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REVIEWARTICLE

A LITERATURE REVIEW ON DIGITAL IMPRESSION IN PROSTHODONTICS

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ABSTRACT
The success of fixed restoration depends upon the accurate impression. Newer techniques including digital impressions and digital scanners have emerged as a result of the problems of traditional impressions, such as choking and foul taste. Digital imprinting and computer-aided design/computer-aided manufacturing technologies has many advantages over traditional methods. Using CAD/CAM systems, intraoral scanner technology makes exact three-dimensional photographs of dental structures, which helps in prosthesis design and fabrication.An implant-supported prosthesis uses digital impressions combined with CBCT data to design custom abutments and prosthesis.

***Keywords*:**CAD/CAM systems, digital Impression, Prosthodontics

INTRODUCTION

Accurate impression of prepared or unprepared teeth is the most important stage in the fabrication of perfectly fitting fixed or removable dental prosthesis. [1, 2] The assessment of the quality of permanent restorations can be accomplished through two primary clinical factors that is; internal and marginal fit. Marginal fit is among the most crucial factors for assessing the clinical efficacy of fixed restorations.Inadequate marginal fit may result in secondary caries, plaque retention, and luting cement dissolution. Since the internal fit affected the crown's seating and, in turn, the marginal fit, it is also regarded as a success criterion for crowns. Reduced fracture toughness, lost axial retention, and absent rotation stability can result from improper internal fit. [3]

The conventional impression procedure involves replicating anatomy of intraoral structures using impression material and forwarding this data to dental laboratory for the indirect fabrication of dental restorations. Polyether (PE) and polyvinyl siloxane (PVS) are the most commonly used conventional imprint materials in fixed prosthodontics for creating definitive impressions.[3] Traditional impression techniques, which involve trays and impression materials, can be prone to errors such as distortions or bubbles, volumetric alteration in impression materials, expansion of gypsum products leading to ill-fitting prostheses. Newer techniques like digital impressions and digital scanners have emerged as a result of its downsides of conventional method, which include gagging, an unpleasant taste, and so on.[4] With application of computers in dentistry and advances leads to development of digital impression concept.[5] The digital impressions are used for fabrication of crowns, bridges, and dentures.[6]

DIGITAL IMPRESSION METHOD

CAD/CAM Systems

An optical impression is now either directly or indirectly made by a data acquisition unit that collects data from the prepared tooth in the mouth cavity and converts it into virtual impressions. The three primary components of CAD/CAM systems are (i) software for generating virtual restorations and (ii) adjusting all milling settings; and (iii) a computerised milling device that fabricates the restoration from a range of restorative materials. [7] The CAD phase is carried out by the first two components of the system, whereas the CAM phase is handled by the third. Based on their ability to exchange digital data, CAD/CAM systems can be divided into two groups: open and closed.[8] All three components of a CAD/CAM system—software, the milling machine, and data acquisition—are available in closed systems. [3] Scanners, design software, processing tools, milling variations, CAD/CAM processing materials, and future technologies are examples of CAD/CAM components used in dentistry.

Impression taking procedure

Lasers and other optical scanning technologies can be used by dentists to create digital imprints. It is necessary to verify the system software before taking a digital impression. The tooth that has been prepped needs to be dried out and tissue retracted using a gingival retraction cord before digital impression. A thin layer of titanium dioxide is applied to the dried tooth to present distinct spots for scanning, speed up recording, and enhance 3D picture capture (fig 1, 2). The prepared tooth area can be quickly and painlessly scanned. The prepared tooth is scanned from several perspectives, and its neighbouring areas are generated in software. Without the use of traditional impression materials, optical scanning technologies create realistic, machine-generated reconstructions of the hard and soft tissues of the jaw. The impression data is then transferred to software, which uses it to generate an exact digital 3D model of the oral cavity. This ensures that all the necessary data is captured accurately and efficiently. This 3D model can be used to create restorations in a laboratory or on a milling machine, possibly with the aid of a CAD-CAM system. [1,5,8,9]

Digital scanners

Single image/video cameras and lab scanners are examples of intra-oral optical scanners. There are 2 types of laboratory scanners: mechanical and optical. [3] Intraoral scanners employ advanced technologies such as optical coherence tomography and confocal microscopy to obtain precise images of the oral cavity. [5] 3D surface scanners can be divided into two primary groups in practice: contact and non-contact scanners.

