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Intraoral Digital Scanners – An Overview

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ABSTRACT

An accurate impression is one of the most challenging tasks in dental practice. A variety of impression materials are available like alginate, polysiloxane, polyether, silicones etc. However, these materials have certain limitations either related to flavour, gag reflex, disinfection process. As an attempt to overcome those limitations Dr. Werner Moreman in 1986 introduced CEREC-1 digital scanner. These scanners have a handheld camera wand that captures 3D virtual images of teeth when passed around the oral tissues. The images so obtained can be used in making orthodontic study models, obturators and for many other procedures like in preparation of crowns, appliances and positioning of implants. As this technique is more efficient, less time consuming and comfortable to patient compared to conventional impression techniques, it may become a routine procedure in the near future.

INTRODUCTION

Most of the successful dental treatment procedures require an accurate impression in order to ensure the reproduction of the intraoral condition as accurately as possible that would finally improve the quality of restoration. Despite of improvements in the properties like better taste, shortened setting time of materials, impression making is still uncomfortable to patient and time consuming to clinician. To overcome all these, intraoral digital scanners have evolved [1].

Evolution of Digital Scanners

It was 18th century where comes the method of taking impressions, making models and constructing appliance. Since then many impressions materials were developed by dentists such as plaster of Paris, impregum which was the first elastomeric impression material, condensation silicone, addition silicone, agar, alginate etc. All of these materials have certain limitations either related to dimensional stability, gag reflex, disinfection process, modulus of elasticity etc. In the recent years the intraoral digital scanners were developed as an alternative to the conventional impression techniques [2].

The advent of intraoral digital scanners coincides with the development of Computer Aided Design and Manufacturing (CAD/CAM) and the introduction of Chair side Economical Restoration of Esthetic Composites (CEREC) in 1984. Prof. Dr. Werner Moremann in 1986 introduced CEREC-1, the first system into the dental office in Switzerland, which is today known to be Sirona dental system 2. The subsequent CEREC 2, CEREC 3 and eventual CEREC 3D system has put back the original technology in 1994, 2000 and 2003 respectively. Cadent in 2001 introduced the Ortho CAD system that could design a virtual setup of 3D digital models, indirect bonding trays. Later in October 2006 Bronte's technologies in Lexington built The Lava Chair side Oral Scanners (C.O.S) acquired by 3M ESPE (s. Paul, MN) in October 2006.

Cadent developed in-office iTero digital impression systems in 2006 and it was capable of full arch scanning by 2008. He also put forth the iOC system for iTero users in late 2009. True definition scanners were introduced by 3M ESPE in 2012, six months later Lythos was released by Ormco [2].

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Disadvantages of Conventional Impression Materials that Lead to Development of Intraoral Digital Scanners

Pulls, tears, bubbles with the impression materials; voids in the impression material or cast, tray to tooth contact, separation of material from impression tray [3], temperature sensitivity, limited working time, material shrinkage, inaccurate pouring, model over trimming, breakage during shipment, patient's perception as unpleasant treatment experience, an extra in-office space to store the models [4].

Types of Intraoral Scanners

Intraoral digital scanners fall under either of the 2 systems namely "CLOSED SYSTEM" and "OPEN SYSTEM" according to the digital file created.

Closed system

In this system the digital file created by the intraoral scanners are in a proprietary format that only works with the software and mills or printers of same format or company. These systems offer only a specific set of clinical applications.

Open system

In these systems files can be imported to any CAD software, mill and printer. The files created are saved in a commonly used format. The common file type for 3D models is "stl" – Standard Triangulation Language. These systems offer a theoretical limitless set of indications.

Equipment and Scanning Technology

Digital intraoral scanners fall under Class I medical electrical devices; designed fulfilling the standards of ANSI/IEC 60601-1. Every scanner has 3 major components: A wireless mobile workstation to support data entry **(Figure 1)**. A computer monitor to enter prescriptions, approve scans and review digital files. A hand held camera wand to collect the intraoral scan data [5]. The technology used by the wand to capture surface data determines the measurement speed, resolution and accuracy of the scanners. Four types of imaging technology are currently employed.

