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Intraoral scanners – An overview

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ABSTRACT

Background

Common impression materials used in Fixed Prosthodontics like polyether and polyvinvlsiloxane have excellent dimensional stability, but many factors like temperature, surface wettability of gypsum products and disinfection procedures may result in material distortion and affect accuracy of the prosthesis. In the conventional CAD-CAM technique, the impressions have to be poured in gypsum and the models obtained sent to the labs where these stone models are scanned with an extra oral scanner and prosthesis fabricated. An improvement to this became possible when intraoral scanners were introduced which could directly scan the hard and soft tissues inside the oral cavity to obtain a completely digital impression. ManyIntraoral scanners are available now. Some Intraoral scanners need a powder of titanium dioxide or magnesium oxide to eliminate reflection while scanning the target area while others do not .The intraoral scanners project a light source on the target area. The images obtained are processed by software and a 3D model is obtained. There are different principles on which different scanners work.

Aim

Digital dentistry has created a paradigm shift in the field of Prosthodontics. This article provides an overview of the intraoral scanners, their clinical applications in Prosthodontics and their working principles.

Conclusions

Digital impressions are a boon in the field of Prosthodontics. IOS have simplified the clinical procedures and have eliminated the various disadvantages of conventional impression materials. Currently, there are many commercially available IOS in the market which are accurate for making crowns, bridges,veneers, inlays/onlays, dentures and even for smile designing. However, there is no sufficient data available that supports the use of IOS for full arch prosthesis. IOS have also proved to be a boon even in the field of Implant Prosthodontics.

Keywords: Intraoral scanners, digital scanners, CAD/CAM systems, optical impressions, digital Prosthodontics.

INTRODUCTION

Making impressions has been an integral part of Prosthodontics. The most commonConventional impression materials used for impression making are polyether and polyvinvlsiloxane. Buttoday, fabrication of fixed prosthesis using CAD-CAM technique has become popular. This became possible due to the advent of extra oral scanners which could scan the master cast sent to the lab and the prosthesis could be designed and fabricated digitally. An improvement was the capability of these scanners to scan the impression directly obviating the need for pouring the impression in gypsum/ die stone. However, the latest development is the introduction of intraoral scanners which can directly scan the hard and soft tissues of the oral cavity to achieve a complete digital impression.

IOS have evolved to a great extent since the first one was introduced in 1973. The technology which is used has improved significantly over the years. Likewise, the capabilities of the IOS have expanded from scanning a

single tooth to multiple teeth and now to scanning full arches.

REVIEW

The concept of CAD/CAM was introduced in dentistry by Dr.Duret in 1973 in one of his papers titled "EmpreinteOptique"i.e. Optical Impressions[16]. He then got a patent for a device in 1984. Some CAD/CAM systems like 3M Lava C.O.S. and CEREC need a powder of titanium dioxide or magnesium oxide to eliminate reflection while scanning the target area. The need for Titanium powder is needed more in first generation IOS but in the newer IOS, there is no need of spraying powder before scanning. Literature suggests that powder spraying may be a cause for reducing the quality of scans.[1, 2, 3, 4].

IOS can be classified into three categories[15]:

1. **Class A** - where the manufacturer includes a scanner, CAD software and a milling unit.
2. **Class B** – which includes a scanner and a CAD software but without a milling unit.
3. **Class C** – which includes a scanner but no software or a milling unit of its own?

The IOS that have their own CAD software and a milling unit making in-office milling possible thus reducing the lab cost and time of prosthesis fabrication. IOS are used in every field of dentistry today but have made a paradigm shift in the field of Prosthodontics. Some of the clinical applications of IOS are given in Table 1.

Table 1: Clinical Applications of IOS

1.	Diagnosis and treatment planning
2.	Fabrication of wide range of prosthetic restorations like inlays, crowns, veneers , bridges etc.
3.	To identify 3D position of implants
4.	Digital smile designing
5.	Fabrication of surgical guides for implant placement
6.	Diagnostic wax- up
7.	For making the patient easily understand the complete treatment.
8.	Patient education

The IOS available currently work on one of the following principles[17]:

TRIANGULATION

The position of a point of a triangle is recorded knowing the positions and angles of two points of view. One of the scanners based on this principle is CEREC

In 1987,Dr. Werner Mormann introduced the first commercially available system CEREC^{R} by Sirona dental systems LLC (Charlotte, NC). The full form of CEREC is Chair side Economical Restoration of Esthetic Ceramics[16]. Former system was applicable only for the fabrication of inlays and onlays but the latest versions like CEREC Omnicam introduced in 2012, CEREC AC and CEREC Primescan are used not only for onlays and inlays but also for fabrication of crowns, bridge, laminates and veneers[16]. Both CEREC Omnicam and Primescan are powderless systems but Primescan has a faster scan speed of 2-3 minutes as compared to Omnicam which has a scan speed of 8-12 minutes. Another major difference between the two is thePrimscan is autoclavable but this feature is missing in Omnicam.