Figure 1. Digital scanner

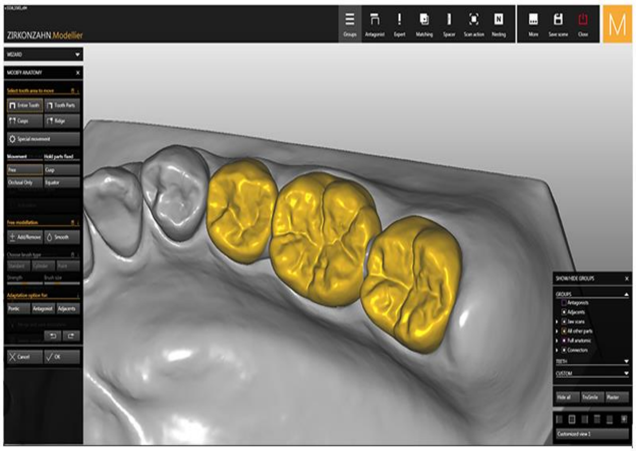

Figure 2. Digital scanning of teeth

a)Contact Scanners: Contact scanners use a probe that makes direct touch with the thing being

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copied. The intended surface is scanned either linearly or radially by the mechanical measurement probe. The probe features a ceramic shaft with a ruby bead at the end. Alumina crown copings are then milled using the 3D data. Eg: procera

b)Non Contact Optical Scanners : Triangulation is a technique used by several 3D laser scanners to create 3D surface images. The object to be scanned is exposed to a laser beam, and an apparatus resembling a camera takes pictures. One can generate laser scans by gradually scanning a location. Non-contact scanners rely on radiation, ultrasonic, and light, which are based on several distinct principles, rather than physical contact. (Table 1). [3] Two types of non contact scanning systems are available in the market:

i. CAD/CAM Systems

Example: The CEREC Acquisition Centre (AC) (Sirona Dental Systems) and E4D Dentist™ system (D4D Technologies) Fig 3.

Figure 3. Sirona Dental Systems

ii. Dedicated Three Dimensional Digital Impression Systems

Example: Lava™ Chairside Oral Scanner C.O.S. (3M ESPE) and the iTero™ system (Cadent). Fig 4

Figure 4. Lava™ Chairside Oral Scanner

Table 1. Available digital impression systems

Digital impression method	Manufacturer
CEREC	Sirona Dental System GmbH (Germany)
iTero	CADENT Ltd (Israel)
DPI-3D	Dimensional Photonics International, Inc. (USA)
Lava™ C.O.S.	Lava Chairside Oral Scanner; 3M ESPE (USA)
\Trios	3SHAPE A/S (Copenhagen, Denmark)
MIA3d™	Densys3D Ltd (Israel)
Plan scan	Planmeca Oy (Finland)
3D Progress	MHT S.p.A. (Italy) and MHT Optic Research AG (Switzerland)
Direct Scan	HINT –ELS GmbH (Germany)
IOS Fast Scan	IOS TECHNOLOGIES, Inc. (USA)
Blue scan	TRON 3D GmbH (Austria)
E4D	D4D Technologies, Llc (USA)
Condor	Remedent Inc. (Belgium)
CS 3500	Carestream Health, Inc. (USA)
Dig Imprint	Steinbichler Optotechnik GmbH (Germany)

Digital impression procedure involves three main production methods [5]

a)Chairside Production: Within the dental office, every component of digital impression system is located. Restorations can be created in the same appointment by using intra-oral cameras in place of traditional impressions. The Cerec® System is an illustration of a chair side system.

***b)Laboratory Production*:** The digital impressions taken in the dental clinic are sent as data file to a dental laboratory where master casts are made. Using milling machines and dental design software prosthesis is prepared.

***c)Centralized Production*:** Using satellite scanners, dental laboratories transmit data to a central production centre using this way. The restorations are made in the centre and then returned to the lab. This method lowers the equipment investment.

Scanners are classified as; i) optical scanners, which use light (laser or white light) for 3D imaging, examples CEREC®, E4D, iTero, and Lava C.O.S and ii) mechanical scanners, which use a ruby ball to mechanically read structures, examples the Procera Scanner by Nobel BioCare.

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Design software: Dental restorations including crowns and FPD frameworks are made using design software. Some systems balance between extensive capabilities and ease of use by using proprietary formats, even if many systems use the STL data format.

Processing devices: Three types of milling devices are used by processing machines to transform design data into physical restorations: 3-axis (like inLab by Sirona, Lava by 3M ESPE), 4-axis (like Zeno by Wieland-Imes), and 5-axis (like Everest Engine by KaVo, HSC Milling Device by etkon).

Milling variants: It consists of wet milling, which is appropriate for metals and glass ceramics, and dry processing for zirconium oxide blanks, which is less expensive but has greater shrinkage. Wet milling also employs a cooling liquid to prevent overheating.

