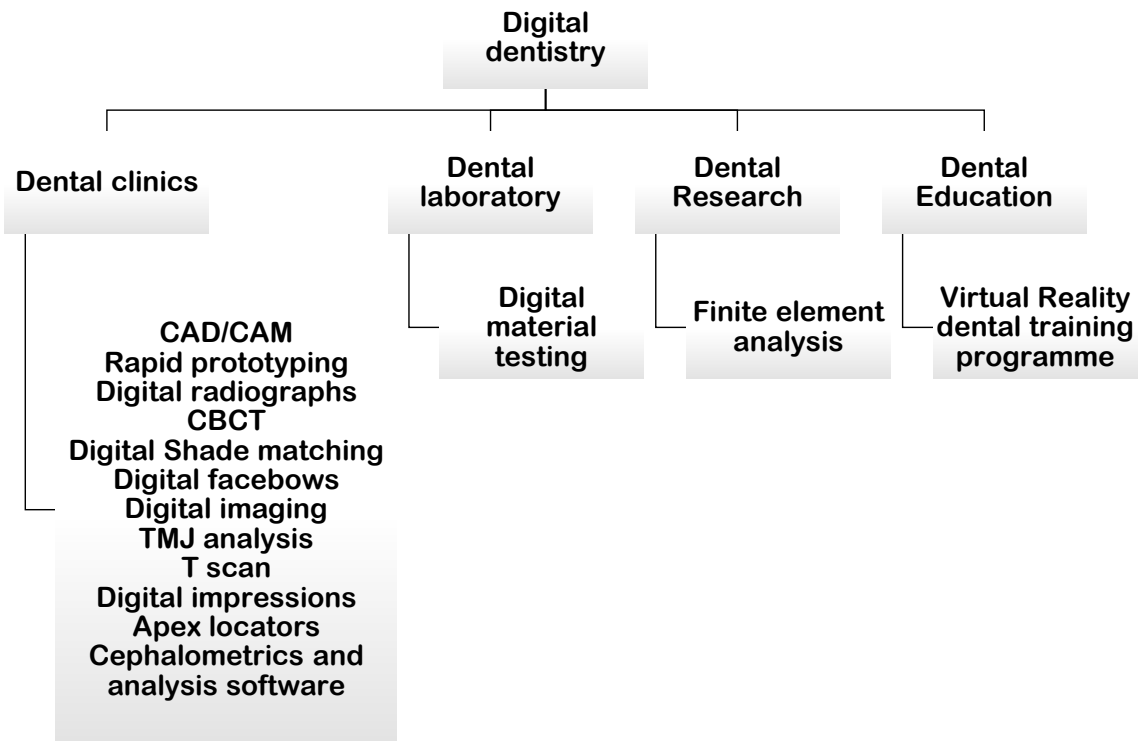

Figure 1: Aspects of digital dentistry

prosthesis fabrication, rapid prototyping, and stereolithography for maxillofacial prosthesis as well as digital face bows, virtual articulators, and many others to mention.[5]

Impact of digitalization in clinical dental practice

Digitalization has pronounced impact over dental practice management, patient's motivation and various treatment procedures. The quality of care has improved through enhanced diagnosis and consultants are now able to provide modern solutions to the traditional dental problems. Computer-aided design and computer-aided development and intraoral imaging are the main fields of digital dentistry, both laboratory and clinician-controlled, dental caries diagnosis, computer-aided implant dentistry, digital radiography including computed cone beam tomography, lasers, digital shade matching, intraoral and extraoral photography, practise and patient record management, including digital education of patients.[5-9] This way digitalization of clinical dental practice can improve the accuracy and predictability of treatment outcome, while reducing the treatment duration. (Table 1)

Digitalization in clinical diagnosis and treatment planning

Digitalized radiography mainly including radio-visiography, cone beam computed tomography, cephalometrics and orthopantogram.[10-12] Their precision enable practitioners to distinguish the earliest changes occurring in hard tissues and helps in early diagnosis of incipient and interproximal caries. It is possible to store and share these digital images. There is also decrease in radiation exposure.

CBCT is very helpful in diagnosis and treatment planning in implant and maxillofacial dentistry.[13] However, it proves to be disadvantageous as these images cannot be used for legal purposes and also equipment cost is very high.[14-15]

Computer aided design and manufacturing (CAD/CAM)

Major development in the CAD/CAM systems occurredin the 1980's. CAD/CAM

Table 1: Digital dentistry in clinical practice

Digitalization in clinical practice	Methods
Patient records	Various digital softwares are available to keep the patients records whose copy can be shared to the patient as well as to fellow clinicians and laboratory for better effieciency of the work
Diagnosis	Caries detection solution, Digital x rays, CAT scans, Dignodent, Orthopantographs, Cone Beam Computed Tomography, MRI, Intra oral camera, Optical scanners, microscope, Velscope, The Wand, Digital photography, Periometer, Perioscan, Tscan, EMG's,
Treatment	Air abrasion technology, soft tissue and hard tissue lasers, digital impressions, electric handpieces, CAD/CAMS, digital shade maching, Tscans, Digital anaesthesia systems, virtual drilling systems.

is used for fabrication of inlays, onlays, conventional crowns, veneers, fixed partial dentures, implant abutments, implant crowns, surgical guides, complete dentures and maxillofacial prosthesis.[16-17] All types of CAD/CAM systems consist of three basic components, a digitalization tool or scanner that converts the geometry into the digital data, a computer software that processes this data and a production technology that converts the data set into the desired product. Digitalization instrument is an intraoral-camera which replaces the conventional impression. CEREC system, the first CAD/CAM system in dentistry, is currently available in its third product generation.