This system is based on the principle of Active Triangulation technique where a 3D acquisition camera projects blue light onto the target area at an angle and reads it at a different angle. The telecentric beam captures the details in a single view. CEREC first generation scanner is a powder system where the target tooth surface area is covered with a layer of Titanium dioxide powder before scan is started. Once scanned, the prepared tooth surface is projected on the monitor screen where the die is cut virtually and finish line is delineated .The system then presents an idealized restoration. Once the restoration is finalised, a block of ceramic / composite is mounted in the milling unit and we then get the finalised physical restoration.

Earlier versions had an acquisition camera with an infrared laser light source but the later versions have blue light emitting diodes (LEDs) which are responsible for a greater precision. In-office milling is possible with this scanner which takes less than 4 minutes.

IOS FAST SCAN TM

It came into the market in 2010 by IOS Technologies (USA). It is the only system where the camera moves within the wand. The operator just has to hold the wand in three positions i.e. buccal, lingual and occlusal to scan complete arch. It acts as a standalone scanner and makes in-office milling possible. It is also based on the principle of Active Triangulation.

ACTIVE WAVE FRONT SAMPLING

It needs a camera and an off-axis aperture module. This module rotates around an axis and generates a rotation of point of interest (POI).The pattern that forms gives the distance and depth of the object of interest.

LAVA CHAIRSIDE ORAL SCANNER (C.O.S.)

This system was introduced in the market in the year 2008 by 3M ESPE (Massachuseets, USA). Titanium dioxide powder has to be sprayed on the target area before scanning. It works on the principle of Active Wave front sampling where a single lens imaging system is used to get 3D data .Three sensors capture images at different angles to obtain surface patches. The scanner tip is the smallest in this system with around 13.2 mm width. It allows real time model construction in video form. High speed scans are

possible with this system because of multiple blue LED cells in scanning wand. In-office milling is not possible with this system[16]. **LAVA Scan ST Scanner** is another generation IOS by 3M where it has retained the 3D video technology of C.O.S. but it is light in weight thus rendering it easy to use, has 50% faster scanning time than the first generation scanner and can even be used for long span bridges.

CONFOCAL IMAGING

It is the acquisition of focused and defocused images from certain depth. The target tooth surface area then can be reconstructed by many successive images taken at different focuses and angles. Some of the IOS based on this principle are-

ITERO

It was introduced in the market in around 2007 by Cadent iTero (Cadent, Carlstadt, NJ).It is based on the principle of Parallel Confocal Imaging where a red laser beam is projected on the target area. The reflected beam then passes through a focal filter such that just the image that lies at the focal point is projected on the screen. Five scans are made each of occlusal , lingual , buccal , interproximal surfaces and 45 degree view of the remaining arch[16]. Then patient is asked to close into centric occlusion and a virtual bite registration is scanned. No in-office milling is possible with this scanner. It is a powderless system .

E4D DENTIST

It was introduced in the year 2008 by D4D Technologies LLC (Richardson, TX). This system has made in-office milling possible. It has a computer, monitor, laser scanner also known as Intraoral Digitizer and a separate milling unit[16]. It is based on the principle of Optical Coherent Tomography and Confocal Microscopy where a red laser is used to vibrate at 20,000 cycles per second. This generates a 3D image of the target area. The intraoral digitizer is held at a distance from the target area with the help of rubber tipped boots extending from the head of the scanner. Dentist has to hold the foot pedal and release it to capture the images. The 3D-IC everythingfeaturesof E4D captures actual images and as successive images are taken, IC Everything model is generated. Images are obtained at different angles that are later compiled by the software. It is a powderless system and can function as a single visit treatment option.