Digital Design and Manufacturing: The restoration is designed in the lab using CAD software, and it is subsequently manufactured with metal alloys, zirconia, and lithium disilicate using CAM machines. [5]

Materials used in CAD/CAM processing: The materials include silica-based ceramics like lithium disilicate infiltration ceramics like Vita In-Ceram variants, metals like titanium and chrome cobalt, and resins for temporary or permanent restorations.

Data Files and Designing [5]

Digital impression systems create two types of data files:

i) **Open architecture files**: They are commonly referred to as STL files, are compatible with a variety of design programs, and are independent of manufacturers. Greater commercial prospects and compatibility with various labs and applications are made possible by this flexibility.

ii) **Closed architecture:** These files, which offer integrated solutions for CAD and CAM from the same manufacturer, are manufacturer-specific. By ensuring compatibility and support, this frequently results in improved accuracy and usability. For example, any CEREC device can send files to a participating Sirona Connect lab via Sirona Connect.

DIFFERENT DIGITAL SCANNING CONCEPTS

Active wave front sampling, parallel confocal, triangulation, and stereophotogrammetry are some of the several scanning concepts that are currently accessible. Active wave front sampling involves rotating a single off-axis aperture around the optical axis. Consequently, the target point image will seem to spin on the image plane. Triangulation is a technique that allows one to estimate the location of a triangle point by knowing the positions and angles of two points. Light is moved up and down in a parallel confocal system to capture images at different depths. [10]

i. CEREC System

CEREC 1 system (Sirona, Bensheim, Germany) is the first intra-oral digital imprint system introduced to market on 1987. The "triangulation of light principle," which centres the junction of three linear light beams on a particular spot in three-dimensional space, serves as the foundation for this technology. The most dependable gadget now available from CEREC is the fourth generation, or CEREC AC Bluecam. An LED blue diode produces a visible blue light type that serves as the image's light source. Wthin one minute, the CEREC AC Bluecam can capture a quadrant image. The preparation can be examined from any angle on a computer monitor once the scanning process is complete. Using a CAD technology called "Bigeneric," an idealised restoration design is produced. Then dentist can modify the restoration using a number of on-screen tools. Using CEREC Connect data can be send to the dental laboratory is an additional option for fabricating the restoration. [3] To construct dental restorations, CEREC 1 paired a milling unit with a three-dimensional (3D) digital scanner. [4]

ii. IOS technologies

IOS consists of a computer, software, and a portable camera. Accurately capturing an object's three-dimensional geometry is the aim. The widely used digital format is called STL (Standard Tessellation Language). Software compiles individual photos or videos taken by the camera under a light projection after identifying POIs (points of interest).[4]

iii. Lava C.O.S. System

In year 2006, an intraoral digital imprint device LavaTM C.O.S. (Lava Chairside Oral Scanner; 3M ESPE, Seefeld, Germany) was launched. This is an intraoral digital imprint device. The active wave front sampling concept serves as the foundation for this technology. Lava C. O. S. produces extremely accurate image quality because of high data redundancy, which is connected to numerous overlapping images. With a width of just 13.2 mm, the Lava C. O. S. offered the tiniest scanner tip. [3]This method collects 3D data from a video sequence and models it in real time by combining image processing algorithms, cutting-edge optical design, and real-time model reconstruction. The teeth seen as brilliant white on the display during the scan and any regions that stay red require additional scanning. [1]

iv. iTero System

iTero released in 2007 by Cadent Inc. (Carstadt, NJ). The iTero technology, which is based on the concept of parallel confocal imaging, takes intraoral surface and contour images via laser and optical scanning. For tooth surfaces, coating with scanning powder is not necessary when using the iTero system for parallel confocal scanning. [3] A light beam from the scanner bounces off the surface of the teeth. Only information that is correctly reflected back through the filtering device at the focal distance is captured. A set of scans from the prepared tooth's occlusal, lingual, facial, mesio-proximal, and disto-proximal angles, as well as extra scans for neighbouring teeth, are requested to be recorded by the operator. Every dentition in opposition is scanned independently. The iTero system is a movable cart with a well-designed configuration that holds a computer, display, mouse, integrated keyboard, foot pedal, and scanning wand. [1]

v. TRIOS system

3Shape (Copenhagen, Denmark) introduced in year 2010 as a new type of intraoral digital impression system. During the scanning procedure, the TRIOS intraoral scanner uses no powder. Because of its straightforward design, which consists solely of a handheld scanner, and its connectivity with various PCs and iPads, the TRIOSR Pod provides greater mobility and versatility.

