

Role of Intraoral Scanner in Digitalizing Dentistry

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Abstract

Intraoral scanner (IOS) has revolutionized digital dentistry. The three-dimensional imaging technique has significantly improved in the last decade. This review aims at providing the reader with a comprehensive insight into the IOS techniques, their superiority, limitation, and their application in dentistry. It also discusses the protocols to disinfect IOS to limit cross-transmission in the dental office. Diagnosis, treatment planning, and rehabilitation have seen a paradigm shift with the IOSs ever-evolving technology. Thorough knowledge of scanning protocol, handling, ambient light scanning condition, reflectivity from the object, the effect of the presence of fluid, mobile tissue, and the method to disinfect the scanners to make the scanner user friendly. Digital scanning technology has not yet reached maturity because of the limitation in cost, coverage area, requiring training and experience, and variation in accuracy based on the number of units of prosthesis. Since the IOS is an evolving device, further research will enable more widespread use of it.

Keywords: Accuracy, Cross-transmission, Digital impression, Disinfection protocol, Intraoral scanner.

INTRODUCTION

The first step in the digital dental workflow is the digitalization of tooth geometry using optical equipment known as intraoral scanners (IOS).^[1] IOS is a medical device used for capturing direct optical impressions and composed of a handheld camera(hardware), a computer and software.^[2] This technique was first put to use in dentistry by Dr. Francois Duret in 1973.^[1]

Aside from the operational features of an IOS system, such as the speed of use, the need for powder, the size of the intraoral wand and tips, and the price, technology used, the mesh quality of the obtained data, and the accuracy (truth and precision), the important fundamentals like disinfection of the system should also be considered.^[3]

The quality of the intraoral scanner is measured in terms of accuracy, trueness, and precision.^[4] According to the definition by the international standard organization in 1994, “accuracy” is the combination of “trueness” and “precision,” where “trueness” is defined as the “closeness of agreement between the arithmetic mean of a large number of test results and the true or accepted reference value” Meanwhile, “precision” was defined as “the closeness of agreement between different test results.”^[4]

Even though the conventional impression has been used in clinical practice for decades, it has a number of limitations, including manipulation of material, impression distortion, no

of steps involved, risk of cross-infection, restricted laboratory options, difficulties in restricted mouth opening patient, errors due to transport, technique sensitivity, time-consuming, and patient discomfort.^[2]

The advantages of IOS are less patient discomfort, time-efficient, simplified clinical procedures, no more casts, better communication with the dental technician, and more laboratory options and treatment plans can be discussed more effectively.^[5]

The disadvantages of IOS, which further needs to be modified, are difficulty detecting deep marginal lines of prepared teeth, purchasing and managing costs, and errors in scanning due to saliva/fluid on marginal surfaces.^[5]

DISCUSSION

Before using the intraoral scanner, it is important to know how the scanner work. Irrespective of the type of imaging technology employed by IOS, all cameras require the projection of light that is then recorded as individual images

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or vide15o and compiled by the software after recognition of the points of interest.^[6]

The first two coordinates (x and y) of each point are evaluated on the image, and the third coordinate (z) is then calculated depending on the distance to object technologies of each camera. The different intraoral scanner uses different technologies and principle to reconstruct the image from these points (Table 1).^[1,6,7] Some intraoral scanner requires reflective coating on tooth surface to accurately scan the tooth surface.^[6] Based on the principles on which the intraoral scanner works and the requirement of the powder, they are classified (Figure 1).^[1,8]

There are many factors that affect the efficiency of intraoral scanners. These factors are mesh quality, light ambient, need for the anti-reflecting coating (powder), and the extent of the region to be scanned.^[6] The mesh quality of the digitized mouth is an

important factor that influences the capabilities of the geometry reproduction of an IOS.^[6] The multiple sets of points or point clouds generated through the optical sensors are subsequently registered (aligned with respect to each other) and are converted into a surface model represented as a triangle mesh.^[6] TRIOS 3 showed the highest consistency and best mesh quality.^[3] The photographic scanning techniques evaluated presented higher mesh quality mean values than those of the video-based scanning technology.^[3] Chair lighting conditions obtained the highest consistency in terms of the mean mesh quality value.^[3]

