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Review Article

Digital Impression is a future of Dentistry-A Review

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ABSTRACT:

In recent decades, the integration of digital devices into dental practice has become increasingly prevalent. The advent of CAD/CAM technology has enabled the creation of implant-supported restorations through a streamlined digital workflow. Digital impressions serve to convert the intra-oral conditions into a virtual model, marking the initial phase of this digital process. The precision of this step is critical, as it directly influences the success of the overall treatment by ensuring the accurate transfer of the implant's position. Inadequate execution of this procedure can result in a misalignment of the final prosthesis, potentially leading to both mechanical and biological complications over time. Furthermore, digital impressions facilitate a more efficient data collection process, mitigating many of the limitations associated with traditional impression techniques. This advancement not only enhances patient comfort but also increases the reliability of prosthesis design and manufacturing processes.

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INTRODUCTION

In industrialized countries, there has been an improvement in the quality of life, and this has led to a lengthening of the average life, leading to an increase in partial or complete edentulous which requires complex prosthetic rehabilitation.[1] Impressions is simply meaning a negative replica of the hard and soft oral tissues from which a positive reproduction can be achieved.[2]With the introduction of computers and its advancements, it has led the dentistry to its next level. Digital dentistry, in particular, digital impressions have led to significant changes in impression making.[3]The digital method of making impressions has great accuracy and will for sure reduce the necessity for traditional impression methods soon. The data is stored in specific software for further fabrication of restorations or positive replica or any other appliance manufacturing. This also allows the retrieval of data at any given point of time for further analysis and follow-ups[4].

Digital intraoral imaging represents an innovative method that enables the dentist to construct a virtual computer-generated copy of the hard and soft tissues with the use of lasers and other optical scanning machines. This technology of three-dimensional (3D) digitization was introduced in the 1980s. A lot of technological advance-ments have happened which has resulted in the present generation of intraoral scanners. Patients feel these are more comfortable and easier compared to older methods[5]. Thus, the goal of this review article is to provide with adequate knowledge of digital impressions evolved in dentistry and its clinical application

History of Digital Impressions[6]

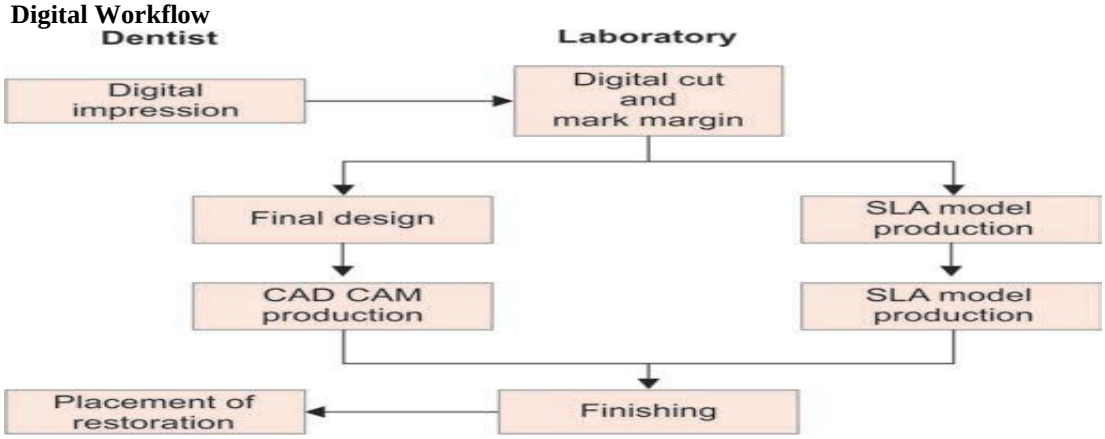
CAD/CAM was first introduced in the field of dentistry by Dr. Duret in 1973. It was later modified and modifications were done by Dr. Mormann, a Swiss Dentist, along with Mr. Brandestini, who was an electrical engineer. The first ever digital system for dental impressions to be commercially available was CEREC. Over the years, many systems such as 3Shape Trios, Cadent iTero, 3M Lava Chairside Oral Scanner (C.O.S.), as well as E4D Dentist have been introduced[6]. CEREC 1 combined a 3-dimensional (3D) digital scanner with a milling unit to create dental restorations from commercially available blocks of ceramic material in a single appointment.