Three system of researches actively pursued application of CAD/ CAM techniques. These are described in Table 2:

With the help of CAD/CAM it is possible to scan the denture base morphology and jaw relation record in a single appointment and export those data into virtual tooth arrangement program where teeth can be articulated and then export the data to a milling device for fabrication of complete denture. It makes the insertion of complete denture possible in the second appointment without compromising the denture quality.[17-18]

The use of CAD/CAM considerably reducechairside time, provides accuracy, precision and preserves obtained digital data to allow for spare prosthesis fabrication or for replacement or fabrication of surgical template that aids in future planning for implant surgeries.[19]

Dental material testing using digitalization

Testing of physical, mechanical and biological properties of dental materials has become more efficient using digitalized testing instruments.[20] Introduction of finite element analysis incorporates a computer

Table 2: CAD/CAM system

Systems	Various Parts	Data Processing
French system	3-D probe system based on electro-optical method Surface modelling and screen display Automatic milling by a numerically controlled 4-axis machine	By Shape recognition software
Minnesota system	Optical impression - Photograph based system using a 35-mm camera with magnifying lens. Milling with a 5-axis N/ C machine.	Data obtained in the dental office is sent to another location for processing and machining.
Swiss system	A desk top model computer Display monitor permitting visual verification of quality of data being acquired Electronically controlled 3-axis N/ C milling machine	By an interactive CAD unit

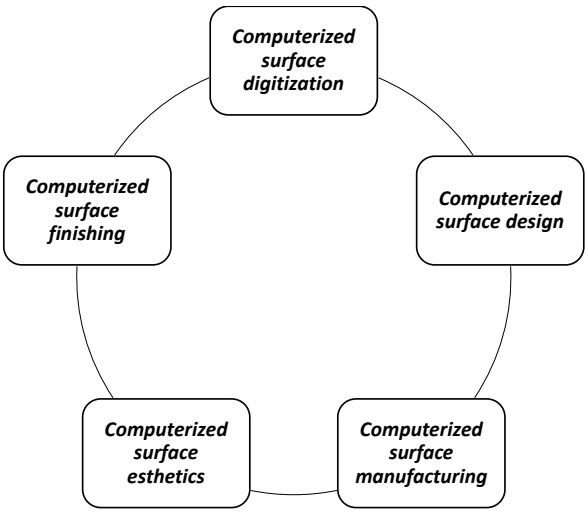

Figure 2: Stages of fabrication of CAD/CAM dental restoration

model of a material or design that analyzes the stress transferred by various materials, their mechanical properties, effect of different designs on dentofacial structures, implant placement and their loading.[21-22]

Dental material testing consists of four phases including cellular general toxicity, local tissue irritation, pre-clinical, and clinical evaluation. Current availability of different screening assays, detailed knowledge of chemical properties of dental materials, tissue engineering, stem cell, genetic transfer, biomaterials and growth factor therapies have helped tremendously in better testing of dental materials.[22]

Digitalization in training and education of dental students

Traditionally trainees learned to conduct surgery under the supervision of consultants but it proved to be costly, time consuming and have variable effectiveness. Virtual reality dental training gives access for practice on three-dimensional virtual oral cavity. It simulates learning by including the possibility of repeating various operations and committing mistake on patients.Virtual reality computer assisted simulation system showed effective capability of evaluating student's preparation through computer tracking.[4] Students tend to acquire the skills at the faster rate and in shorter period of time.

Digitalized technique has proved efficient in Teaching restorative procedures, tooth preparation, sutures, and other implant related surgeries is better and efficient with digitalized technique. It offers a feeling of working on patient without risk of doing it.[23]

Virtual articulators

Virtual condylar and incisive guidance can be precisely measured by jaw movement analyser. These virtual articulators are kinematically able to design prosthesis by simulating the mandibular movement. It calculates specific sites where opposing teeth come in contact during mandibular animation so that specific masticatory movement can be simulated. It also provides with correct occlusal surface to enable smooth and collision free movements.[24-25] Virtual articulators are also helpful in patient's education and thereby improving the compliance of the treatment.