vi. E4D Dentist

In 2008, D4D Technologies LLC was established in Dallas, Texas. For Dream, Design, and Develop, it is an acronym. To ensure a high-quality product, a protracted beta-testing and fine-tuning stage is involved. It is made up of separate milling equipment, a laser scanner, and a design centre with a computer and monitor on a cart. Using a red laser light, the E4D Dentist IntraOral Digitiser is a single-image camera that records intraoral images. Additionally, it records data that is reflected from both soft and hard tissues. To guarantee that every image is successfully scanned, the software offers real-time feedback on each scan.[1]

Advantage of digital impression over conventional [5,11]

1. Scanning process is quick and non-invasive.
2. Digital impressions not only enhance accuracy but also reduces the time required for both patients and clinicians.
3. The digital data can be immediately transferred to dental laboratories
4. Better communication and collaboration between dental professionals
5. Results in better-fitting prostheses,
6. Enhancing patient comfort and satisfaction
7. Reducing the need for multiple appointments
8. Eliminating discomfort from impression trays.
9. Selective capture of areas, easy to reproduce, and instantaneous visualisation

Disadvantages of digital impression

1. Expensive and need for scanners and software, Complex digital equipment
2. Require significant training.
3. Sensitive to moisture contamination

LIMITATIONS OF DIGITAL IMPRESSION

The intraoral digital imprint has been discovered to have numerous drawbacks. Certain systems require the tooth surface to be sprayed with powder, which could result in an uneven powder layer. Additionally, the scanning accuracy could be impacted by the displacement of the scanner. [3]

COMPARISON BETWEEN CONVENTIONAL AND DIGITAL IMPRESSION

***i.Accuracy*:** By evaluating the die that was made using the impression, accuracy can be determined. The size of the preparation region, the location of the finish line (sub- or supra-gingival), the impression material and technique, the fabrication procedure, and the restorative material are some of the factors that affect the marginal fit. It has long been believed that a marginal fit of 120 m or less is optimal for the clinical effectiveness of full crowns. [3] When compared to conventional impression, the digital version exhibits better impression accuracy and marginal fit.

***ii.Patient Acceptance*:** Patient Acceptanceis evaluated using individualised questionnaires and visual analogue scales (VAS). Evaluation criteria include patient comfort, gag reflex, queasiness, difficulty breathing, pain, perception of time, anxiety, taste irritation, and familiarity with the powdering technique utilised for digital imprints. Patients are more accepting to digital impressions because they are more focused on their comfort. [3] Using the Trios 3 IOS (3 Shape) by VAS and DI, patients' subjective convenience level, anxiety, terrible mouth taste, queasy feeling, pain sensation during impression taking, patients' satisfaction with convenience, and speed were measured. [11,12]Because there is less pain, anxiety, and gag reflex with digital impressions compared to conventional methods, and patient acceptance is good.

Although the accuracy of IOS systems seems promising and equivalent to traditional approaches, Aswani et al. from the review paper noted that they are still prone to errors. [11] According to Chandran et al.'s systemic evaluation, indicating that digital impressions are superior to conventional one. [2] According to Chochlidakis et al., digital impression techniques outperform traditional methods in terms of marginal and internal fit of permanent restorations.[13] Trapti et al concluded that, Digital impression techniques provide a clear advantage over conventional methods in terms of precision, patient experience, and clinical efficiency. [14]

***iii.Operator Preference*:** It is also assessed using a number of factors, including operator perception, working time, and process difficulty. The workflow of the digital impression technique is faster. The intraoral scanner has a lower learning curve and required less handling. [3]

APPLICATIONS OF DIGITAL IMPRESSIONS

1. **Complete Denture:** By taking exact 3D pictures of edentulous arches, digital impressions completely transform the process of making complete dentures. This makes it possible to use CAD software to precisely design the denture foundation and tooth arrangement. Virtual try-ins allows final fit and occlusion changes before to the milling or 3D printing of the actual dentures.
2. **Removable Partial Denture (RPD):** The teeth, dental arches, and edentulous areas are first scanned. After that, the metal structure and prosthetic teeth are designed using CAD software.
3. **Fixed Partial Prosthesis:** Digital impressions offer a high-accuracy scan of the prepared teeth and surrounding tissues for fixed partial prosthesis. Bridges and crowns are designed using this data.
4. **Maxillofacial Prosthesis:** Using CAD software, a digital model of the prosthesis is created from the detailed 3D pictures obtained from the initial scan.
5. **Implant-Supported Prosthesis:** In order to create a full 3D model, digital imprints first scan the areas around implant sites and neighbouring teeth. This information is then combined with CBCT scans.

CONCLUSION

Digital impression gives accurate replica of prepared tooth structure. CAD/CAM technology gives better clinical results and fabrication of dental restorations using digital impressions.. The field of prosthodontics will probably use more digital technology as it develops, which will raise the standard of dental care even further.

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Consent for publication
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