CEREC 1 was designed for the fabrication of ceramic inlays and onlays. Cerec 2, Cerec 3, Cerec 3D were introduced in 1994, 2000 and 2003

CAD/CAM Systems
The introduction of CAD/CAM concepts into dental applications was the brainchild of Dr. Francois Duret [4]

CAD/CAM systems comprise of three main components[8]:
1. A unit for acquiring data, for collecting information of the teeth prepared and the adjacent tissues and later transforms into visual or optical impressions directly or indirectly;
2. Different software will be used for designing the final restorations, which are secured in optical impressions and prepared for the milling.
3. A computerized milling system for the final manufacturing of the restoration of any suitable restorative material.
The first two components of the system are associated in the CAD phase, while the third one is the CAM phase

Digital Workflow



Digital impression machines and technology[9]
There are mainly eight systems available from six different organizations, with three basic systems now in use to create digital impressions,
• Lava chair side oral scanner by 3 m
• CEREC AC by Sirona systems
• The CADENT ITERO system

Various Commercially available Scanning systems[3]
1. ITero
2. Lythos
3. Fast scan
4. Plan scan
5. True definition
6. Trios
7. Carestream CS 3500
8. CEREC

Types, Propositions and Features of Different Digital Systems[10] The main digital impression systems those are available on the market include CEREC, Lava C.O.S. system, iTero, E4D, and TRIOS. They vary from each other in terms of various features such as working principle, light source, the necessity of powder coat spraying, operative process, and output file format.
CEREC System [10]
The CEREC 1 system (Sirona, Bensheim, Germany) was brought to market in 1987 together with the Duret system as the first intraoral digital impression and CAD/CAM device. The principle of this system is designed with the concept of "triangulation of light," where the intersection of three linear light beams is focused on a certain point in 3D space. CEREC AC Blue Cam is the fourth-generation product and currently is the most prevalent CEREC system. LED blue diode is the light source which will emit visible blue light for the image capturing. The CEREC AC Blue Cam can capture one quadrant of the digital impression within 1 minute and the antagonist in a few seconds. In 2012, the latest and newest CEREC system, CEREC AC Omnicam, was brought to market. Bluecam can only be applied for a single tooth while Omnicam can be used for a single tooth, quadrant, or full arch

Lava chair side oral scanner by 3 m

CEREC AC by Sirona systems

CADENT ITERO

Lava C.O.S. system [11]Lava TM C.O.S. (Lava Chairside Oral Scanner; 3M ESPE, Seefeld, Germany) is an intraoral digital impression device invented in 2006 and brought to market in 2008. The principle on which it works is active wavefront sampling. Single-lens imaging system is used to obtain the 3D data under active wavefront sampling. Three sensors are used to capture clinical images from different angles simultaneously such as to develop surface patches with in focus and out-of-focus data by proprietary image-processing algorithms. The Lava C.O.S. has the smallest scanner tip—only 13.2- mm wide. The scanner sends out pulsating visible blue light as light source and they work with a mobile host computer and a touch-screen display. In most cases, supporting CAD software and CAM device are used for designing and manufacturing of data proprietary files exported by Lava C.O.S.

iTero system[11] Cadent Inc (Carstadt, NJ) introduced iTero to the market in 2007. They work on the principle of parallel confocal imaging; the iTero system captures intraoral images and contours them by laser and visual scanning. Coating of teeth with scanning powder is not recommended in this system, it can capture all the structures in mouth without any use of coating powder. Red laser is used as a light source in this system and further it consists of a host computer, a mouse, a keyboard, a screen, and a scanner. iTero is an open system in the treatment of crowns, FPDs, veneers, implants, aligners, and retainers. Digital image files are sent as an STL format, which can be shared by any other lab equipped with a CAD/CAM system.