Triangulation

In this technique, the distances and angles from the laser light and known points are measured. The distance between the laser source and the sensor is known, as is the angle between the laser and the sensor. As light reflects off the object, the system determines the angle of reflection and therefore the distance from the laser source to the objects surface according to Pythagorean Theorem. A thin coating of opaque "powder" is to be applied on the target tissues to provide uniform and predictable light dispersion.

Parallel confocal imaging

It projects laser light on to target tissues through a filtering pinhole. This small aperture in front of the sensor blocks any light from above or below the plane of the focus. Only focussed light reflected off the target tissue will re-enter the filter and reach the sensor, thus maximizing the accuracy of the scan. This system tomographically slice the object and stiches together thousands of slices of data to create a complete picture referred as "Point and stich reconstruction".

Accordion fringe interferometry (Afi)

Uses two lights sources to project three patterns of light, called "Fringe patterns", onto the teeth and tissues. As a fringe pattern hits the surface, it distorts and takes on a new pattern based on the unique curvature of the object. Distortion in this fringe pattern is known as "Fringe curvature". A high definition video camera records the surface data points of fringe curvature. These scanners have a higher dynamic range of luminosity, allowing reflective surfaces to be scanned without powder coating.

Three dimensional in motion video

A trinocular imaging is done using a HD video camera. Three accurate views of the tooth are recorded by the three tiny video cameras at the lens. A light dusting of powder is needed. Both AFI and 3D in motion video imaging use HD video cameras rather than a sensor to rapidly capture images in real time [5].

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Figure 1. Shows the parts of Intra oral digital scanners – Computer monitor, Hand-held camera wand (Source Dentium rainbow iOS company).

Powdering

Some digital scanners require application of a thin layer of coating in order to avoid dispersion of light [6] from multiple translucent layers of the tooth and restorative material at unpredictable angles. This enhances scanning accuracy by increasing the number of surface data points and providing uniform light dispersion. Titanium dioxide opaque mixture, Zirconium oxide with amorphous silica and aluminium hydroxide are the powders used.

Various Intraoral Scanner Systems

Itero scanners

It is the frontrunner of intraoral digital scanning technology. It produces powder free digital images by means of parallel confocal imaging. It produces open-source file type named Landlord [7].

Equipment

Display monitor, scanner wand; built in, sealed, antiseptic keyboard; wireless mouse and a wireless foot pedal that frees the operator's hands to hold the wand; a mobile cart enables the unit to be moved. Wireless router synchronizes data with the cloud. The wand is comparatively large and bulky that uses disposable sleeves fitted over the scanning end. It also helps in retraction of cheek, tongue, soft tissue.

Technique

Scanning is done holding the wand at 45° angle to gingival margin, starting at the distal most molar of lower left buccal quadrant and moved mesially to capture both buccal and occlusal landscape. This procedure is repeated on lingual side. Thus scanning is done by quadrants.

The True Definition Scanners

It uses 3D in motion video imaging technology.

Equipment

A light weight wand, touch screen display, a powder dispenser and a wireless internet connection to upload to cloud, build on rolling cart for easy transport. The wand is cleaned with sterile wipes. It captures a faultless data in real time.

Technique

The operator simply captures the anatomy with the hand piece and observes as an accumulated 3D mesh video. During the scan the wand is kept about 10 mm from the tooth surface. Scanning is done in sextants. Scanning can be done in any path but most preferable is to begin on the posterior occlusal surface of first premolar moving from lingual to buccal and back to occlusal. The process is repeated in the anterior sextant beginning with first premolar to make sure at least one tooth to overlap.

The Lythos Scanner

Designed specifically for orthodontic purpose.

Equipment

Small touch screen monitor for data entry, medium sized ergonomic wand and a wireless modem. Disposable sleeves are used. A heated mirror prevents lens from fogging.

Technique

Occlusal surfaces of the entire arch re scanned first, enabling the system to pinpoint the locations of the images being acquired. The advantage of this registration method is that if the scan is interrupted the Lythos system “knows” where it left off once the wand is placed back in the mouth. Following occlusal registration, the scan is divided into quadrants, beginning on the buccal side of the lower right terminal molar. The wand is swept mesially, quickly capturing multiple teeth in real time [8].

3 shape trios

Uses advanced Parallel Confocal imaging technology. Wand has disposable tips and heater to prevent lens fogging. The most interesting aspect of the software is an “Auto-fill” feature that can automatically patch areas of the missing data. Full colour scan is also available with these systems [9].

