Review Article

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# DIGITIZATION IN PROSTHODONTICS

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## ABSTRACT:

The technology is now available to run a practice almost paper free. It is theoretically possible to store clinical notes, photographs, and radiographs; and study models on disc, and refer or consult online. In recent years, it has developed significantly into the major dental branch, currently used by the increasing number of dentists and dental technicians worldwide. 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._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. CAD-CAM was first patented in dentistry followed by various other technologies like CT, CBCT. It has revolutionized not just the ceramic technology, but has also been used for the CAD-CAM implant surgeries, maxillofacial prosthesis and diagnostic splints.

**Key words**: Prosthodontics, Digitization, CAD/CAM Technology, CBCT, Optical Impression.

## INTRODUCTION:

Dentistry can be dated back to eighteenth century, when impressions meant use of waxes and plaster of Paris; and the dental equipment consisted of hand driven and later water driven motors. From then, there has been a long journey to achieve contemporary paraphernalia. Along with limited materials and equipment there were selective treatment options, but with the passing years and 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.[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.[1] Digitalized dentistry enables efficient, fast and precise and error free production of fixed prosthodontics appliances. Early 1980s also paved a way for computer aided

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design/computer aided manufacturing (CAD-CAM) technology.[2]

There is endless scope of digitalization and technology in prosthodontics– let it be in the clinical and lab procedures like use of CAD-CAM technology, stereo lithography, rapid prototyping, use of virtual articulators and digital face bows, digital radiographs, or in the field of training education and research by the use of virtual patient program, dental software, optoelectronic recording of jaw motion, retention testing device, audio visual aids the list will remain endless.[1,2]

The future of digital imaging could include the testing and upgrade of x-ray equipment and software on-line. Research is also continuing into the development of credit card size 'smart card', which could carry a patient's medical and dental notes along with their radiographic images. It is important that advances in technology are accepted and the benefits that they produce utilized in order that clinical practice and patient care continue to improve.[3]

## Various Digitalization Techniques used in Prosthodontics:

Over the past years the use of digital technologies has had a great impact on many fields, from communication to education. This digital revolution started in the latter half of the 20th century by converting analog objects/signals into digital bits and bytes. Over time such technological advances have changed, and still do change, how people and businesses carry out their normal everyday activities. Some activities have become redundant and fade out, while new activities appear and take their place.

The dentistry is also a field which is increasingly experiencing the impact of digitalization. Digitalization will impact all aspects of dentistry; even alter the flow of traditional treatment processes. Workflow between the different parties involved (dentists, surgeons and dental laboratories) can be affected drastically. The claim that dental workflows will change because of digitalization is widely accepted. Renowned dental surgeons and implantologists, such as Professor Daniel Wismeijer of the Academic Center for Dentistry Amsterdam, acknowledge the impact of digitalization on the dental profession. Prof. Wismeijer describes digital dentistry as follows: *"The patient will remain analogue and the in-mouth piece (bridge, crowns, etc.) he or she receives is analogue. Everything in between will become digital."* He continues: *"with the support of digital dentistry, the whole world (practices, labs, etc.) can be involved in optimizing the value chain".*[4]

## Straumann Digital Solutions:

In the beginning of 2010 Straumann launched a new array of integrated computer-based technologies under the name of 'Straumann Digital Solutions'. These technologies can be categorized into three competencies: computer guided surgery, intra-oral scanning, and CAD/CAM prosthetics.[5]

Straumann's vision of Digital Solutions is that "the patient and the restoration will remain analogue and everything in between will become digital".

