APPLICATION OF INTRAORAL SCANNERS IN PROSTHODONTICS-A REVIEW

[1]Arunpriyatharsini S,[2]Anandh B

[1] Senior Lecturer , Department of Prosthodontics and Crown & Bridge, CSI College of Dental Sciences and Research, Madurai
[2] Reader, Department of oral and maxillofacial surgery, Tagore college of dental sciences , Chennai, Tamilnadu, India.

ABSTRACT

A paperless office is now a routine part of life and in the field of dentistry, it shows consistent progress. The technological evolvement of intraoral scanners has enhanced their usage in various fields of Prosthodontics. Intraoral scanning has become the most exciting area of interest with which 3D virtual images are captured and the prosthesis is milled. Recently these advanced technologies are used more than conventional techniques to overcome the problems associated with the latter. This review article presents the science of scanning technology and the application of intraoral scanners in different aspects of Prosthodontics.

INTRODUCTION

Advances in digital dentistry have a significant impact in various fields of Prosthodontics ranging from diagnosis to final treatment plan. CAD-CAM technology and its digital flow counterpart have simplified treatment procedures and reduced appointment time when used precisely. Though conventional impression has been the standard of practice for many decades, it is associated with time consumption, patient discomfort, and an undeniable degree of technical and manipulative skills and errors.

The digital impression with the use of an intraoral scanner has been recognized as a more rapid and convenient technique from the perspective of both the clinician and the patient. The intraoral scanners are considered a paradigm shift as an alternative to impression materials. It has become possible to mill frameworks designed with materials like ceramics, zirconia, and alumina that cannot be cast1.

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Address for correspondence:
DR. S.Arunpriyatharsini - Senior lecturer
Department of Prosthodontics and Crown & Bridge, CSI College of Dental Sciences and Research, The Tamilnadu Dr.M.G.R. Medical University, Madurai, Tamilnadu, India.
Phone no. 9597241691
Email address- dr.priyadarshini27@gmail.com

A scanner is a device, with which the images are obtained and digitized for any type of objects [5]. The digital workflow for manufacturing the prostheses is to capture the image of the structure inside the oral cavity and then the acquired images are transferred to a computer program to design the desired restoration via CAD and finally, the restoration is processed from the desired material based on the design data[5]

EVOLUTION OF DIGITAL IMPRESSION SYSTEMS

Dr.Werner Mormann Brandestini introduced the first intraoral scanner in the 1980s and was first applied to patients in 1985[8]. Thenceforth a lot of companies have marketed in-office intraoral scanners that are increasingly user-friendly and produce precisely fitting dental restorations by capturing dimensional virtual images of tooth preparations and transferring these images as viable dental restorations by directly fabricating using CAD/CAM.

SCANNING TECHNOLOGY

Digital intra-oral scanners are considered class I medical electrical devices designed and committed by standards of ANSI /IEC 60601-I[4].

The scanner has three major components[4]

- ✓ A wireless mobile workstation to support data entry.
- ✓ A computer monitor to enter prescriptions, approve scans and review digital files
- ✓ Handheld camera wand to collect the scan data in the patient's mouth.

The imaging technology currently employed is Triangulation, Parallel confocal imaging, Accordion fringe interferometry, and Three-dimensional motion video. The operating methods of intraoral scanners can be either image-stitching or video-sequencing methods. Image stitching scanners record individual images, they have a field of view in the form of a cone, so they cannot collect information from those hidden surfaces, hence necessary to make several shots of the same area to collect all the information. Video technology scanners record the scanned areas working similarly as a video camera through sequential shots at high speed[4].

