Digital impression – A Review.

Devikaa T.C, Priyanka Kumari, Shubhanshi Omar, Honey Jaiswal
Post Graduate Student, Department of Prosthodontics Crown & Bridge, Rama Dental College Hospital & Research Centre, Kanpur, Uttar Pradesh, India

Abstract
Dentistry has witnessed tremendous advancements in all its branches and newer devices have been continuously introduced in the practice. Digital impressions by intraoral scanning (IOS) have become an increasingly popular alternative to conventional impressions. They provide a 3D visualization of entire dentition in high resolution and creating record of hard and soft tissue to monitor oral diseases and condition. Impressions using scanners are more accurate, time efficient, decrease the patient's discomfort and make clinical procedures easier as compared to conventional technique. Intraoral scanning is regularly used by dentists and laboratories to design and fabricate esthetic and durable restorations while retaining maximum tooth structure, its use among dental infancy. CAD/CAM images can be used as a visual aid to improve self-care by demonstrating the health of a patient's oral cavity. A literature search was done to extract the studies on the advantages of digital impression over conventional impression, limitations of digital impression and recent advancements in intraoral scanners. After exclusion and inclusion criteria 30 articles were included for this narrative review. This article is a review of digital impression techniques over conventional impression techniques with different types of scanner and its key features.

Keyword: Digital, digital impression, conventional impression, scanner, virtual

Address of correspondence: T.C.Devikaa, Department of Prosthodontics Crown & Bridge, Rama Dental College Hospital & Research Centre, Kanpur, Uttar Pradesh, India
Email- devikaavineeth0021@gmail.com **Contact-** 9176063036. **DOI:** 10.5281/zenodo.5205375
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Introduction

Dental impression is a only procedure that records the oral tissues which are used for diagnostic purpose, treatment planning and prosthesis fabrication.[1] Conventional impression has been used for many decades, it is associated with material preparation, increased chairside time, patient discomfort, laboratory preparation and risk of infection. Digital impressions were introduced in dentistry in mid 1980s. [1]

Intraoral Scanners provide 3D visualization of real time intraoral images. The working principle of intraoral scanners include triangulation of light, active wavefront sampling, confocal imaging. The scanned images are processed into digital data and reflected as virtual model which is then transferred as stereolithography format (STL) and designed in CAD software and milled in CAM software.[4]

Intraoral scanner reduce the clinic time, enhance patient comfort and allow for visualizing the adequacy of the impression immediately, also minimize the material wastage and the ongoing cost. The intraoral scanner is composed of a handheld camera, computer, and software. The most widely used digital format is the open Standard Tessellation Language (STL) or locked STL-like. This format is a succession of triangulated surfaces in which each triangle is defined by three points and a normal surface. This technique uses a timed laser light directed at the structure and then reflected back to the camera where the data are captured and recorded.[4]

Another type of intraoral scanner is parallel confocal imaging. This technique is based on acquisition of focused and defocused images from selected depths. Parallel confocal imaging can detect the sharpness of an area to infer distance to the object that is associated with the focal length of the lens. [7]A tooth can then be reconstructed by consecutive images taken at different focuses and from altered angles around the object, allowing the clinician to directly place the handheld scanner on the tooth and increase stability. The sharpness of the area being scanned is directly related to the dexterity of the clinician, creating distortion and blur if the handheld scanner is not held appropriately.[8]

The scanned model will remain virtual and they have the advantage of transfer. The dimensions of the impression may remain precise and prosthesis fabrication will have a accurate fit. The digital workflow can be used in all fields of dentistry including maxillofacial, implants and restorative dentistry[9]. The old generation intraoral scanner has limited scanning range and use powder application for opacification, the latest scanner has a wide scanning range and can be used for full mouth cases. They have a open and closed system. Digital impression is a huge advancement especially in this pandemic era where risk of exposure to infection should be avoided[9]

Search strategy:

A literature search was conducted in pubmed, embasse, google scholar using the key words digital impression, intraoral scanners, virtual, trueness, precision and using the Boolean operator intraoral and digitization, tooth or teeth, scan or digitization or digital impression. Articles were obtained on applying the inclusion and exclusion criteria. Additional articles were retrieved from google scholar by combining intraoral scanner, digitization, conventional impression (Table 1 and 2).