## Computer guided surgery:

The computer guided surgery product that Straumann offers consist of three main components: coDiagnostiX planning software, gonyX surgical template production tool, and the Guided Surgery Kit and Implants. The process for guided surgery starts off with a master model of the teeth impression that represents the patient current situation. This is the basis for the production of the scan and surgical template. From this master model a scan-prosthesis is made to represent a provisional teeth set-up.[5]

## Intra-oral scanning:

Straumann is the exclusive distributor in Europe of the Cadent's iTero intra-oral scanning system4. This technology of intra-oral scanning enables the dentist to create 3D images of the patient's teeth using a digital scanner from inside the mouth. The intra-oral scanner is developed to replace the conventional process of impression taking in the dental practice and model casting in the dental laboratory. The 3D images can then be imported into CAD software to be used restorative procedures.[5]

## CAD/CAM Technology:

Straumann provides a vast portfolio of CAD/CAM products: scanners, modeling software, a full range of prosthetics and durable materials. Modern dental prosthetic inlays, crows, onlays and bridges are designed with the help of computer (CAD) and then milled on computerized machines (CAM). Impression models are scanned using 3D scanners, or directly scanned by the intra-oral scanning. The dental technicians model the tooth restoration on a computer. The data are then sent to centralized production centers, which produce the prosthetic in a range of biocompatible, durable and esthetic materials, including high-performance ceramics. CADCAM's solutions extend from single tooth inlays right up to 14-unit full-arch restorations.[6]

CAD/CAM was introduced in dentistry in the year of 1971. The use of CAD/CAM technology in dentistry is increasing, both in the dental laboratory and general practice settings, to fabricate all-ceramic inlays, onlays, crowns, and veneers. Only one CAD/CAM system is currently available for in-office chair side use, CEREC® 3D by Sirona Dental Systems. There exists a misconception that the CAD/CAM process is complicated and time consuming. However, this CAD/CAM system is simple to operate, versatile, and precise. All-ceramic restorations can be designed and milled chair side, traditional impressions and temporaries are eliminated, and the patient leaves the appointment in about an hour with a final restoration in place.[4]

**Definition: CAD/CAM Systems:** Computer Aided Designing/Computer Aided Machining systems that can produce

dental prosthesis with help of robots or computers.

The first report on CAD/CAM, published in 1973, made it clear that the optical impression technique, or dental CAD/CAM, encompasses all methods of analysis including diagnosis and treatment, working in space, and developing means of measurement that are preferably optical.[6]

**General Principles of CAD/CAM:** All true CAD/CAM systems exhibit there computer-linked functional components, although the degree of sophtication may differ.

- A means of data acquisition
- Restoration design.
- Restorative production.

The first stage requires digital data to be collected from the patient's mouth this is equivalent to traditional impression taking.[7]

**Uses of CAD/CAM in prosthodontics are as follows:**

1. Inlays and onlays
2. Crowns and bridges
3. Fabrication of post and cores
4. Complete denture fabrication
5. Removable Partial Denture Prosthesis Fabrication
6. Designing the placement of the Implant[8]
7. Designing the maxillo facial prosthesis [9,10]

**Clinical steps in the fabrication of CAD/CAM Crown:**

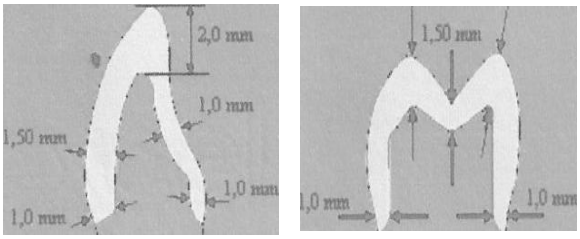
A. Crown Preparation

B. Optical Impression.[7]

**A. ALL CERAMIC CROWN PREPARATION:**

The functional cusps should be reduced 2.0 mm, nonfunctional cusps should be reduced 1.5 mm, and the central fissure area should be reduced at least 1.5 mm to ensure adequate strength to the crown. In addition, axial reduction of the tooth should be a minimum of 1.2 mm.