TRIOS

It was introduced in the market in around 2010 by 3 SHAPE (Denmark). It works on the principle of Confocal Microscopy, where the target tooth surface can be constructed by successive images obtained at different focuses from different angles. It is mainly related to acquisition of focused and defocused images from different depths[16]. The focal plane position should continuously vary without moving the scanner to obtain the sub scan. Scans upto 1000 3D pictures making it precise. In-office milling is possible with this system. Additional feature includes a wireless scanner with fastest scanning speed[15].**D1000**, was later introduced by 3SHAPE which has four 5MP cameras and a blue LED technology with a full arch scan time of 25 seconds and 30% faster scanning speed. Latest generation scanner introduced by 3SHAPE is the **Red E Scanner** which includes two to four 5MP cameras and autostart scanning. E3 and E4 models are best suited for implant bars. Major advantage is its 20% enhanced speed as compared to former generations. Its complete arch scanning time is 9 seconds as compared to former generation scanner which is 24 seconds.

ADVANTAGES OF INTRAORAL SCANNERS OVER CONVENTIONAL IMPRESSIONS (TABLE 2)

IOS have been more advantageous in clinical practice as compared to conventional impressions. Literature suggests that optical impressions have better *precision* and *truness*[5,6,7].The main factor that decides the trueness and precision of a scanner is the scanning and the software that builds the 3D model.[1,8,9,10].Some studies reveal that digital impressions are *preferred more by the patients* than conventional impressions.[11,12]. They have *higher resolution*. IOS have eliminated the need for plaster models.[1, 13, 14]. They have also reduced the time of the procedures. Certain IOS like newer generations of CEREC and E4D Dentist have made in-office milling possible thus reducing the chair side time and leading to simplified procedures.[1, 13, 14]It has also led to the elimination of use of disinfectants. The dentist gets enough time to stop bleeding or remove saliva from the target area and then continue the scanning. It has led to simplified clinical procedures especially in difficult areas and complex cases. Once the learning curve is completed, it becomes easy for the clinician to use IOS in difficult cases too[1, 10.]

Table 2: Advantages of IOS over conventional impressions

1.	Patient comfort
2.	Reduced working time
3.	Simplified clinical procedures
4	Easy patient communication
5.	Easy communication with labs
6	Prevents making of stone models
7	Enhanced precision
8	Improved workflow
9	Digital archiving of clinical data
10.	No need of disinfection.

Table 3: Steps eliminated by the use of Intraoral Scanners

At Office	In Lab
Tray selection	Use of dental stone
Use of impression materials	Die cutting
Disinfection of impressions	Articulation
Shipping impressions	Scanning of casts

Table 4: Principles of various IOS Systems

IOS		WORKING PRINCIPLE	NEED OF POWDER
1.	CEREC	Active Triangulation	Yes
2.	iTero	Parallel confocal imaging	No
3.	E4D Dentist	Optical coherent tomography	No
4.	LAVA (C.O.S.)	Active wave front sampling	Yes
5.	TRIOS	Confocal microscopy	No
6.	IOS FastScan™	Active Triangulation	No

Table 5: Advantages of newer generation IOS over first generation IOS

Older generation scanners	Newer generation scanners
Questionable use in long span restorations	Full arch scan in less than 3 min.
Difficult to detect deep marginal finish lines	Detects deep marginal finish lines.
Good scan speed but not as newer generation IOS	Faster
3D colour models not possible	In-color 3D models possible
Fewer clinical applications	Provide colour and texture thus enhanced clinical applications

Trueness and Precision of Intraoral Scanners

Many studies have been conducted to evaluate the accuracy of scanners for both quadrant scan and complete arch scan. Youn-Gyeong Moon et al [20]conducted an in-vivo study to compare the accuracy of intraoral scans between quadrant scans and complete arch scans using TRIOS Chair side Scanner in 100 patients and concluded that complete arch scans had more errors when compared to quadrant scans, these errors were more in the posterior area .Maxillary scans showed more errors than mandibular. They concluded that a longer scanning time leads to such errors. Burcu et al[21] conducted an in-vitro study to evaluate the accuracy of six intraoral scanners for single crown preparations. They concluded that that trueness and precision values ranged from 25 and 10µm to73.5 and 60 µm. Zsolt Nagyet al[23] conducted a study on cadaver maxilla to compare the trueness of seven intraoral scanners and a physical impression. They concluded that deviation increased as distance from scan origin increased .The physical impression was superior to IOS for full arch scan, although the newer systems have clinically acceptable results.

CONCLUSION

IOS have not only simplified the clinical procedures but have also eliminated various disadvantages of making conventional impressions .There has been a constant upgradation of the scanners since their introduction , from powder systems to powderless systems and from scanning single tooth to scanning full arches. Each scanner has its own advantages but the choice of selection mainly depends on the learning curve of the practitioner.

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