Digital impression vs Conventional impression

Single tooth scanning- Studies have revealed that digital impression has been more accurate when compared to conventional technique in single tooth scanning but in case of detection of deep margin lines, subgingival margin preparation, bleeding there were seen some significant errors in reproducing the surface anatomy at the finish line region[2]. The scanning in these regions are difficult due to accumulation of blood and presence of gingiva over subgingival finish line, hence light transmission is obscured which result in incomplete scanning[2]

Quadrant arch scanning- Digital impression tend to show some deviation when the scanning span increases. In scenarios when the total occlusal convergence angle of the tooth decreases there is shown some significant errors in scanning.[4] In short span bridges accuracy of digital impression is comparable and tend to be more accurate than conventional impression but in case of tight interproximal contact, steeper surfaces of teeth, gingival surfaces digital impressions showed greater amount of inaccuracies. In 4 unit bridges digital impression showed very high accuracy in terms of trueness or precision when compared to conventional impressions.[2]

Whole arch scanning- Digital impression showed deviation in the posterior region when scanning the whole arch. The anterior segment shows less deviation when compared to posterior region.[2] In case of crowding or inclination scanning resulted in inaccuracies, especially when there is pooling of saliva or metallic restoration due reflection of emitted light from the surface.[2]

Advantages of digital impression:

Digital impression has a lot of advantages in many factors when compared to conventional impression. [12] It increases patient comfort, reduced working time and provide hassle free treatment. Since no impression material is placed in the patient's mouth, there is no issue of gagging and patient comfort is also increased, there is no worry of distortion of the material on removal. Once the dentist has learned to use the scanner, the impression can be taken in few minutes.

Accurate reproduction of surface anatomy and morphology is very important for the fabrication of prosthesis, digital impression reduces the burden on the operator and chairside time is also reduced. The newer technology enables us to replicate anatomy, morphology and even replicate the natural colour of the dentition.[14]

Impression tray must be sterilised and even the impression has to disinfectant on removal from patient mouth which even cause dimensional stability to the impression if immersed in the disinfectant solution for a longer duration. When impressions are made using intraoral scanner such problems are avoided and there is reduced risk to the operator and to the patient.

Digital impression provide us real time visualisation of 3D images, hence with reduced time and effort the impression can be rescanned or corrected. In conventional impression models have to be fabricated to check for any inaccuracies in the impression.[13] Impression made by intraoral scanner can be archived and saved for future references, unlike conventional impression cast/models need not have to be stored. Some intraoral scanners have cloud based technology hence enable to share the impression with the third party if needed.[13]

Real time visualisation of 3D images enables a proper treatment planning of the clinical scenario in terms of abutment evaluation, calculating interarch space, pontic evaluation, evaluating functional and morphological design of the restoration, hence promising results can be achieved without any impression or fabrication of diagnostic models.[7] Merging the intraoral impression with the CT scan helps us in a comprehensive treatment planning for implants and maxillofacial reconstruction which enables proper treatment planning, virtual matching of natural colour tone of gingiva and tooth, helps in shade matching and determine the prognosis of the treatment. Digital impression can be used as search tool in disaster management for identifying the missing persons and in can also be used in forensic purposes for identification of the victim.[2,4,7]

Sterilisation of intraoral scanners:

When compared to conventional impression, intraoral scanner provide less exposure to pathogens by avoiding direct contact with the impression, pouring the cast and packaging the material. According to CDC classification, intraoral scanners have non-critical and semi-critical surfaces. The scanning wand, touch screen, and base are non-critical surface, disposable sleeves or tips which cover the sensor are semi-critical surfaces. All the non-critical surfaces can be cleaned with a disinfectant liquid that is approved by EPA. The non-critical surfaces must be cleaned first and then wiped with a guaze dipped in the disinfectant or cleaned with a premoistened disinfectant wipe.[17,18]