The facial and lingual walls of the crown preparation should be done in two planes to avoid thin areas in the milled restoration. Rounded shoulder or chamfer margins, at least 1.0 mm thick, ensure a strong edge of material to prevent fracture of the restoration. A sloped shoulder (90°-120°) ensures a strong edge of material while providing a good transition of translucency and shade between the tooth and crown at the margin area. Thin areas at the margins, such as light chamfers or bevels, are predisposed to fracture and are not recommended.[6]



**B. OPTICAL IMPRESSION**

- POWDERING
- ACQUIRING SINGLE OPTICAL IMPRESSION
- ACQUIRING MULTIPLE OPTICAL IMPRESSION POWDERING:

**Background Information on Powdering:**

To make an optical impression it is necessary to powder (or opaque) the tooth surface to be imaged because of two reasons: The surface of the tooth must be covered with a non reflective coating to make it easier for the infrared camera to see the details.[7]

## CONE BEAM COMPUTED TOMOGRAPHY

CT technology was developed by Sir Godfrey Hounsfield in 1967 and there has been a gradual evolution to five generations of the system.

- ✓ First generation scanners consisted of a single radiation source and a single detector and information was obtained slice by slice.
- ✓ The second generation was introduced as an improvement and multiple detectors were incorporated within the plane of the scan.
- ✓ The third generation was made possible by the advancement in detector and data acquisition technology.
- ✓ The fourth generation was developed to counter this problem. A moving radiation source and a fixed detector ring were introduced. This meant that modifications to the angle of the radiation source had to be taken into account and more scattered radiation was seen.
- ✓ Finally the fifth (sometimes known as the sixth) generation scanners were the introduction to reduced *"motion" or "scatter"* artifacts.[12]

***CBCTs*** for dental, oral, and maxillofacial surgery and orthodontic indications were designed to counter some of the limitations of the conventional CT scanning devices.[13]

(I CAT CBCT)

The radiation source consists of a conventional low-radiation X-ray tube and the resultant beam is projected onto a flat panel detector (FPD) or a charge-coupled device (CCD) with an image intensifier. The FPD was shown to have a high spatial resolution. The cone beam produces a more focused beam and much less radiation scatter compared with the conventional *fanshaped* CT devices. This significantly increases the X-ray utilization and reduces the X-ray tube capacity required for volumetric scanning.[13,14]

***CBCT Data***

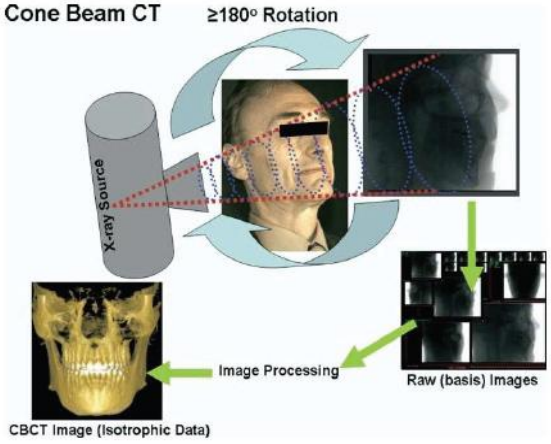
- The tube and the detector perform one rotation (180 or 360°) around the selected region.
- The resulting primary data are converted into slice data.
- The reconstructed slice data can be viewed in user-defined planes.

The CT volume consists of a 3D array of image elements, called voxels. Each voxel is characterized with a height, width, and depth. Since the voxel sizes are known from the acquisition, correct measurements can be performed on the images.[12]

**CBCT as compared with conventional CT**

The following is a summary of the additions and modifications of CBCT as compared with conventional CT, which make CBCT a more appealing alternative:

- Radiation dose is lower. This is mainly because of the lower effective tube current used for the CBCT: while the voltage of the source is approximately the same (90–120 kV), the current is roughly between 1 and 8 mA for the CBCT while e.g., for the multislice CT the current is around 80 mA but can also be as high as 200 mA.
- Detection systems are different (FPD or CCD with image intensifier.
- The resolution is higher; this is mainly due to lesser isotropic voxel size.
- There is less artifacts caused by metallic structures but because of lower dose there is more noise and detailed information about soft tissues is lost.
- CBCT is less expensive and smaller.[13]




CBCT Image Production

**CBCT Acquisition Systems:** There are various classifications of devices but CBCT devices may be divided to fit into four subcategories based on the need of the clinician: and one field of view of the scan (FOV).