Lighting conditions influenced the accuracy (trueness and precision) of the digital scans.^[6] For the iTero Element scanner, chair (10 000 lux) and room (1003 lux) lighting improved the trueness and precision mean values.^[9] For the CEREC Omnicam scanner, zero lighting resulted in better trueness and precision mean values. For the TRIOS 3 scanner, room

Table 1: Technology and principles used in intraoral scanner^[1,6,7]

Technology	Principle	Specific feature
Confocal Microscopy Confocal technique achieves images or structure even within thick tissue specimen by a process known as optical sectioning. Ex 3Shape Trios iTero	Laser beam passes through an aperture and focused on a small focal volume through objective lens, the reflected light is than re-collected by the lens	Advantage: Can reconstruct surface of opaque specimens and interior imaging of non-opaque specimens. Better contrast with higher resolution Disadvantage: Ensure accurate image but require large optics that may lead to difficulties in clinical practice
Active wavefront sampling With this technique, a single aperture is moved from one position to another in the sampling plane and a single image is recorded at each spot Ex Lava C.O.S	Require camera and off axis aperture module which moves on a circular path around the optical axis to produce point of interest and image is formed by calculating these points	Advantage: More accurate, eliminate the need for multiple cameras, require only one optical path. Disadvantage: Require powder coating for accurate scanning.
Triangulation Triangulation is a non-contact digital technique to construct 3D image of the object Triangulation is divided into two techniques: a. Passive triangulation b. Active triangulation Passive triangulation technique can measure only high contrast target and well-defined edges therefore Active triangulation technique is used in scanners Ex Cerec Omnicam, Dentsply Sirona CS 3500, Carestream	Uses two detector which forms two point of view and the position of the object is calculated the position and angle of these two points of view (trigonometric calculation)	Advantage: Offers highest trueness Accuracy can be improved by increasing the number of pixels of camera and shorter measuring distance (accuracy of measuring the distance is directly proportional to square of the distance itself. Disadvantage: Accuracy is affected by surface reflectivity. Difficult to capture the target surface (surface underneath the concave area) which is invisible (occlude) by laser or camera.
Stereophotogrammetry The distance between two points that lie on a plane parallel to the photographic image plane can be determined by measuring the distance between them Stereophotogrammetry, a more sophisticated alternative to photogrammetry, estimates the 3-D coordinates of points on an object OCT Noninvasive high resolution optical imaging technology based on interference between signal from an object under investigation and a local reference signal Ex E4D	Relies on passive light projection and software by algorithmic analysis of all the coordinated (x, y, and z) of the image Interferometer in OCT scanner split broadband source into reference field which is focuses through scanning optics and objective lens on the tissue surface which is than scattered back and interferes with reference field on surface of photo detector	Advantage: Relatively small Easy handling Cheaper Advantage: Provides high resolution Broader the emission bandwidth of the source is better resolution and contrast can be achieved. Disadvantage: Scanning is limited to superficial layer if blue or ultraviolet spectrum light source is used.

OCT: Optical coherent tomography

(1003 lux) lighting provided better trueness and precision mean values.^[9]

The IOSs that required powder coating showed better trueness.^[10,11] The uniformity of powder coating thickness can have an impact on the quality of the impression.^[6] The powder layer has a thickness of approximately 20–40 µm.^[6] Fast Scan and True Definition IOSs, which require a powder coating before scanning, exhibited significantly better trueness than IOSs that did not require powdering.^[10,11]

The efficiency of the intraoral scanner is also dependent on the extent of the region to be scanned.^[6] CS3500, CS3600 and Trios 3 are recommended for full arch scan, while Trios 2 and i500 is not recommended.^[12] The posterior scan shows poor accuracy when compared to the anterior segment of the arch.^[12] Trios show better results in single and two implants.^[12] CS3600 show the better result in the full arch.^[12] Large scanned regions will not affect trueness, but it affects precision.^[13-15] The longer the scan range, the larger the error.^[13-15] Different intraoral scanner has proven to be better in different edentulous condition (Table 2).^[16-20]

