



Review Article

Digital impressions in prosthodontics – past, present and future trends

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ABSTRACT

Recording of the basal seat and surrounding teeth accurately is an important task in dentistry. It is done previously by conventional impression materials like alginate, agar, elastomeric impression materials, due to its drawbacks like gagging, unpleasant taste etc. newer methods like digital impressions and digital scanners had evolved. Digital scanners include a computer display and a hand held wand with a camera to capture the intraoral images in three dimensions. Digital impressions are more accurate, time saving and increases the comfort of patient compared to conventional impressions.

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1. Introduction

With the introduction of computers and its advancements, it has led the dentistry to its next level.¹ Digital dentistry, in particular, digital impressions have led to significant changes in impression making.

During past decades, conventional impression techniques have been used to register the teeth and surrounding soft tissues. But there were certain drawbacks like volumetric changes in impression materials, expansion of gypsum products etc., which sometimes necessitates remake which consumes energy and expenditure.^{2–4} To get over these difficulties, Intraoral scanner (IOS) was developed in the field of dentistry.⁵

Currently, the combination of IOS and CAD/CAM have provided ease for laboratory communication, reduced chair-side operator time, easier treatment planning, acceptance of case and final reduction in time of treatment.^{6–8}

1.1. History and Evolution of digital impression systems

Fabrication of models from impressions had been there since 18th century.^{9,10} In 1856 Dr. Charles Stent⁹ used an impression material for fabrication of device under his name for correction of oral deformities. Sears¹¹ introduced agar-impression material for crowns. Impregum – 1st polyether elastomeric material was introduced by ESPE in 1965.¹²

Condensation Silicone was developed but the drawbacks were dimensional inaccuracy. With the advent of Polyvinyl Siloxane it solved many of the problems like modulus of elasticity, dimensional accuracy, tear strength, poor odor, taste and superior flow.¹²

CAD/CAM (Computer Aided Design/Computer Assisted Manufacturing) had been used since 1960's in the manufacture of airplanes and automobiles. The First application of CAD/CAM in dentistry was by Dr. Francois Duret in 1970's in his thesis "Optical Impression". In 1984, Duret invented and patented a CAD/CAM device and illustrated the crown fabrication in 4 hours. At the same time, Dr. Mormann and Dr. Brandestini originated, the first profit oriented digital impression system the CEREC1, in 1985.¹³

CEREC 1 combined a 3-dimensional (3D) digital scanner with a milling unit to create dental restorations

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from commercially available blocks of ceramic material in a single appointment. CEREC 1 was designed for the fabrication of ceramic inlays and Onlays. Dr. Mormann also licensed today Sirona Systems. Cerec 2, cerec 3, cerec 3D were introduced in 1994, 2000 and 2003.¹²

1.2. Conventional vs Digital Impressions

Abutment – tray selection – gingival retraction – impression – disinfection – laboratory shipping – cast pouring – restoration fabrication¹⁴

Abutment – gingival retraction – scanning – digital transfer of impression to lab – digital designing – restoration fabrication¹⁴

1.3. IOS technologies

IOS is composed of a camera that is handheld, computer and software. The goal is to record three-dimensional geometry of an object with precision. STL(Standard Tessellation Language) is the extensively used digital format. Other formats include PLY files, Polygon File Format. Regardless of imaging technology used by IOS. After identification of POI (point of interest) software assembles individual images or videos recorded by the camera under a light projection.¹⁵

Light Capture and Projection: In 3d reconstruction field there are two techniques. Active and Passive techniques, Active techniques involve Triangulation a procedure and uses red, white or blue light for real texture and color of tissues for reconstruction by projecting the light from the camera onto an object. Intraoral tissues are illuminated only by ambient light and reliant to a certain level of the texture of the object in passive technique.^{16,17}

Laser Confocal microscopy Scanning: It is a microscopic technique for scanning 3-dimensional objects by fluorescent microscopy. Marvin Minsky in 1957 introduced the basic principle in confocal scanning.¹⁴

Optic triangulation: It is a method of measuring object to the distance without touching them in microns to millimeters.¹⁴

Optical coherence tomography: It uses light instead of sound, and it is similar to ultrasound imaging.¹⁴

Active Wavefront Sampling (AWS): Active wavefront sampling (AWS) is a surface imaging technique, which uses only a single camera and optical path.¹⁴

Various Commercially available Scanning systems

1. iTero
2. Lythos
3. Fast scan
4. Plan scan
5. True definition
6. Trios
7. Carestream CS 3500
8. CEREC

1.4. iTero

Cadent inaugurated iTero in 2007 later it is obtained by Align Technology, Inc in 2011. It utilizes Confocal parallel scanning microscopy principle.¹⁸

1.4.1. Accessories

Computer monitor, scanner wand, mouse, foot pedal, keyboard and a mobile cart. Wand is bulky and large and in order to prevent cross-contamination disposable sleeves are used to cover the wand during the scanning procedure.