E4D system[12] The E4D system was developed by D4D Technologies, LLC (Richardson, TX). It works under the principle of optical coherence tomography and confocal microscopy. Micro mirrors and red laser are used as a light source to vibrate 20,000 cycles per second. E4D's are having high-speed laser those formulates a digital impression of the prepared and proximal teeth such as to create an interactive 3D image. The images are obtained in every angle with the laser technology. The software will compile all the images. The image library can wrap around a precise virtual model in seconds. This system also functions as a powder-free intraoral scanning device. The E4D system can work with a chairside-milling device just like CEREC AC Bluecam and Omnicam systems. That means this system can also function as a "single-visit treatment" and provide high-strength ceramic prostheses or composite even for minimally prepared teeth

TRIOS system[13] A new type of intraoral digital impression system, TRIOS, was introduced in 2010. This system works under the principle of ultrafast optical sectioning and confocal microscopy. They maintain a fixed spatial relation of the scanner and the object being scanned and recognizes variations in focal plane of the pattern over a range of focus plane. Moreover, they have a quick scanning speed of up to 3000 images per second thereby reducing the influence of relative movement between scanner probe and teeth. Similar to the iTero and E4D systems, the TRIOS intraoral scanner is a powder-free device in the scanning process. TRIOS include two parts: TRIOSR Cart and TRIOSR Pod. The TRIOSR Pod is having a handheld scanner which offers better flexibility and mobility, so due to its simple construction it is compatible with other computers and iPad also.

Advantages of Conventional Impressions[4]
1. The technique is well known and acceptable
2. Simple equipment needed
3. Cost ranges from low-to-moderate
4. Known accuracy
5. Relatively simple and predictable clinical technique.

Disadvantages of Conventional Impressions[4]
1. Creates mess
2. Discomfort for the patient
3. Air bubbles or debris cause inaccuracies
4. Stocking the materials and trays.

Advantages of Digital Impressions [14]
1. Comparative accuracy with conventional impressions
2. Simpler to use after a period of learning
3. Eliminates the mess
4. Discomfort for patient is reduced
5. Eliminates the need for stocking materials and trays
6. Need for disinfection eliminated
7. No risk of cross infection
8. Easy transfer to laboratory
9. Eliminates the need to articulate the casts
10. Tasks of pouring the impression, making the base, and trimming are eliminated
11. Long-term storage of data.

Disadvantages of Digital Impressions [14]
1. Lack of dentist’s familiarity with the concept
2. Complex digital equipment
3. High initial cost of purchase.

Classification of the scanners[5]

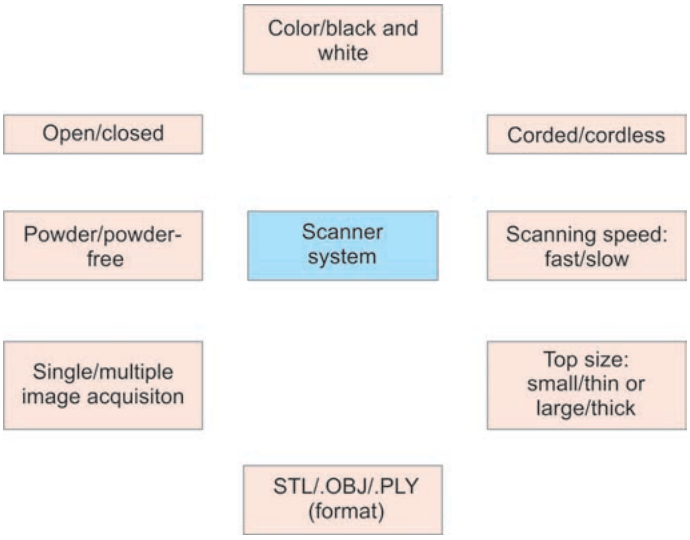
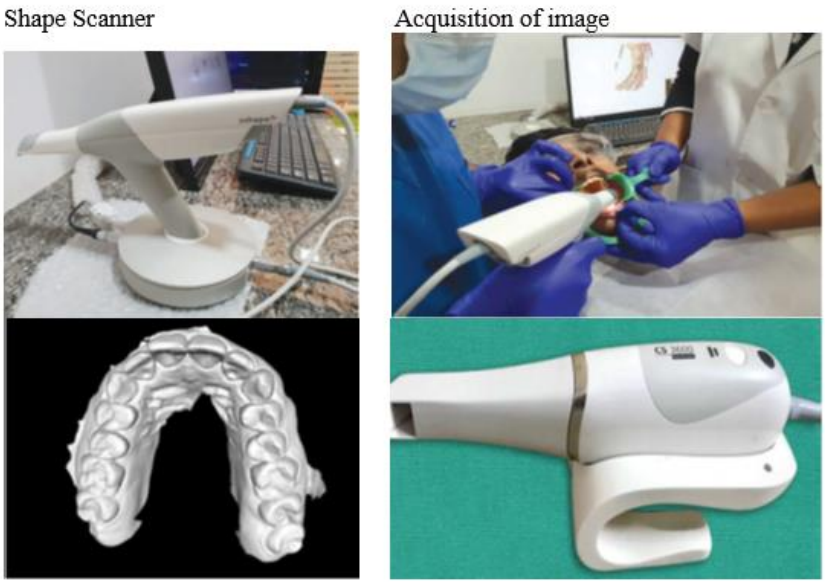