- Dentoalveolar (FOV less than 8 cm)
- Maxillo-mandibular (FOV between 8 and 15 cm)
- Skeletal (FOV between 15 and 21 cm)
- Head and neck (FOV above 21 cm)[8]

**Uses of CBCT Technology:**

1. Diagnosis.

2. Clinical application.

3. Clinical evaluation of treatment outcomes.[5]

**Clinical Applications of the CBCT:**

CBCT provides information for 3D models made by rapid prototyping. The obtained 3D models can serve as a matrix that enables precise planning of operations such as for mini-implant positions in anatomically complex sites.[18] CBCT is also a tool for the evaluation of surgical and orthodontic treatment.[6] There have not been a lot of papers published but they are increasing in their number as the CBCT is becoming more readily available.[12]

## OCCLUSAL RECORDING SYSTEM -THE T-SCAN II:

"*The Future Force in Occlusal Diagnostics*"

The T-Scan is the most accurate system available to measure occlusal forces and quantify how well balanced a patient's occlusion is the novices can use the T-Scan to more quickly develop their skills. With the T-Scan, you can take the guesswork out of the articulation paperwork. With the T-Scan, evaluating these forces is as simple as having a patient bite down on our ultra-thin sensor (above) and having the computer analyze and display the data. [19]

**Choose from 2D or 3D Views:**

The T-Scan II lets you to measure the relative force of each individual contact in two different views:

The 2D Contour view looks most similar to articulation paper markings on a patient's teeth.

In the 3D View, the force levels are shown by both color and column height. The 3D view also makes it easier to visualize and understand occlusal relationships during excursive movements.

T-Scan can measure force over time, it is an indispensable tool for appraising the sequential relationships of a from MIP or CR position into a lateral excursion.

In addition to looking at the different views of maximum intercuspal forces in a static mode, you can also use the T-Scan to assess the dynamic aspects of an entire functional movement. After recording a T-Scan occlusal movie you can store the data in your computer and retrieve it as needed. T-Scan's vivid, full-color graphics can be transferred into other documents for patient records or insurance reports.[19,20]

The occlusal forces that are applied to implant prosthesis can be a potentially destructive factor in shortening the potential longevity of any implant prosthesis. Both material failures and implant de osseointegration have been attributed to excessive occlusal loading to dental implants.[19]

Poorly directed and non-uniform occlusal loading will torque prosthesis and apply

stresses that may ultimately result in prosthetic failures.

To definitively attain this goal, it is necessary to employ computerized occlusal analysis, which affords the operator a precise way to assess the force and time factors that are contained within the tooth contact points present on implant prosthesis.[19]

**Perceptions lessened in Implant Patients:**

Prior to the development of the T-Scan II, the common implant prosthesis occlusal adjustment technique was to employ articulating paper markings alone, with force and time interpretation based upon patient confirmation of occlusal "feel". Through a dental prosthesis without neurological feedback to the Central Nervous System. This makes subjective patient perceptions as a guide to occlusal force balance a very inaccurate way to assess the quality of the occlusal forces that are present on implant prosthesis.

The areas of implant prosthodontics where the T-Scan II can greatly raise the level of occlusal precision are:

1.Balancing and centering the occlusal forces on a full arch complete implant supported fixed prosthesis.

2. Removal of lateral interferences.

3. Establishing delayed implant loading.

4. Centering the occlusal forces on a full arch.

5. Removal of lateral interferences in excursive function that will place excessive forces on the occlusal materials while inducing shear stress in the supporting bone.

6. By analyzing implant prosthesis lateral excursive function with the T-Scan II, precise illustration of interference location, and how long (in time; fractions of seconds) the involved teeth are maintaining contact.