Rapid prototyping

Rapid prototyping (RP) refers to automatic construction of mechanical models from graphical computer data. RP involves a variety of emerging technologies that manufacture specific parts in a few hours directly from CAD models, without the need for human interference. It is one of the types of computer aided manufacturing (CAM).[26-27]

Stereolithography technique is used to create contact free reproduction of facial features, mirror image of anatomic parts and can compensate for patient growth

and material distortions.[28] It is used in fabrication of obturators, surgical stents, burn stents, nasal and auricular prosthesis with the rate of accuracy of 0.1 to 0.4 mm.[26] Stereolithography surgical templates are being used for surgical and Prosthodontics implant planning and placement. Guided surgeries are minimally invasive treatment procedure which can be performed without raising the flap and the prosthesis is delivered achieving immediate functional loading.[29-31]

Digitalized dentistry impacts on dental research

Scientific research is fundamental for professional development of dentistry. Despite the fact that old techniques still form basis of scientific dental research, the research quality outcome has been enhanced on by newly adopted techniques and led to development of latest equipment and enhanced treatment techniques. Computers and variety of software have been a great assist in research studies.[32]

The application of computerized/ software digitalization has been incorporated in what is known as finite element analysis (FEA) based models. FEA is used for analysis and design of complex structures based on force and displacement relationships.[33] This technique has been used to examine the stresses and mechanical properties of different materials; effects of variable designs on dentofacial structures; implant loading and their positioning etc.

The use of Digital Instron (test equipment designed to measure the mechanical properties of materials and components) for material testing, retention testing equipment, the use of software for anthropometric, cephalometric, and aesthetic ratio studies is another field where digitalization has helped in research.[34]

TMJ analysis and diagnosis of musculoskeletal disorders

Nowadays TMJ imaging can be done by CBCT, nuclear imaging, magnetic resonance imaging, nuclear imaging, positron emission tomography. These enhancements improve the understanding the complexities of the joint, its pathology and its possible treatment.[35]

Jaw tracking devices example K6 Diagnostics are used to study the jaw movements and consequent occlusion which may be microtraumatic for TMJ disorder.[35-36] Electromyography (EMG) is used to detect the elevated muscle activity associated with malocclusion directed nociception and help in diagnosis of musculoskeletal disorders. An EMG device, such as BITESTRIP, can record muscle activity for some hours and help in diagnosis of nocturnal bruxism. These techniques aim at studying the stomatognathic system as accurately and precisely as possible.[37]

Digital shade matching

Shade selection is a complex procedure considering variations and differences in the optical properties of new generation cosmetic restorative materials. Visual shade matching is the most common method; however, it varies depending upon the clinicians color perception and experience, light condition, tooth background and the type of shade guide used.[38-39]

Digital camera is capable of recording the digital data which be analysed by the appropriate imaging software which will give the accurate shade selection. Digital shade selection is more convenient and may provide with the entire spectrum of color space of natural teeth. Digital imaging is also an objective and efficient tool of communication with dental laboratory.

Digital impressions

Various systems available in market for digital impressions are cerec systems, E4D denist system, iTero system, The LavaTM chairside oral scanner. They vary from each other in terms of key features such as working principle, light source, the necessity of powder coating spray, operative process and output file format.[40-41] Digital impression represents a remarkable superiority in efficiency over conventional impressions.[42]It takes less time for re-scans as only missing and unacceptable areas are rescanned whereas in conventional impression, the entire arch is needed to be retaken. Also, the patient comfort is more due to absence of tray fit, taste of material and setting time of the impression material. Restoration fit is more accurate when a digital impression is made.

Digitalized dentistry in occlusal correction

T scan or Matscan permit for accurate study of occlusal contacts and force generated, while examining the slightest occlusal interferences.[43-44] These scanners aim to register the patient occlusion on the 60-micron thick disposable sensor to record the patients bite and force of every tooth in contact. Software uses these records to make an actual simulation of the patient occlusion on the monitor during various functional and parafunctional movements.

There are at least 8 generation of T scanners available in market.[44] T scan demonstrates sufficient sensitivity and specificity as a diagnostic tool and presents higher reliability in intraoral conditions even in presence of saliva. This technology reduces the subjective interpretation of occlusal data analysis. It also provides with registration of dynamic occlusal information.

Digitized dentistry and patient motivation

With the use of intraoral cameras, education software, videos, 2-dimensional or 3-dimensional images of different techniques and procedures help in creation of good sense of understanding between dentist and the patients and help them to reduce their dental fears and impose trust and educationregarding their oral health conditions. This digitalized procedure is termed as on the spot consultation that builds trust, saves time and contributes for pronounced patient motivation.[45]Also the images saved can be used for legal purposes in future.[46]

CONCLUSION

Progressive application of digitalization in different specialities of dentistry will pace future of contemporary dentistry. Dental practice would be more convenient for both dentist and patients if the above discussed technologies are wisely implemented. The main concern regarding the dental technologies is their high cost; however, the researches continue to make these technologies available in reach of the dental practitioners. Dental professionals must go hand-in-hand with the newfound advancement all around the world and same holds true for digitalization as it continues to prove to ease the dentists as well as the patients.

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