Table 1: Comparing the 3 scanner systems.[4]

Features	Cadent iTero	3 MLava C.O.S.	Sirona Cerec AC
Optical Technology	Parallel Confocal/Tele centric	Wave front Sampling Technology (3D in Motion)	LED/Laser Sampling
Powder Required	No	Yes	Yes/opti spray
Focal Depth	13.5 mm 1:1 exact focus	Range from 5 to 15mm	Range from 5 to 15mm
Indications	All	Up to 4UB, and singles	All
Models	Milled/Polyurethane. Removable dies, soft tissue profile	Additive/SLA in blue resin. One solid model and one working model.	Additive/SLA; no tissue
Data Import/Export for Digital Interface	Major CAD front end systems - Dental Wings, 3 Shape, CEREC In-Lab, Standard STL Binary File.	LAVA	Cerec Connect
Articulator	All directions, attachment system to Whip Mix full articulator for complex cases	Articulated; centric and lateral excursions	Hinge-only

Planscan (Planmeca, USA) [5]
This scanner is a powder-free system which uses blue laser technology. The scanner is supplied with a USB port that can be connected to laptops. Offers an open system where files can be exported to other systems for milling. The system also provides software to design and a milling device.

CS 3600 (Carestream, United States) [5]
This scanner works on the principle of triangulation with high-definition 3D colour. The device is a powder-free system and an open system available in USB version, where the data can be sent to any other milling device



Digital impression acquired CS 3600 scanner from Carestream

Chairside Digital Impression vs. In-Office CAD/CAM Systems [15]

Digital systems used in the dental office are of two types: digital impression systems and in-office CAD/CAM systems. Capturing a digital impression is the first step in all these Systems.

Digital impression systems use digital scans, thus eliminating need for an impression. The digital image of the prepared tooth is recorded intraorally with a scanner wand, thereby eliminating the need for any impression material to make an impression, disinfection, and pouring the cast. After scanning, the dentist can review the digital image to confirm that the required areas are captured and sufficient occlusal clearance can be check. Digital impressions have advantages like an instant revision of the preparation done, can be viewed at considerably larger magnification. If the problem persists with the scanned images, the dentist can rescan after making necessary corrections. The data can be electronically transmitted to a dental lab along with instructions once the dentist is satisfied with the prepared tooth and scanned digital images.

Digital impressions can be used to fabricate any type of restorations, from inlays to all ceramic crowns. The dental laboratory or its manufacturing partner receives the scanned images, later utilizes a specialized software to identify the margins of the prepared tooth, then digitally marks and does die trimming. A 3-dimensional (3D) printed or milled model is obtained by the laboratory, which can be used for fabricating the desired restorations. Restorations can be fabricated on these models using both digital and traditional methods. The laboratories can also use the digital impressions, and monolithic pressed or milled restorations to produce model-less restorations, which reduce the turnaround time for laboratories

Chairside CAD/CAM

CAD/CAM for chairside use comprises of both a scanner and a mill for fabricating a restoration. The dentist can use these systems for in-office scanning, designing, and milling a full-contour restoration. The dentist can fabricate the chairside restoration using the CAD/CAM system software rather than electronically sending the data to a dental laboratory. The software also contains multiple tools for modification of the proposed restoration. These tools can also be used for adjustment of the interproximal contacts, occlusion, height of contour and other features. The restorations can be customized based on the material by using stains, glazing, and firing in a porcelain oven, thereby providing the clinician more control and freedom. Cementation of the final restoration can be done on the same day thereby, reducing the number of appointments. Patient respond positively to these types of systems as temporary restorations are not required and number of appointments are less.