7. Segmental implant loading with a time delay in combination cases of implants and natural teeth.[20]

## COMPUTERIZED JAW RELATION RECORDING SYSTEM

Dental Software extends and enhances the capabilities and provides many options for data analysis and presentation.[21]

- Overlying curves on the screen for progressive treatment monitoring and a variety of evaluation possibilities; zoom for diagnostically relevant parts of the curve.
- Dynamic motion (Replay) - both right and left recordings can be viewed at the same time, in real time or slow motion.
- Many options for case presentations - three-dimensional movement of the hinge axis and time curves.
- More detailed calculations of the condylar data - can be repeated for various articulators.

- Increased communication with lab - data can be transmitted online to the technician Gamma Dental Software works on IBM compatible PC's, no special hardware required. Allows creation of patient databases, stores additional documents like text files and pictures.

## COMPUTERIZED REMOVABLE PARTIAL DENTURE DESIGN -STELLIGRAPHE

Stelligraphe is a powerful and simple professional tool. Few clicks of mouse to indicate the teeth absent to pose the crowns and the bridges). The last click to validate and Stelligraphe realize instantaneously: [22]

Stelligraphe: Software patented by Doctor Gaillard and Jourda and carried out by Jacques Orliac and Philippe Beaugrand.

**Stelligraphe – Characteristics**

Vast panoply of tools to work out the prosthesis:

- Extraction of teeth
- Crowns, bridges
- Establishment of hooks, brackets, supports.

The recently introduced Total Porcelain System combines the dental colorimeter, Shade Eye System (SES) and Vintage Halo Porcelain based on the new color concept of natural teeth – dental colour space.[22]

**Clinical Evaluation of the Colorimeter**

1. Ambiguity of shade taking has been reduced.
2. Less time is required for color reconstruction
3. Even in difficult cases for shade taking it is easier to select the proper porcelain powders.
4. Gives a clean and safe image to patients in terms of infection control and promotes the reliability of dentists.

Database means the accumulated data with which we can classify, sort, update, search, or print out the needed information. Data in other data files can also be linked as a relational database.[23]

## DIGITAL IMPRESSIONING

Much of the credit for the boom in the demand for digital dental impressioning systems lies with the dental laboratories. Many dental technicians, to assure that the prospects for their future within the dental industry remain viable; have embraced digitization of impressioning devices, coping and framework design technology, and milling machines capable of producing superior restorations. In many cases, savvy laboratories are convincing their customer dentists to join the digital revolution.[24]

There are two classifications of digital dental-impressioning devices:[24]

- ✓ CAD/CAM devices
- ✓ Dedicated intraoral digital scanners

The Finite Element Method is an approximate numerical method of stress analysis, used in solving complex structural problems by dividing the complex structures into simpler and smaller segments. The technical improvement in computers and finite element software has improved the accuracy and speed of this analysis. It reveals stress and strain throughout the entire structure in response to specific load.[25]

**Advantages**: The FE method has some distinct advantages over other methods of stress analysis:

1. The technique is non-invasive.
2. The tooth, alveolar bone, the periodontal ligament can be simulated and when the material properties of these structures are assigned, it is the nearest that one can possibly get in simulating the oral environment in-vitro.
3. The actual stress experienced at any point can be measured.
4. The actual displacement of the tooth can be visualised graphically.
5. Reproducibility does not affect physical properties of the involved material and the study can be repeated any number of times.
6. The FEM has a potential for accurate modeling of a real object of complicated shape and different material properties.[25]

## CONCLUSION:

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 golden age of dentistry.

Digitization started to influence dental fraternity with the form of audio visual aids in both teaching and patient education. Digitization 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. Today a practicing dentist needs to be equipped with the latest fast changing technology so as to pose a great challenge.

The literature regarding recent techniques helps us assimilate latest trends for benefit of patient and expansion of dental profession as a whole. The transition from old to new occurs with the basic aim of making patient's life better.

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