The semi-critical surfaces come into contact with oral cavity can be sterilised by using a autoclave or by using disposable sleeves or tips. Initially the sleeves are cleaned with soap water thoroughly and dried using a linen free paper towel and then autoclaved. Most of the scanner tips are removable, hence they can be autoclaved and reused. After

sterilisation, it is inspected for any damage or scratches, if in case any they should be discarded. It is also advisable to refer to the instructor's manual for disinfection protocol.[16,17,18]

Conclusion:

Within the limitations of this review, it appears that, digital imaging is one of the crucial step for diagnostic purposes and short-span scanning. The accuracy of IOS systems is superior when compared to the accuracy of conventional impressions. Studies have shown that intraoral digital scanners are becoming integral of modern dentistry. Rescanning are quick, easy and inexpensive. Since the different IOS systems appear to have the potential to provide an outcome of superior accuracy without any statistically significant difference, no preference for a particular system can be made. Patient as well as operator prefers digital impression technique with higher level of acceptance and satisfaction.

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Table 1

Inclusion criteria	**Exclusion criteria**
Last 10 years articles	Articles involving use of digital impressions in used as a surgical guide
Articles with numerous citations	Articles emphasizing more on digital impression usage in other fields other than dentistry.
Studies evaluating digital impression over conventional impression	Articles that does not have much citations

Table 2

Scanner	Company	Working principle	Scanning mode	Key features	indications
Cerec bluecam	Sirona bensheim, Germany (1985)	Triangulation of light	Short wavelength blue light emitting diode photography technology with titanium oxide powder coating	Powder application helps in light dispersion and produce accurate images	Single tooth /single quadrant
Cerec omnicam	Dentsply sirona Germany	Triangulation of light	Three dimensional images with real colour with real time videophotometry technology	3D images with natural colour and chairside milling unit	Fabrication of single crown, inlay, onlay, implant abutment and Scanning of scan body
Cerec primescan	Dentsply sirona Germany	Triangulation of light	Scanning depth upto 20 mm with photorealiastic scanning and artificial intelligence	Higher scanning speed, increase scanning depth hence subgingival preparation can be scanned with greater accuracy	Full arch scanning, subgingival preparations

Shape trios	3shape, copenhagen, Denmark	Ultrafast optical sectioning and confocal microscopy	Video-photometry with red laser light	Telecentricity and Scanning speed of 3000 images per second	3D profile of soft tissue and hard tissue,
Planscan 2015	Planmeca, driven by E4D Technologies		Blue laser light with real time video streaming technology	Removable scanner tip with built in heater, captures hard and soft tissue of various translucencies	Inlays, onlays, crown and bridges
Lava COS	3M ESPE, seefeld, Germany	Active wavefront sampling	Continuous 3D video imaging in motion	Replication of finish line, automatic bite registration	Fixed partial denture cases
IOS Fastscan 2015	IOS technologies	Active triangulation	Camera moves with the wand, sheet of light sweeps across the surface of teeth which projects as 3D real time image	Eliminates hand movement distortion, depth of focus and surface resolution is good	Monolithic and IPS EMAX crown and bridge
3D Progress 2015	MHT (Medical High Technologies) S.p.A (IT) and created by MHT Optic Research AG (CH)	Confocal microscope principle with Moire effect	Internal accelerometer helps to rotate, zoom the 3D scanned model	Smart pixel sensor, real time automatic stitching, special optical system to reach the end of jaws	Full arch, single tooth scan, implant abutment scanning (powder coating required)
Bluescan-I	Austrian research institute	Active stereoscopic vision principle	Two video cameras that record stereoscopic 3D images	Anti-fogging, Anti shake protection, smallest scanner, USB connection	Reduced mouth opening scenarios, posterior tooth scanning
Cara i500 2018	Kulzer in partnership with Medit	Cloud based workflow management	Two high speed cameras, video based scan, open system	High resolution coloured scan, integrated cloud system (data exchange easier)	Single custom abutment, veneer, 3 to 5 unit implant bridge, implant guide
Condor	Remedent Inc.	Cloud based workflow technology		Compare panaromic x-ray with intraoral scanner, hyper realistic colours, disinfectable and small handpiece, detection of margin line	Full arch, inlay, onlay, crowns and bridges, reduced mouth opening scenario