The intraoral scanner detects the shape of an object by the light reflected on it and captures it as 3D data. The light projected on the dental arches, including prepared teeth or the implant scan bodies is done by a probe with a hard steel tip or sapphire. The camera should be held in a range of between 5 and 30mm of the scanned surface depending on the scanner and technologies[6]. It was reported 3900K and 500 lux condition was the most appropriate lighting condition for taking a digital impression[1]. The images of the dentogingival tissues or the implant scan bodies captured by imaging sensors are generated as point clouds. These point clouds are then triangulated by the software, creating a 3D surface model (mesh). Tens or hundreds of measurements are taken per inch resulting in a 3D representation of the shape of the object. The glossy and translucent features of dentition and reflective properties of metal prostheses make it tough for recording accurate impressions. To ease this task, titanium dioxide powder[7] can be used to enhance the opacity of the surface and make a uniform reflection of light. The need for powder and opacization is typical of the first-generation IOS; however, the more recently introduced devices can detect optical impressions without using powder. Recently liquid-type scanning-aid material has superior shape reproducibility than the powder-type[7].

IOS have different scanning speeds, and the latest-generation devices are generally faster than the oldest ones. The experience of the clinician and the size of the tip play a role as well, especially in the case of second and third molars. A scanner with a tip of limited dimensions would be preferable for the patient's comfort during the scan; scanners with more voluminous tips allow excellent scanning in posterior areas.[3]

Scanning accuracy is based on different technology, which includes the scanner selected, the resolution at which the tooth is digitized, the learning curve, scanning calibration, ambient light scanning condition, surface characteristics, mobile tissue, reflective restoration, presence of saliva, powder used and mesh quality differences between IOS. Recently developed Intraoral scanners underwent rapid advances in hardware which included various advances in anti-fog heating devices, Color scanning, portable design, and video imaging methods. Also, the recent ones are convenient, smaller, wireless, light-weight, cost-effective, as well as supporting database through cloud computing[5].

USES IN DIAGNOSTIC FIELDS:

IOS can be used to obtain digital impressions between upper and lower teeth to determine 3D positional relationships for diagnosis and treatment planning. This rapid diagnosis saves more time than that is required for conventional impressions and plaster setting time. By taking an optical impression on the day of diagnosis and importing it into CAD software the interarch relation, and its existing or the proposed occlusal relationship can be verified and the treatment plan can be done during patient consultation on the day of the visit[5]. Kuhr et al observed that there is little or no significant difference between impressions made with polyether and IOS impressions. Grunheid et al found measurements of tooth positions and arch dimensions were similar between IOS virtual models and alginate impressions. The outcome of these studies states that the IOS can be used reliably for treatment planning purposes.[2]

USES IN FPD:

The IOS accuracy was found to be influenced by the tooth morphology, where sharp edges, steep areas, proximal and gingival areas had influenced the accuracy[8]. IOS impressions that evaluated molar preparation are insignificantly more accurate than incisor preparation scanning. This is attributed to the steeper surfaces of the incisors as opposed to molars. One study evaluated the effect of altering the total occlusal convergence angle (TOC) of the maxillary central incisor. They reported that IOS is efficient in accurately recording the prepared tooth regardless of the TOC, while the PVS impression accuracy deteriorated with TOC of less than 8 degree[2].

For single tooth and short-span scanning of up to 4 units, the IOS systems proved efficient to conventional impressions. But there is a reduction in trueness and precision as the scanning span increases. Mehl et al found that single tooth scanning was more accurate than quadrant scanning[2]. Studies evaluated the accuracy of IOS for whole arch scanning is more vulnerable to deviation than conventional methods.. Further, the anterior segment of the arch was more accurate than the posterior segment for the IOS-generated models. This may be due to the reduced preparation height and inclination for posterior teeth. IOS cannot capture the whole arch with a single scan, multiple overlapping scans have to be taken and combined via stitching algorithm. As a consequence, every stitching process can introduce additional discrepancies. Eventually, the error will be propagated for every stitching process. This explains that the inaccuracy increases as the span of the scanning increases. For longer span prosthesis, in addition to accurately recording the tooth surface, the occlusal relationship has to be registered, which is very difficult to record by IOS after preparing several teeth.