The field of prosthodontics makes extensive use of intraoral scanners. It has eased the workflow in fixed dental prosthesis, removable dental prosthesis, and implantology with better accuracy and less time-consuming.^[1,5]

In cases of fixed dental prosthesis, study comparing the influence of finish line design (tangential, shoulder, and

chamfer) and position (supragingival and equigingival) on the efficiency of IOS concluded that the supragingival and chamfer or tangential finish line gives better result for single crown.^[21,22] Use of IOS for a single crown improves the quality of preparation as it provides instantaneous visualization for better self-assessment and immediate refinement.^[23] While comparing the marginal accuracy of CAD CAM manufactured single crown using 9 IOS s (Omnicam®, CS3500®, CS3600®, True Definition Scanner®, DWIO®, PlanScan®, 3D PROGRESS Plus®, TRIOS 3®; PlanScan®, 3D PROGRESS Plus® and True Definition Scanner® may have showed the best performances.^[24]

In the field of removable dentures, IOS are used for the fabrication of complete dentures and framework of partial dentures, retrofit crown, or double crown retain removable prostheses.^[25] With the use of IOS, the removable dental prosthesis can be fabricated immediately and with better fit as it eliminates the error of polymerization shrinkage (0.45–0.9%) of conventional technique with the help of CAD-CAM milling.^[25]

High impression accuracy is required for implant retained prosthesis, especially screw retained as the passive fit of prosthesis provide better long-term stability and clinical outcome. Digital impression provides lower inter-implant distance and inter-implant angle error with higher trueness when compared to conventional impression.^[26] Better trueness in partially edentulous cases when compared to completely edentulous cases.^[4] When comparing the influence of scan body material on the accuracy of IOS, PEEK shows the best result among PEEK, Titanium, and PEEK-Titanium scan body.^[26] Studies report a gradual distortion of digital impression accuracy as the scan range expands. This can be attributed to the accumulative error of the stitching process.^[4] Digital impressions covering large spans are inevitably associated with a larger amount of stitching, thereby making the scan procedure more prone to errors.^[4]

The digital workflow reduces the steps and working time compared to analogic workflow, and the possible infection transmission.^[27] There are no physical impressions or materials/instruments to disinfect, no transportation is required, and the number of appointments is decreased.^[27] Whenever possible, a fully digital approach should be implemented during the COVID-19 pandemic to limit infection risk in prosthodontics.^[27]

The intraoral scanner comprises the wand (wand body and wand tip), cradle, touch screen, and wheel-stand handle.^[28-30] Thorough disinfection of all the parts of the scanner is important to limit cross-infection, especially wand, as it comes in contact with the intra-oral environment of the patient. The different intraoral scanner requires different disinfection protocol based on heat and chemical resistance of the material of the scanner body.

For the autoclavable (Trios, 3600 Care stream)^[28,29] intraoral scanner, clean the tip with soap water and a soft dish brush,

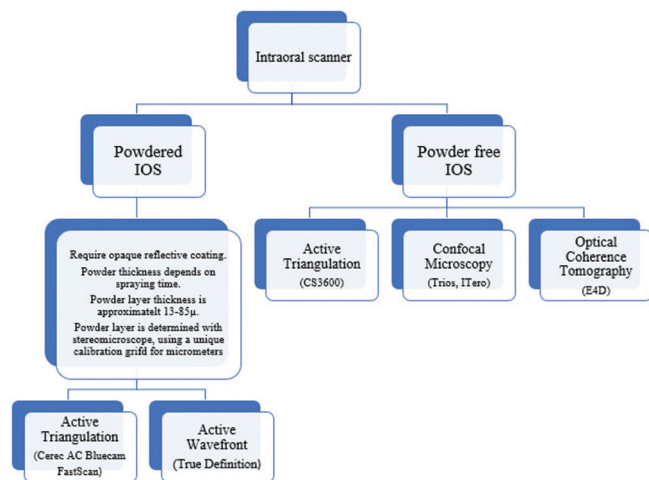


Figure 1: Classification of intraoral scanner based on working principle^[1,8]

