Review Article

Pros and Cons of Intraoral Scanners: An Overview

Sonu Solanki*, Rajeev Srivastava, Sourabh Khandelwal, Raveena Makker, Vedant Patel, Nency Parihar

Department of Prosthodontics, Crown and Bridge and Implantology, Index Institute of Dental Sciences, Indore, Madhya Pradesh, India

Abstract

Today, intraoral mapping technology is one of the most exciting new areas in dentistry since three-dimensional scanning of the mouth is required in a large number of procedures. since the concept of intraoral digital impression was put forward in early 1980s. This new digital impression technique is expected to bring about absolute digitization to the mode of Prosthodontist. An optical-impression by an intra-oral scanner (IOS) involves optically measuring the surface shape of the target teeth or gums directly in the patients mouth. These systems are capable of capturing 3D virtual images of tooth which can be used to create accurate master model on which the restorations can be made in a dental laboratory. Precision, accuracy, and hassle-free procedures have made these systems user-friendly and patient – friendly. The use of these products is rapidly increasing around the world and presents a paradigm shift in the way in which dental impressions are made. These article discuss: (1) How IOS works; (2) categories and principles of IOSs; (3) different types of IOSs currently available; (4) accuracy of intra oral scanners; (5) advantages and limitation of IOSs; (6) accuracy of IOSs; and (7) clinical impact of IOSs.

Keywords: Intraoral scanner, Dental impression, Digital impression

Introduction

The introduction of computers and its advancements, it has led the dentist to its next level. Digital dentistry in particular, digital impressions have led to significant changes in impression making. Since the 18th century, conventional impression techniques have been used to register the three-dimensional (3D) geometry of dental tissues.[1] Nevertheless, volumetric changes of impression materials and expansion of dental stone seem error-prone, and thus the process requires the services of an excellent dental laboratory. To overcome these difficulties, impression with IOS (intraoral scanner) was developed for dental practice. The advent of intraoral digital scanners coincided with the development of computer-aided design and manufacturing (CAD/CAM) technology and the 1984 introduction of Chairside Economical Restoration of Esthetic Ceramics [Figure 1].[2]

The implementation of the IOS device in dental practices coincided with the development of CAD/CAM technology in dentistry, with numerous advantages for practitioners. Now a days, IOS and CAD/CAM provide easier planning of treatment, case acceptance, communication with laboratories, reduced operative time, storage requirements, and reduced treatment times. The last decade has seen an increasing number of optical IOS, and these are based on different technologies; the choice of which may impact on clinical use.[3,4]

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Intraoral scanners (IOS) are devices for capturing direct optical impressions in dentistry. Similar to other 3D scanners, they project a light source (laser, or more recently, structured light) onto the object to be scanned, in this case the dental arches, including prepared teeth and implant scan bodies (i.e., cylinders screwed on the implants, used for transferring the 3D implant position).[5] The images of the dentogingival tissues (as well as the implant scan bodies) captured by imaging sensors are processed by the scanning software, which generates point clouds. These point clouds are then triangulated by the same software, creating a 3D surface model (mesh). The 3D surface models of the dentogingival tissues are the result of the optical impression and are the "virtual" alternative to traditional plaster models.[6]

How do the They Work?

CAD/CAM systems are having three main parts:

1. A data acquisition unit, which gathers the information or data from the prepared teeth and the adjacent structures

Address for correspondence: Dr. Sonu Solanki, Department of Prosthodontics, Crown and Bridge and Implantology, Index Institute of Dental Sciences, Indore, Madhya Pradesh, India. Email: sonusolanki098.ss@gmail.com

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and then converted into visual or optical impressions which are created directly or indirectly at the same time.
2. Different softwares are used for designing the final restorations which are secured in optical impressions and prepared for the milling parameters.
3. A computerized milling system for the final manufacturing of the restoration with solid blocks of the appropriate restorative material. The first two parts of the system are associated in the CAD phase, while the third one is the CAM phase.[7,8]

Types of Intraoral Scanners (IOS)

Extraoral scanners

All the scanning procedure done out of the oral cavity, its applied on the master cast.[9]

Contact system

It is called mechanical scanner or non-active scanner that mean the operation of digitizing basically accomplished by mechanical reading by moving a touch probe (ruby ball) line-by-line around the object and the 3D structure measured.[9]

Figure 1: Intraoral scanner in use

Non-contact scanner

It- is also called optical scanner or active scanner. Another technique for digitizing using optical methods, by which the data capturing mechanism done by non-contact method, a ray of light (which is a combination of all colors) or a laser (which is single color light source) are the source of illumination. The basis of this type of scanner is the collection of 3D structure in a so-called triangulation procedure. Here, white light or laser used for surface data digitized by projecting them on the object, and a digital camera which is represented by the receptor unit registered the reflected patterns.[10]