Care stream dental Cs 3500

This unit features “Parallax” scanning technology, a derivative of parallel confocal imaging. The light guidance system helps in capturing the complete intraoral data. Its unique feature is a direct USB connection that can be plugged into any computer. Scanning tips can be sterilized and reused as many as 20 times and there are two tip sizes to accommodate children and adults.

Plan scan system

Uses sophisticated triangulation method. Do not require powdering. Sterilisable tips. Fog free scanning with a heated mirror. Adjustable field of view software. A laptop based design centre for portability [10].

Lava cos (Chair side oral scanners)

Method used for capturing 3D impressions involves “Active Wave Front Sampling (AWS)”, which enables 3D in motion technique. Powdering is required.

Equipment

A mobile cart containing a computer, touch screen monitor and a scanning wand with tip. The camera at the tip of the wand contains Light Emitting Diodes (LEDs) and lenses. Disinfection involves replacement of plastic sheath or wand.

Sironascerec and apollo systems

This involves three systems namely:

CEREC omnicam

Produces full colour 2D and 3D images and captures half arch and full arch impressions. Camera has an anti-shake feature. During scanning, the camera must be moved between 0-15 mm over the tooth surface. No powdering is required [11].

CEREC bluecam

Contains a blue light emitting diode with a specific wavelength designed to capture better detail. Powdering is required for scanning.

Apollo Di

The system has APOLLO DI software, APOLLO DI intraoral camera and an imaging unit. Camera wand is moved 2 to 20 mm over the tooth surface during scanning [2].

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Applications of Intraoral Scanners

Intraoral scanners captures full arch 3D impressions [12] that are helpful in designing obturators for patients with cleft lip and palate with minimal discomfort [13]; preparation of orthodontic study models useful for a various procedure like diagnosis, model analysis, appliance fabrication [6]; designing fixed partial dentures and complete dentures [14]; making of permanent restorations; as a guide in implant tracing, accurate placement of abutment [15]. Usually young patients prefer digital scanning rather than conventional impression technique hence it can be used in designing various appliances for the children such as habit breaking, space maintainers, space regainers, crowns [16]. When these impressions are connected to a milling machine the treatment can be completed in the same day called "One Day Dentistry" **(Figure 2)**.

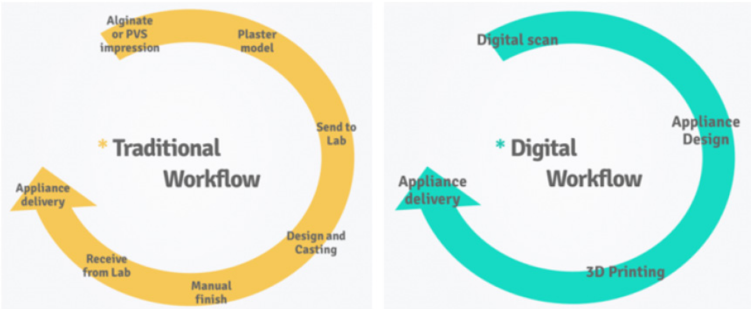

Figure 2. Difference between digital and traditional work flow Source: intechopen.

Accuracy and Time Efficiency

Many studies have been conducted to compare the accuracy of models produced by intraoral scanners and conventional impression techniques [17]. Most of them concluded equal accuracy with both the techniques and few studies concluded that the digital impressions are more accurate and less time consuming than the conventional techniques [18-20].

Limitations of Intraoral Digital Scanners

This digital equipment is very expensive requiring a trained operator and an up-to-date laboratory support to operate and maintain the device [21,22]. Brackets bonded on the lingual side of the teeth reduced the accuracy in arch width measurements that would potentially cause significant clinical errors and hence a scanner that can produce accurate and precise image should be selected in these cases [23,24].

CONCLUSION

Intraoral digital scanners help in improving both practice efficiency and the patient experience better than conventional alginate and PVS impressions. Digital impressions improve the effectiveness of treatment by reducing the visits, which would be beneficial to patients in terms of efficient planning and comfort. With such numerous advantages and benefits, digital impression will likely be a routine procedure in the near future and with few improvements this technique would have a wide use in dental world.

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