In aesthetic areas, the prosthetic margins placed subgingivally may be more difficult for the light to correctly detect the entire finishing line. Unlike the conventional impression materials, light cannot physically detach the gum and therefore cannot register ‘non-visible’ areas. Similar problems occur in case of bleeding, as blood may obscure the prosthetic margins. However, the latest-generation scanners are characterized by very low errors in full-arch impressions, especially with the introduction of a new intraoral scanning system with a greater depth of capture, (up to 20 mm according to its manufacturer)

Uses in implantology

IOS is successfully used to capture the 3D position of dental implants and to process implant-supported restorations. The 3D position of the implants captured with the IOS is sent to the CAD software, where the scan bodies are coupled with an implant library, and the desired prosthetic restorations can be drawn within minutes. This restoration then can be physically realized by milling through a powerful CAM machine. Capparè et al. compared the accuracy of digital versus conventional impressions in 50 patients who needed to be rehabilitated with full-arch screw-retained prostheses, each supported by 6 implants. The subjects were categorized into two groups, the test group (optical impressions with IOS) and the control group (conventional impressions). In the patients of the test group, the definitive metal structure of the prosthesis was milled in CAD/CAM, while in the patients of the control group, it was carried out conventionally. In comparison, the passive fit and the marginal adaptation of the definitive structure with optical impressions were accurate and are confirmed radiographically by the analysis of all 300 implants inserted. The digital procedure saved a great deal of time in the fabrication of the prosthetic structure. The authors concluded that IOS represents a valid alternative for capturing suitable impressions for the modeling and fabrication of milled bars or structures, in support of full-arch prostheses in the maxilla.[9]n complete edentulism:

Evaluating digital scans of edentulous sites especially in the palatal area is difficult because the sites are smooth and devoid of features. The smooth surface of palatal areas are poorly traceable structures, and difficulties arise in stitching the pictures. Lee reported drawing lines on the palate with a mixture of pressure indicating paste and interim zinc oxide eugenol cement, and then the palate could be scanned with an intraoral scanner.. To improve the accuracy of the digital scans of edentulous areas made with an intraoral scanner, Kim et al used a 4×3 mm alumina marker attached to the surfaces of the gingiva with a light-polymerizing resin. But when patients disturb the alumina marker with their tongue they can become loose. Jing - Huan Fang injected flowable composite resin to six different sites on the hard palate with a diameter of 2mm and after polymerizing the resin, glue was applied to the resin marker area either as minute drops. These resin markers are radioopaque and can be used to merge intraoral scans and cone-beam computed tomography (CBCT) data for the virtual planning[10]. However, scanning edentulous areas with a broad palatal vault was found to be difficult.

IN REMOVABLE PARTIAL DENTURE:

Due to the various forms of RPD parts and their classification systems the digital designing of the RPD framework is complicated as compared with FPD framework designs. The software needs to determine the path of insertion, eliminate undesirable undercuts, and identify desirable undercuts. Tregerman et al compared 3 methods for producing RPD frameworks: full analog combined analog and full digital pathways. The full digital pathway was the only IOS-based method and showed a significantly superior RPD framework fit compared to the analog pathway, regardless of Kennedy's classification. The manufacturing of the RPD framework using CAD/ CAM and Rapid prototyping involves preparing dental casts using conventional or digital impressions,scanning the impressions using a digital scanner, determining the path of insertion of the RPD by the software, followed by 3D designing of the framework components and finally, digitally designed partial denture framework with RapidProtyping. In a short-term clinical study conducted by Waleed Hamed Maryod, the retention of digital RPD fabricated with the digital impression, digital designing, and casting a 3D printed pattern was higher than conventional RPD as it was associated with less human intervention[11].

CONCLUSION:

The current implication of IOS is extremely wide in the whole range of prosthodontic restorations. IOS is the remarkable replacement of impression trays, materials, and its consequent cross-contamination. It effectively reduces working time and gives comfort for both clinician and patient. The clinician can easily delete the incorrectly recorded impressions and make a new one without wastage of material. Communication with technicians and clinicians can be easy and immediate through email. The main limitation is in recording the functional movable tissues. At present, the ease of IOS for recording long spans, detecting deep marginal lines on prepared teeth in case of bleeding and in esthetic zones remains questionable, but recently marketed scanners are successful in breaking these shortcomings.

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