Intraoral scanner or digitizers

Dental CAD/CAM firstly developed with Dr. Duret in 1971; he began to produce crowns with the manipulation shape of the occlusal surface using a chain of systems that started with an optical impression of the prepared tooth in the mouth. Also, Young and Altschuler developed an intraoral grid surface mapping system by suggesting the idea of using optical instrumentation to in 1977.[11]

IOS Scanning Technologies

Digital intraoral scanners are considered Class I medical electrical devices, designed and constructed in accordance with the standards of ANSI/IEC 60601-1. Every scanner has three major components:[12] A wireless mobile workstation to support data entry; a computer monitor to enter prescriptions, approve scans, and review digital files; and a handheld camera wand to collect the scan data in the patient's mouth. To gather surface data points, energy from either laser light or white light is projected from the wand onto an object and reflected back to a sensor or camera within the wand. Based on algorithms,

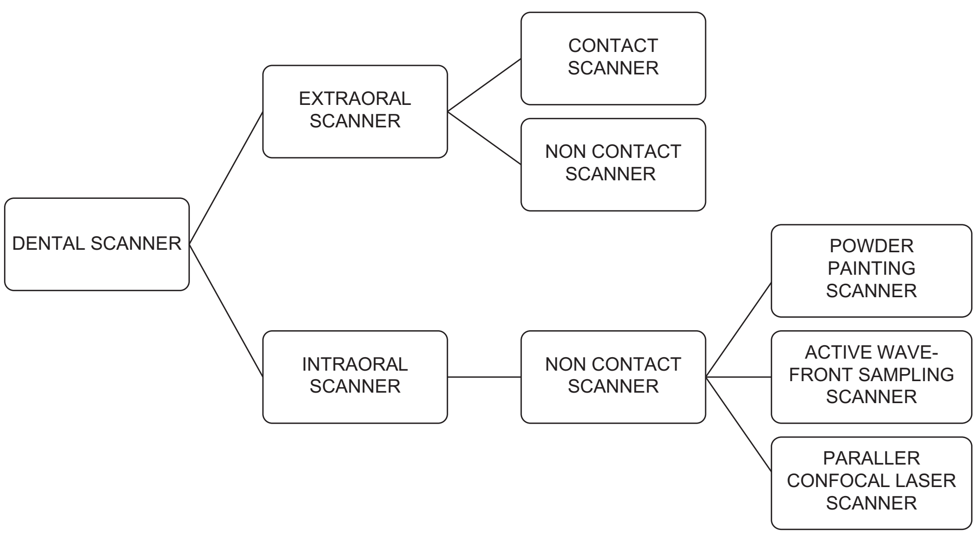

Figure 2: Flow-chart

tens or hundreds of thousands of measurements are taken per inch, resulting in a 3D representation of the object's shape.[13] The technology used by the wand to capture surface data determines the measurement speed, resolution, and accuracy of the scanner.[11] The most widely used digital format is the open Standard Tessellation Language (STL) or locked STL-like This format is already used in many industrial fields and describes a succession of triangulated surfaces where each triangle is defined by three points and a normal surface.[14]

IOS Works on Two Principles

1. Light Projection and Capture
2. Distance to Object Technologies
    i) Triangulation
    ii) Parallel confocal imaging
    iii) Accordion fringe interferometry (AFI)
    iv) 3D in-motion video

Light Projection and Capture

Within the 3D reconstruction field, there is a clear distinction between passive and active techniques. Passive techniques use only ambient lighting to illuminate intraoral tissues and are reliant on a certain level of texture of an object. Active techniques use white, red, or blue structured lights projected from the camera onto the object that is less reliant on the real texture and color of tissues for reconstruction. In active techniques, a luminous point is projected onto an object and the distance to the object is calculated by triangulation.[4]

Distance to Object Technologies

Triangulation

Triangulation is based on a principle that the position of a point of a triangle (the object) can be calculated knowing the positions and angles of two points of view [Figure 8a-d]. These two points of view may be produced by two detectors, a single detector using a prism, or captured at two different points in time.[4]

Parallel confocal imaging

Confocal imaging is a technique based on acquisition of focused and defocused images from selected depths. This technology can detect the sharpness area of the image to infer distance to the object that is correlated to the focal length of the lens. A tooth can then be reconstructed by successive images taken at different focuses and aperture values and from different angles around the object.[4]