Table 2: Different intraoral scanner proven better in different edentulous condition

Region/Type of prosthesis	Scanner
For complete arch	Conventional is either better or equal to digital scanner ^[16]
For partial arch	conventional>digital (confocal laser scanner>active wavefront) ^[17]
For single tooth preparation	Primescan ^[18]
For full-arch implant impression	Confocal laser scanner ^[19,20]

dry it with a paper towel and pack it in a paper sterilization pouch to sterilize. Keep the sterilization pouch in autoclave at 134° for 4 min or 121° for 45 min to complete sterilization of scanner tip.^[29]

For scanners which is sensitive to heat, high-level disinfectant (iTero) can be used. Apply disinfection solution on soft lint free, nonabrasive cloth, gently wipe the optical surface without producing any scratches. Never submerged the tip in the cleaning solution. Do not use ammonia-based or chloride-based solutions. For proper disinfection, dampen all the external surfaces of the wand body and wand tip, including optical surface and ensure they remain wet for at least 1 min.^[30] Approved cleaning and disinfecting material for intraoral scanner is tabulated in Table 3.^[27-30]

Clinical implications of intraoral scanner in every treatment modality provided by prosthodontics are; In complete denture, the use of digital impression, virtual facebow records, and articulation has reduced the chairside time and number of visits.^[31,32] In fixed dental prosthesis, the use of digital impressions along with the CAD-CAM system has made it possible to deliver the prosthesis on the same day. It lessens the dentist and technician's burden with better esthetics and survival of prosthesis.^[32] In cast partial denture, IOS and CAD CAM system help to fabricate partial denture with better fit and accuracy.^[32] In implantology, intraoral scanner helps to plan the implant treatment before the extraction of tooth, aids in fabrication of surgical stent for accurate placement of implant and it made immediate loading protocol possible and delivery of prosthesis on the same day which improved patient's psychological status.^[31]

Intraoral scanner has the limitation such as, it requires patient and doctor acceptance of new technology and learning curve. Dry scanning field is required to minimize the error.^[2,32] As it cannot simulate the dynamic occlusion, the mandibular position acquired by intraoral scanner is not changeable though some CAD software provides virtual articulator system, which requires more clinical evidence.^[32] Apart from the purchase expense, some scanner comes with a closed system or a cloud-based storage system which require additional cost to transfer it into the optical impression. The system requires upgradation also.^[32]

With the everyday advancement in the field of digital dentistry, the use of IOS is increasing with various advantages like real-time visualization and refinement of procedure, storable

data for future reference, patient convenience, merging with maxillofacial data, reduce the risk of infection and improve efficiency in treatment. However, the various setback like sceptical attitude towards the quality of impression accuracy, expensive initial cost, and difficult to accept the paradigm shift in treatment practice from analog to digital dentistry which require further revolutions.

CONCLUSION

With the everyday advancement in the field of digital dentistry the use of intra oral scanner is increasing with various advantages like real time visualization and refinement of procedure, storable data for future reference, patient convenience, merging with maxillofacial data, reduce the risk of infection and improve efficiency in treatment. But the various setbacks like sceptical attitude towards the quality of impression accuracy, expensive initial cost and difficult to accept the paradigm shift in treatment practice from analog to digital dentistry which require further revolutions.

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Table 3: Approved cleaning and disinfecting materials^[27-30]

Material	Active Ingredient	Contact time (minutes)
CaviWipes1/CaviCide1	Quats-alcohol	1
CaviWipes/CaviCide	Quats-alcohol	3
Clorox HP Wipes	1.4% Hydrogen Peroxide	5
Oxivir® 1 Wipes	AHP Hydrogen Peroxide	1
Clinell Universal range wipes	≤50% Peracetic Acid	2

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