1.4.2. Procedure

Quadrant wise scanning is done by holding wand at 45 degree angle to the margin of gingiva starting at most distal of left lower buccal quadrant moving mesially recording both buccal and occlusal landscape. The same procedure is redone on the lingual side starting with the lower left lingual quadrant. The total time is 15 minutes.¹⁹

Recent advancements: Various scanners released by Align Technologies include¹⁹:

- iTero HD 2.9
- iTero Element
- iTero Element flex
- iTero Element 2
- iTero Element 5D

1.5. Lythos

Ormco Corporation inaugurated Lythos in 2013. It utilized Accordion Fringe Interferometry principle, specially designed for Orthodontic purpose.²⁰

1.5.1. Accessories

It is portable, with a touch screen, small well-designed wand, wireless internet connectivity and a disposable tip.¹⁴

1.5.2. Procedure

Scan is started by Pointing wand tip on the occlusal surface and moving from left to right of lower arch followed by upper arch.¹⁸

1.6. Fast Scan

Glidewell laboratories, IOS Technologies inaugurated Fast Scan in 2010. It utilizes the active triangulation principle.¹⁶

1.6.1. Accessories

It is portable, with a touch screen and a large scanning wand. Procedure: In this system, the camera is moved along with the wand, and the wand is held in three positions (buccal, lingual and occlusal) to scan the full arch.¹⁴

1.7. Plan scan

E4D Technologies (Richardson) introduced PlanScan in 2008. It utilizes Optical Coherent Tomography principle.¹⁶

1.7.1. Accessories

It has three removable tips, a cradle and a power cable. Planmeca software is used for data process and analysis.¹⁸

1.8. True definition

3M ESPE inaugurated True definition scanner in 2013. It utilized 3D in-motion video imaging technology.¹⁸

1.8.1. Accessories

It consists of a touchscreen display, powder dispenser, lightweight metal wand, wireless internet connection.

1.8.2. Procedure

Scanning is begun with the posterior occlusal surface of the first premolar. The scan was done in sextants, moving from lingual to buccal and finishing back on occlusal.²¹

1.9. Trios

3Shape inaugurated Trios in 2010. It utilizes confocal microscopy principle.¹⁶

1.9.1. Accessories

It is available as TRIOS Cart which has smart multiscreen with 3D visualization and Wifi connectivity, TRIOS Chair integration with USB connection to computer display (laptop), computer screen, autoclavable tip, and anti fog heater. It can auto fill the missing areas.²²

Recent advancements:²²

- TRIOS 3 basic
- TRIOS 3
- TRIOS 4

1.10. CS 3500

Care stream Dental inaugurated CS 3500 in 2013. It utilizes confocal microscopy principle.¹⁶

1.10.1. Accessories

It is portable, without trolley, USB connection and consists of a wand. It requires no external heater to prevent fogging. Two scanning tips are present for adults and children.¹⁶

Procedure

Angulation of scan can be up to 45 degrees and depth upto 16mm.¹⁸

1.11. CEREC and Apollo systems

Sirona Dental System introduced CEREC in 1987. It utilizes Active Triangulation and Confocal Microscopy

principle.^{23,24}

Accessories: Currently three digital systems are available which include

- CEREC Omnicam
- CEREC Bluecam
- Apollo DI

CEREC Omnicam produces full arch and half arch impressions with full color, 3D and 2D images. It has a small camera tip, handpiece with a rounded camera tube. The clearance between scanner and tooth must be 0 to 15 mm.¹⁶

CEREC Bluecam has a blue light-emitting diode for detail capturing. It can be used for scanning full jaw, quadrant and a single tooth. The camera is placed directly over the tooth.¹⁶

Apollo DI utilizes Apollo DI software and Apollo DI intraoral camera. These scans are black and white and the camera is moved 2-20mm over the tooth surface during scanning.¹⁶

1.12. Advantages

Minimizes discomfort: Digital impressions by IOS minimize the transient discomfort by the placement of impression materials and trays in the patient mouth.²⁵ It terminates the use of impression trays, materials, etc. As per literature reports patients opt to optical impressions rather than conventional impressions.²⁶

Time-saving: Through the scanning of the patient's soft and hard tissues chairside time is reduced. Time-consuming procedures like pouring the casts etc. are eliminated.²⁷

Easier workflow: Procedure of impression is simplified for complex cases for example severe undercuts, multiple implants which enable conventional impression procedure difficult, and the procedure for repeating the impression is easier without remaking the entire procedure.^{28,29}

Communication with Laboratory Personnel: IOS enables the clinician to communicate with the laboratory personnel instantaneously after the scan, if the laboratory personnel is not satisfied clinician can make an instant remake of the scan without a second appointment for the patient.^{25,28,29}

Improved Patient relationship: With the advent of IOS the relationship between the clinician and the patient was improved and the patient is more involved in the workflow and has a positive outcome on overall treatment.^{25,28,29}

1.13. Disadvantages

Sub-gingival margin detection: There was a problem of detection of deeply placed gingival margins and also IOS scanning is a little bit troublesome in case of bleeding as it may conceal the prosthetic margins and makes the scan inaccurate.³⁰ IOS cannot displace the soft tissue margins and cannot register dynamic tissue relationships.³¹

Learning Curve: Learning Curve adaptation for IOS is difficult for Older Clinicians with less desire and experience with computers and technology. Also, it is important to note that there is a debate on which scanning technology is better than the other, as there was little information provided by the manufacturer.³²

Cost-sensitive: The initial purchase costs of IOS are very high, even after the release of many new models into the market.^{25,30}

Also, additional managing costs like software up-gradation, etc were also present. In addition to the above, the laboratory personnel also must be familiar with digital workflow.^{25,30}

2. Clinical Implications

IOS is utilized in various fields of dentistry.

In Prosthodontics to make impressions of prepared tooth for inlays, onlays, single crowns which include zirconia, lithium disilicate, a framework for fixed partial dentures, provisional restorations for fixed bridges and implants, Partial removable dentures, Post and Core, Digital Smile Design, Obturators, Surgical guide for placement of implants. IOS is not indicated for long-span fixed partial dentures or fixed full arches, long span implant-supported fixed partial or full arches and Completely removable Prosthesis.³³

In Orthodontics for diagnosis and treatment planning, aligner fabrication and in Invisalign system.³³

3. Conclusion

IOS have many advantages over conventional impression procedure, they improve patient as well as operator comfort, reduces the number of visits and improves practice efficiency of the operator. Due to its undeniable benefits, intraoral scanning will be a routine dental procedure in the near future era.

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None.

5. Conflict of Interest

None.

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