Active wavefront sampling (AWS)

AWS is a surface imaging technique, requiring a camera and an off-axis aperture module. The module moves on a circular path around the optical axis and produces a rotation of POI. Distance and depth information are then derived and calculated from the pattern produced by each point.[4]

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 thee surface data points of fringe curvature.[10]

Figure 3: The iTero 3D digital impression system

Figure 4: The true definition scanner

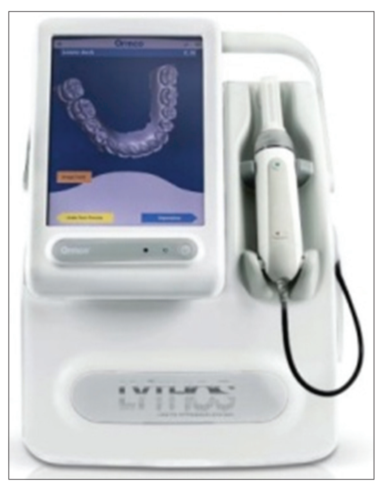

Figure 5: The Lythos scanner

Figure 6: 3 Shape Trios scanner

Figure 7: Lava cos (chairside oral scanners)

3D in-motion video

Stereophotogrammetry. Stereophotogrammetry estimates all coordinates (x, y, and z) only through an algorithmic analysis of images [Figure 3(d)].[14] As this approach relies on passive light projection and software rather than active projection and hardware, the camera is relatively small, its handling is easier, and its production is cheaper.[15]

Various Types of IOS 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.[10] The iTero digital impression system (cadent, Carlstadt, NJ) was introduced in early 2007, following 5 years of intensive research and beta testing. Based on theory of "parallel confocal," the iTero scanner emits a beam of light through a small hole, and any surface within a certain distance will reflect the light back toward the wand.[2]

Equipment

The 117lb iTero unit consist of a 22" liquid-crystal-display monitor; a handheld scanner wand; a built-in, sealed, antiseptic keyboard; a 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 between treatment chairs, which is a particular advantage during busy times of the day.[2]

Technique

Scanning is done holding the wand 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.[15] The scanner takes about 15–20 s to scan facial, lingual, mesioproximal, and distoproximal for each preparation.[16]

The true definition scanners

It uses 3D in motion video imaging technology.[15] It is currently the only third party scanner that has been qualified for use with invasalign's. Similarly, Aligns iTero scanner is qualified for fabrication of the 3M unitek incognito system.[2]

Equipment

The true definition setup comprises an HP workstation with a 22" touch screen display, a light weight wand, a powder dispenser, and a wireless internet connection for uploading to the cloud.[8] The unit weighs 73lb and, like iTero, is built on a rolling cart for easy horizontal surface with a keyboard and mouse, resulting in a slimmer workstation.[8]

Technique

The operator simply captures the anatomy with the hand piece and observes as an accumulated 3D mesh video. During the scan wand is kept about 10 mm from the tooth surface.[10] 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.[8]

The Lythos scanners

Ormco's lythos dgital scanner was designed specially for orthodontic use, based on technology originally developed for the aerospace industry.[8]

Equipment

The most notes worthy feature of the Lythos scanner is its compact size. Weighing only 25lb.The unit consists of a small touch screen monitor for data entry; a.7lb, medium-size ergonomic wand, and a wireless modem. The monitor can be raised as much as 15" with an extension arm for enhanced visibility.[8]

Technique

As with the true definition scanner, images are captured by video in continuous motion. There is no foot pedal, so the operator must rely on visual and light cues from the monitor. A unique occlusal "backbone" scan serves as a reference registration: the occlusal surfaces of the entire arch are scanned first, enabling the system to pinpoint the locations of the images being acquired.[8,9]

3 shape trios

This spring, 3shape, Copenhagen, Denmark, unveiled the TRIOS * color digital impression system.[11] This system