Open vs. Closed Architecture [16]

Digital impression systems can be grouped into two categories based on data files created during scanning: open and closed architecture. Open-architecture files are STL files. These types of files can be used in any software design for final restoration fabrication and are not dependent on the manufacturer. With open-architecture systems; dentists, can work with different laboratories and capitalize on their investments. Open architecture creates more business opportunities for laboratories that can customize the configurations. The laboratory can become an outsourcing partner for other laboratories or choose to assimilate with newer CAD software.

In Closed-system architecture, same manufacturer does data collection and manipulation of data modules. The CAD and CAM configurations are controlled by a single company, which is aware of the performance capacity and specifications of the milling unit and can adapt the CAD and CAM software accordingly. Closed-architecture systems are ideal for laboratories that do not want to indulge in all newer technologies and software from each different manufacturer. The production process from scanning, designing to milling is done by a single manufacturer.

Concerns with Digital Impressions[4]

1. The digital impressions are as sensitive to moisture contamination as traditional impression materials. Blood and saliva obscure the surface of the tooth or margin from the camera and prevents an accurate recording. At best, the camera records the moisture as an inaccurate surface contour; at worst, no data are recorded where moisture has been collected. In either situation, an accurate restoration cannot be fabricated

2. Inadequate management and retraction of soft tissues may prevent visualization of the marginal areas, resulting in an inaccurate recording with the camera. Soft-tissue retraction is somewhat different for digital impressions compared to traditional impressions. Traditional impressions generally require that soft tissues be retracted laterally as well as vertically past the tooth preparation margins. The lateral soft-tissue retraction allows for a bulk of impression material at the margin to avoid tearing it upon removal. The vertical soft tissue retraction allows for impressing tooth structure cervical to the margin to ensure the margin is accurately recorded. Digital impressions only require the soft tissues to be retracted sufficiently laterally to visualize the margins. This may be as little as 150 μm to register the margin of the tooth preparation separately from the soft tissues. This is primary reason diode lasers are particularly popular adjunctive instruments for digital impressions, as they efficiently create lateral retraction while preventing bleeding and ensuring a dry field of view.

3. A general concern expressed by those unfamiliar with digital impression systems is the amount of time taken to make a digital impression compared to a traditional impression.

Future[17]

Digital devices are here to stay and only increase in use soon. The growing technology about hard and software will make these equipment's affordable. The impression wand and the units will get smaller and more user-friendly. The rate of scanning and producing an accurate image will make the machines more successful. An open platform interface may be developed to export and integrate with other imaging modalities like cone beam computed tomography (CBCT) and facial scanners. These files can then be combined and used for diagnosis, treatment planning, and 3D printing to create life-sized analog. The applications of these technologies are voluminous and for sure occupy our majority of day-to-day clinical practice. Machines that acquire data may be developed with other optical hand-sonic systems. Scanning devices of the future should be able to differentiate between hard and soft tissues and blood and saliva and be able to take rapid and accurate images.

CONCLUSION

Digital dentistry is changing the way in which clinicians can provide indirect restorations which are highly precise restorations and accurate models. This increases the chair side productivity with improved lab communication. All materials and technique developed in dentistry always aim to reduce the technique sensitivity and improve patient comfort with predictable accuracy. Intraoral digital scanners have come a long way, the clinician acceptance and usage now become essential to make this digital workflow a success. With a lot of advantages, there are also quite a few drawbacks as discussed in this article. It is also vivid that traditional impressions will stay for certain indications. For digital impressions to become a routine procedure the purchase of the equipment and the initial learning curve are the primary requisites. But for sure the future is digital dentistry.

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