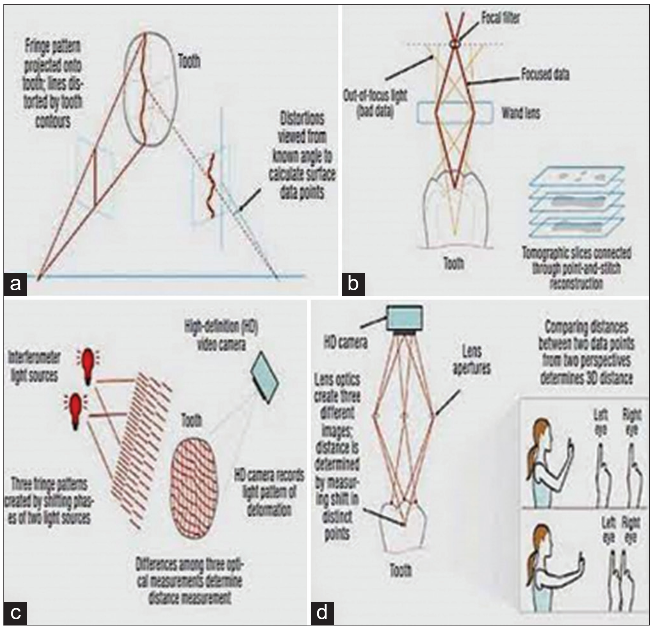

Figure 8: (a) Triangulation. (b) Parallel confocal imaging. (c) Accordion fringe interferometry. (d) Three-dimensional in-motion video

Figure 9: Care Stream Dental Cs 3500 scanner

was introduced in 2010 and reached the market in 2011. This works on the principle of ultrafast optical sectioning and confocal microscopy with powder-free scanning and gives output in the form of 3-dimensional color images of both the teeth and gingiva. Black and white (Trios 3 Mono) version has been introduced which is more economical compared to the colored one. This system is available in both cart and USB version.[16]

Care stream dental Cs 3500

The CS 3500 is designed to be completely portable, requiring no trolley system to move from chair to chair [Figure 9]. The wand can be plugged into any laptop through USB 2 connection. The CS 3500 is designed to give orthodontists the ability to scan a patient's teeth and acquire a color, full arch 3D image. According to the company, the CS 3500 "offers high-angulations scanning up to 45° and a depth of 16 mm, and it features a light guidance system that navigates users through the image-acquisition process."

Lava COS (chairside oral scanners)

The Lava™ Chairside Oral Scanner (COS) was born out of the research of Professor Doug Hart and Dr. János Rohály at the Massachusetts Institute of Technology. The Lava C.O.S. was created at Bronte's Technologies Inc (Lexington, MA) and was acquired by 3M ESPE (St. Paul, MN) in October 2006. The product was launched officially at the Chicago Midwinter Meeting in February 2008.[2]

Equipment

The Lava C.O.S. unit consists of a mobile cart [Figure 3] containing a computer, a touch screen monitor, and a scanning wand, which has a 13.2-mm wide tip and weighs 14 oz (about the size of a large power toothbrush). The camera at the tip of the wand contains 192 Light-Emitting Diodes (LEDs) and 22 lenses.[11]

Technique

The method used for capturing 3D impressions involves Active Wave Front Sampling (AWS), which enables a 3D-in-Motion technique. Using AWS, however, the LAVA C.O.S. captures scanned images quickly (approximately 20 3D data sets per second, or close to 2400 data sets per arch) in video mode and creates a highly accurate virtual on-screen model instantaneously.[11]

Advantages and Disadvantages of IOSs

1. Reduce patients' pain and discomfort
2. Reduce the risk of infection
3. Real-time impression scanning and visualization
4. Simple replication and selective scanning
5. Reduction of cost and waste of materials
6. Virtual follow-ups
7. Tooth and gum color-tone assessment
8. Enable rapid communication
9. Merging with maxillofacial data
10. Improved efficiency in the implant treatment plan.

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. IOS cannot displace the soft-tissue margins and cannot register dynamic tissue relationships.[18,19]

Limitations of IOS

1. Training requirements
2. Visualization of a dry operating field
3. Implant-impression
4. Fixed mandibular position
5. Scanning fees and closed systems.

How to Disinfect the Intraoral Scanner in Your Dental Office

According to CDC classifications, most intraoral scanners are composed of non-critical and semi-critical surfaces. The scanning unit (wand), cradle, touch screen, and base are non-critical. Disposable sleeves or tips which cover the sensor, including any mirrors, are considered semi-critical instruments.

The semi-critical surface on most intraoral scanners is the replaceable scanner tip which covers the sensor and comes into direct contact with the patient's oral tissues.

These disposable sleeves or tips should be removed after each patient. Many can be reused after cleaning and sterilization. Each manufacturer provides specific instructions for tip cleaning which can be found in the instruction manual.[20,21]

Conclusion

The intraoral digital impression technique has been used in Prosthodontics to aid the CAD/CAM process. It helps in improving both practice efficiency and the patient experience better than conventional alginate and PVS impressions. Although conventional impression materials such as PVS and polyether are well developed and present great accuracy in many prostheses, the intraoral digital impression technique has a distinct superiority in work efficiency and saving of materials.

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